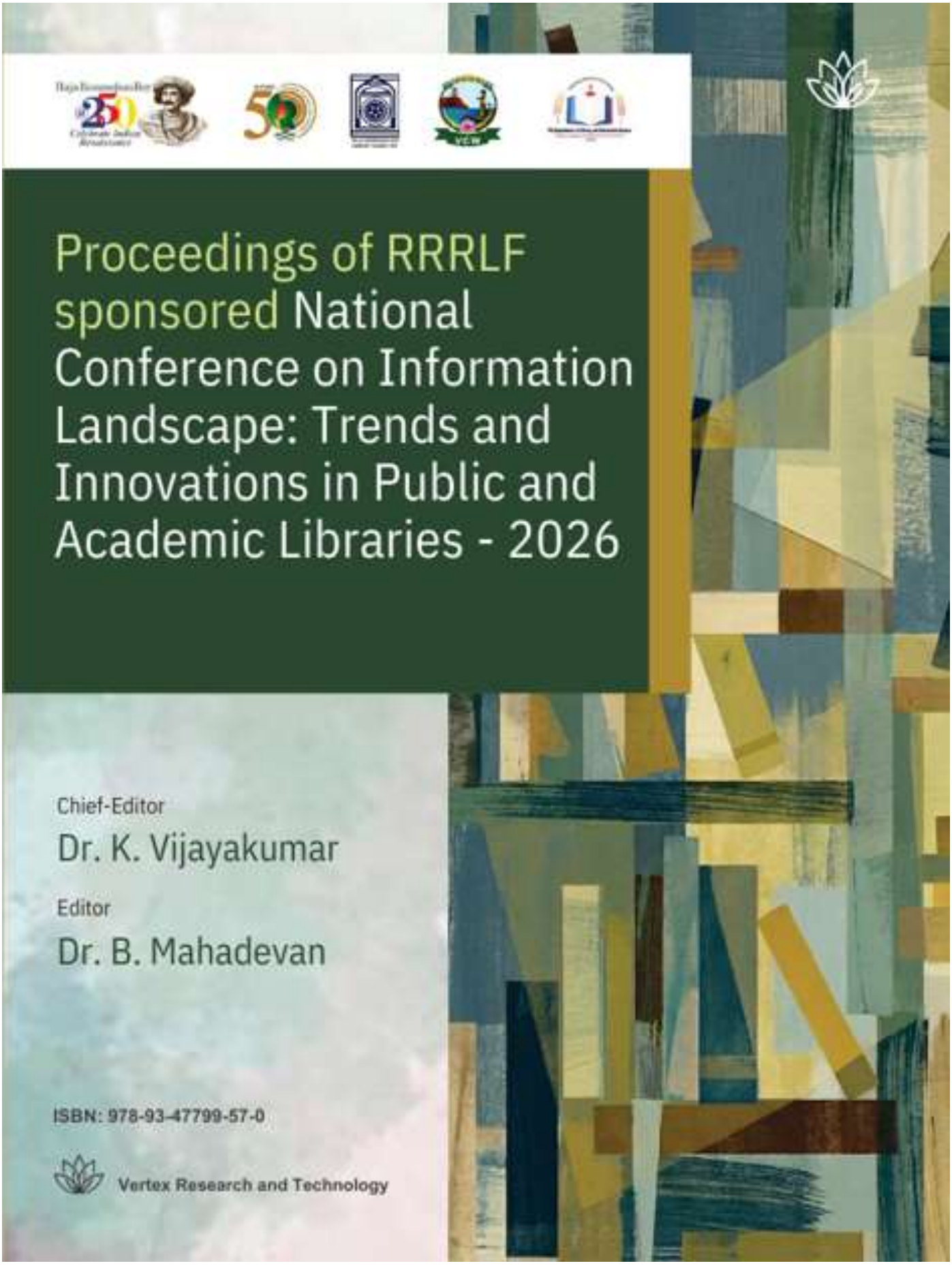


Proceedings of RRRLF sponsored National Conference on Information Landscape: Trends and Innovations in Public and Academic Libraries - 2026

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Dr. K. Vijayakumar

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Dr. B. Mahadevan

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Preface

Libraries are undergoing a profound transformation in response to rapid advancements in information and communication technologies, changing user expectations, and the growing demand for inclusive and sustainable knowledge access. In this evolving context, the **National Conference on Information Landscape: Trends and Innovations in Public and Academic Libraries (NCILTIPAL 2K26)** has been conceived as a vibrant academic platform to deliberate on contemporary developments shaping the present and future of libraries.

Sponsored by the **Raja Rammohun Roy Library Foundation (RRRLF), Ministry of Culture, Government of India**, this national conference aims to bring together librarians, information professionals, academicians, researchers, policy makers, and students to exchange ideas, share best practices, and explore innovative approaches in public and academic library services. The conference highlights emerging trends such as digital transformation, smart libraries, open access initiatives, information literacy, knowledge management, and the role of libraries in achieving sustainable development goals.

NCILTIPAL 2K26 seeks to foster meaningful dialogue on redefining library services in an increasingly digital and user-centric environment. The deliberations and scholarly contributions presented during the conference reflect the collective commitment of the library and information science community towards strengthening information infrastructure and promoting equitable access to knowledge.

The organizing committee sincerely acknowledges the generous support of **RRRLF**, whose continued encouragement plays a vital role in advancing library development across the nation. We also extend our heartfelt gratitude to the resource persons, contributors, reviewers, and participants whose active involvement has enriched the academic value of this conference.

It is hoped that the insights and recommendations emerging from **NCILTIPAL 2K26** will inspire innovation, collaboration, and professional excellence in public and academic libraries.

Dr. B.Mahadevan

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EDITORIAL NOTE

National Conference on "**Information Landscape: Trends and Innovations in Public and Academic Libraries (NCILTIPAL 2K26)**" serves as an excellent platform for bringing together scholars, researchers, practitioners, and students to exchange ideas, share insights, and foster meaningful collaboration. Within these proceedings, readers will encounter a collective commitment to exploring emerging trends, technological innovations, and transformative practices shaping public and academic libraries. This dynamic forum encourages the flourishing of ideas and the sharing of best practices, all contributing to the broader goal of strengthening information access, knowledge management, and user-centric library services. Through the diverse contributions presented, this volume stands as a significant resource in advancing innovative library practices and enhancing the role of libraries in the contemporary information ecosystem.

We extend our sincere gratitude to Thiru. C.Jayakumar, B.A., B.L., President, Vellalar College for Women, Thiru. S.D.Chandrasekar, B.A., Secretary & Correspondent, Vellalar College for Women, Dr. R.Parvathi, Principal, Vellalar College for Women, Dr. K.K.Mythili, Dean – Aademics, Vellalar College for Women, Dr. S.Vishnuvarthani, Dean- Administration, Vellalar College for Women, for their invaluable contributions and unwavering support.

Editorial team acknowledge the significant contribution of 160 papers from 235 authors, including 2 international submissions from Sri Lanka. Following a careful evaluation, 153 research papers have been thoughtfully selected for inclusion in this book, each organized based on the conference theme across interdisciplinary domains. These selected papers, covering Emerging Technologies, Digital Transformation and Innovation, User-centric and Smart Libraries, Open Access and Scholarly Communication, Digital and AI Literacy, Information Ethic, Sustainability and Green Libraries, Collaboration and Community Engagement, Policy, Governance and Advocacy and Capacity, Building and Professional Development, aim to address critical research challenges. We believe that the diverse perspectives presented in this book will significantly contribute to Information Landscape: Trends and Innovations in Public and Academic Libraries during the conference.

About the Conference

The **RRRLF Sponsored Two-Day National Conference on "Information Landscape: Trends and Innovations in Public and Academic Libraries"** is a significant academic and professional event aimed at examining the dynamic changes occurring in the library and information environment. Organized with the support of the **Raja Rammohun Roy Library Foundation (RRRLF)**, Ministry of Culture, Government of India, the conference seeks to provide a vibrant national forum for dialogue, knowledge sharing, and collaboration among library and information science professionals.

In the contemporary knowledge society, libraries are no longer confined to their traditional roles of collection and dissemination of information. Rapid developments in information and communication technologies, digital resources, open access initiatives, and user-centered services have transformed public and academic libraries into active knowledge and learning hubs. This conference is conceived against this backdrop, focusing on how libraries can adapt, innovate, and remain relevant in an increasingly digital and networked information landscape.

The central theme of the conference, *"***Information Landscape: Trends and Innovations in Public and Academic Libraries***,"* emphasizes emerging trends such as digital and hybrid libraries, open educational resources, scholarly communication, institutional repositories, information literacy, research support services, and the application of advanced technologies like artificial intelligence, data analytics, and automation in library operations. Special attention is given to innovative service models that enhance access, inclusivity, and user engagement in both public and academic library settings.

The conference aims to bring together librarians, academicians, researchers, information professionals, policy makers, and students from across the country. It provides an opportunity to present original research, share best practices, and discuss challenges and opportunities faced by libraries in responding to changing user expectations and information behaviors. Through keynote addresses, invited lectures, technical sessions, and paper presentations, participants will gain insights into current developments and future directions in library and information services.

Another important objective of the conference is capacity building and professional development. By facilitating interaction among experienced professionals and emerging scholars, the event encourages mentoring, networking, and collaborative research. The deliberations are expected to contribute to strengthening public and academic libraries, particularly in areas related to digital transformation, quality services, and sustainable development.

The conference also aligns with national priorities related to education, research, digital empowerment, and knowledge dissemination. The support of **RRRLF** underscores the importance of public libraries in nation building and lifelong learning, while the focus on academic libraries highlights their critical role in supporting teaching, learning, and research.

Overall, the conference aspires to serve as a catalyst for innovation and excellence in library and information services. The knowledge and perspectives shared during the two days are expected to inspire participants to adopt progressive practices and contribute meaningfully to the advancement of the library profession in India and beyond.

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S.D. Chandrasekar, B.A.,
Secretary & Correspondent

MESSAGE



Thiru. S. D. Chandrasekar
Secretary, Vellalar College for Women (Autonomous)

I am happy to convey my sincere greetings to all the delegates, academicians, library professionals, researchers, and students attending the National Conference on *"Information Landscape: Trends and Innovations in Public and Academic Libraries."* It is a matter of pride that our institution is organizing this significant academic event focusing on the changing dimensions of libraries in the contemporary knowledge environment.

With rapid advancements in technology and digital information systems, public and academic libraries are continuously evolving to serve diverse user communities more effectively. This conference serves as an appropriate forum for exchanging ideas, examining innovative practices, and reflecting on the future of library and information services.

I appreciate the organizing committee for their committed efforts in bringing together scholars and professionals from across the nation. I believe that the discussions and deliberations of this conference will generate constructive outcomes and significantly enhance academic and library excellence.

I wish the conference great success and hope that the deliberations will result in meaningful insights and lasting academic contributions.

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Dr. (Mrs.) **R. PARVATHI,** M.Sc., M.Phil., B.Ed., PGDCA, Ph.D.,

Principal

MESSAGE



Dr.R.Parvathi
Principal, Vellalar College for Women (Autonomous)

It gives me immense pleasure to extend my warm greetings to all the delegates, academicians, librarians, researchers, professionals, and students participating in the RRRLF Sponsored National Conference on *"Information Landscape: Trends and Innovations in Public and Academic Libraries."* I am delighted that our institution is hosting this intellectually stimulating academic event, which addresses one of the most dynamic and transformative domains of contemporary knowledge society.

Libraries today are no longer confined to physical spaces or traditional functions. They have evolved into vibrant knowledge hubs, driven by digital technologies, data-driven services, open-access movements, and user-centric innovations. In this rapidly changing information landscape, public and academic libraries play a pivotal role in ensuring equitable access to information, fostering lifelong learning, supporting research excellence, and empowering communities.

The theme of this conference is timely and relevant, as it brings into focus emerging trends such as digital libraries, artificial intelligence in information services, research data management, information literacy, and the reimagining of library spaces and services. I am confident that the deliberations, paper presentations, panel discussions, and interactions during this conference will offer valuable insights, encourage collaborative thinking, and inspire innovative practices among library and information professionals.

I commend the organizing committee and the Department of Library and Information Science for their dedicated efforts in conceptualizing and organizing this national-level conference. Such initiatives significantly contribute to academic enrichment and professional development, while also strengthening the institution's commitment to research and knowledge dissemination.

I wish the conference a grand success and hope that the ideas exchanged here will translate into meaningful actions, progressive policies, and sustainable innovations in public and academic libraries across the country. I also extend my best wishes to all the participants for a rewarding and inspiring conference experience.

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MESSAGE



Dr. K.K. Mythili
Dean – Academics, Vellalar College for Women (Autonomous)

It gives me immense pleasure to extend my warm greetings to all the delegates, researchers, academicians, librarians, and professionals participating in the **RRRLF Sponsored National Conference on "Information Landscape: Trends and Innovations in Public and Academic Libraries (NCILTIPAL 2K26)"**, organized by the PG Department of Library and Information Science, Vellalar College for Women, Thindal, Erode.

In an era marked by rapid technological advancement and digital transformation, libraries are evolving from traditional repositories of knowledge into dynamic, user-centric knowledge hubs. The thoughtfully curated themes of this conference—ranging from emerging technologies and digital transformation to open access, sustainability, policy, and professional development—reflect the contemporary challenges and opportunities faced by public and academic libraries.

This conference provides an excellent academic platform for scholars and professionals to exchange ideas, present research findings, and engage in meaningful discussions that contribute to the advancement of Library and Information Science. I am confident that the deliberations and scholarly contributions will enrich academic discourse and inspire innovative practices in the library ecosystem.

I congratulate the organizing committee for their academic vision and meticulous planning, and I wish the conference every success. I sincerely hope that all participants find this forum intellectually stimulating and professionally rewarding.

Dean – Academics

Dr. K. K. MYITHILI M.Sc., M. Phil., P.G.D.C.A.,Ph.D.,
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MESSAGE



Dr.S.Vishnuvarthani
Dean – Administration, Vellalar College for Women (Autonomous)

I am pleased to extend my warm greetings to all the delegates, academicians, librarians, researchers, and students participating in the National Conference on *"Information Landscape: Trends and Innovations in Public and Academic Libraries."* It is a matter of great **honor** for our institution to host this national-level academic event, which showcases the dynamic transformations shaping the information and knowledge ecosystem.

In today's rapidly evolving digital and administrative environment, public and academic libraries are not only transforming their information services but also strengthening governance, resource management, and service delivery mechanisms. This conference provides a meaningful platform to deliberate on emerging trends, innovative practices, and sustainable administrative strategies that support academic excellence and effective library management.

The dedicated efforts of the organizing committee in the meticulous planning and successful execution of this conference deserve special mention. The interactions and deliberations are expected to generate valuable insights, encourage professional collaboration, and contribute meaningfully to the advancement of academic and library services.

I wish the conference every success and extend my best wishes to all participants for a fruitful and intellectually **enriching** participation.

S. Vishnu

Dean – Administration

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Respected Chief Guest, Honorable Dignitaries, Esteemed Speakers, Faculty Members, Librarians, Research Scholars, and Dear Participants, Greetings to all.

It gives me immense pleasure to be associated with the RRRLF Sponsored National Conference on *"***Information Landscape: Trends and Innovations in Public and Academic Libraries (NCILTIPAL 2K26)***"*, organized by the PG Department of Library and Information Science, Vellalar College for Women, Thindal, Erode. I sincerely congratulate the organizers for initiating this timely and meaningful academic endeavor.

In today's dynamic knowledge environment, libraries are witnessing rapid transformation driven by digital technologies. Innovations such as Artificial Intelligence, Machine Learning, Cloud Computing, Data Analytics, and immersive technologies are redefining information organization, access, and dissemination. Libraries are no longer passive repositories but vibrant, smart, and user-centric knowledge hubs.

The conference themes aptly focus on digital libraries, open access, user-oriented services, information ethics, sustainability, policy frameworks, and professional competencies. These areas are crucial for strengthening public and academic libraries in the present and future context.

As information professionals, our responsibility extends to ensuring equitable access, ethical information use, privacy protection, and promotion of information and digital literacy. Continuous professional development and collaborative engagement are essential to meet evolving user expectations.

I am confident that this conference will foster meaningful dialogue, knowledge sharing, and innovative practices, contributing significantly to the growth of the library profession. I wish the conference great success and a truly enriching experience for all participants.

Thanking you,

Chief Editor

K. Vijayakumar

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MESSAGE



Dr.B. Mahadevan
Organizing secretory
Assistant Professor and Head,
Department of library and information Science,
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It gives me immense pleasure to extend my warm greetings to the organizers, participants, and delegates of the **RRRLF Sponsored National Conference** on ***"Information Landscape: Trends and Innovations in Public and Academic Libraries (NCILTIPAL 2K26)"***. Organizing this conference at a time of significant transformation in libraries is both timely and commendable.

In today's knowledge-driven society, libraries play a crucial role in ensuring equitable access to information and supporting education, research, and lifelong learning. Rapid advancements in information and communication technologies have reshaped the information landscape, compelling libraries to adopt innovative, digital, and user-centric service models. Public libraries foster social inclusion, digital literacy, and community engagement, while academic libraries support teaching, research, scholarly communication, and open access initiatives.

The deliberations of NCILTIPAL 2K26 are expected to offer valuable insights into technology-enabled services, information literacy, and sustainable library development. I am pleased to acknowledge the support of the **Raja Rammohun Roy Library Foundation (RRRLF)**, **Ministry of Culture, Government of India**, for its continued contribution to library development. I am confident that this conference will significantly strengthen library services and professional collaboration nationwide.

Organizing Secretary
Dr. B.MAHADEVAN., Ph.D.,
Assistant Professor and Head
PG & Research Dept of Library & Information Science
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Artificial Intelligence Strategy for Information Systems Research in the Future: Comparison between Indian and Foreign Libraries

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Abstract

Artificial Intelligence makes life easier and saves the time of human beings. In this study, the comparison shows between Indian libraries' and foreign libraries' strategies of application, outcome and drawbacks. The study also highlights that the challenges of data privacy due to insufficient funding, technical defects, insufficient experience, etc. In the foreign libraries, there is more advanced equipment and techniques which is lacking in Indian libraries. This study shows that with the help of AI how a library can improve its day-to-day library systems. They have to think about the collaboration, different plans and policies. This present study tries to give solutions for using AI, and how to achieve their goals in libraries. The findings show the advantages of AI in libraries, their information systems and contribution to all libraries.

Keywords: Artificial intelligence, Indian libraries, international libraries, information and retrieval system, user interaction, comparative study, library services.

Introduction

Artificial Intelligence (AI) is now changing libraries so drastically in all areas of user-centric sections by saving the time of the users and satisfying users. This study is about the challenges and applications of AI in all the libraries in the world, and it shows the comparison between Indian and Foreign libraries. In our modern era, Artificial intelligence (AI) is being used in various ways in libraries for retrieval of information, user-centric activities and many more. In this study, the comparison of Indian and Foreign libraries shows both some similarities and dissimilarities. This research highlights that the implications of AI in Indian and Foreign libraries are growing drastically. After using the AI systems, day -to-day activities of the libraries are improving. Also, with the implementation of AI techniques, some machine learning processes are applied to the library for the betterment of its functions 2. For using these systems, users can also get 24/7 assistance for remote access facilities from anywhere. For resource preservation and collection, a predictive analytics solution is a better way for library systems.

Objectives

1. To show the differences and applications of AI in Indian and foreign libraries.
2. To locate the hurdles that both libraries face in implementing AI in their libraries.
3. To distinguish between the research methods and future AI implementations in the library.
4. To scrutinize that after implementation of the implementation of how AI affects both Indian and foreign libraries.
5. To recognize the techniques of AI adoption and practices from all over.
6. To make it recommendable to all other libraries to implement AI tools to broaden their library services.

Literature Review

Libraries around the world have started using AI to handle cataloguing and sorting books, which has been a huge help for the librarians. It cuts down their workload and makes the whole process faster and more accurate. [Mueller and his team (2020)] found that natural language processing (NLP) does a pretty good job at tagging and organizing library stuff, so users can find what they need without pulling their hair out. Then there's

the whole recommendation system thing—you know, like how Netflix suggests movies? Libraries are doing that now, too.[Harper and Moore (2019)] pointed out that these AI-driven suggestions (based on what you've borrowed before) make people happier with the library. Let's not forget OCR (optical character recognition)! AIs have made digitizing old books and documents so much easier. [Lee and Chen (2018)] showed how this technology is a blessing for libraries, especially those with rare historical collections. Now, instead of digging through dusty archives, you can just search a database. Chatbots are another big one. Libraries in Asia and Australia have rolled out these virtual assistants to answer basic questions 24/7 (Jones & Brown, 2019). It's not perfect—sometimes you still need a real human—but it frees up librarians for the tricky stuff.[Predictive analytics: Thompson et al. (2021)] found that AI can predict which books will be in demand, helping libraries manage inventory better. But…there are some serious concerns too. [Smith et al. (2020)] stressed that libraries have to keep their user data tight—otherwise, trust goes out the window. [Garcia and Martin (2020)] warned that if AI isn't properly programmed, it might favor certain groups over others. [Thompson et al. (2021)] repeated the same point about predictive analytics. Libraries need to team up with policymakers to make a particular set of rules for AI use (Thompson et al., 2021). [Staff training is also critical—Jones and Brown (2019)] argued that librarians need ongoing training to keep up with this tech. And can we talk about India for a sec? The AI scene there is fascinating. [Kumar and Gupta (2020)] wrote about university libraries making it work despite shaky infrastructure. [Das (2021)] produced an insight into how AI is changing user engagement in West Bengal's public libraries.[Kaur and Singh (2020)] emphasize the significance of government funding as well as implementation strategies at Indian university libraries. These studies demonstrate that India is getting closer to implementing AI, despite the lack of a proper digital infrastructure.

Table 1: Current Applications of AI in Libraries (Global perspectives)

S.No	Current applications	Percentages
1	Personalized Recommendations	25%
2	Automated Cataloging	20%
3	Digital Collections (OCR)	20%
4	Virtual Assistant/chatbots	15%
5	Predictive Analytics	20%

Table 1 demonstrates the strategic prioritization of various information system technologies; 25% of them display personalized recommendations. This suggests a commitment to encouraging user participation. The 20% statistic for digital collections and automated cataloguing highlights how important accessible resources and efficient resource management are. At 15%, chatbots and virtual assistants are crucial for enhancing user support and communication in general. Predictive analytics, which holds 20% of the market, emphasizes how proactive it is to understand customer trends and priorities. These technologies combine to create a logical framework that improves user experience and operational effectiveness in an increasingly digital world.

Table 2: Challenges in AI Implementation in Indian Libraries

Sl No	Challenges	Description	Examples of Literature
1	Data Privacy and Security	Ensuring user data protection and compliance with regulations	Smith et al. (2020)

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2	Infrastructure and Tech Gaps	Need for significant investment in technology and infrastructure	Nguyen and Patel (2018)
3	Skill Gaps and Training	Shortage of skilled personnel to manage AI systems	Jones and Brown (2019)
4	Algorithmic Bias and Fairness	Ensuring AI systems are unbiased and fair in their operations	Garcia and Martin (2020)

Table 2 describes the main barriers to implementing cutting-edge technology are listed in the table, particularly regarding data management and artificial intelligence. Smith et al. (2020) assert that data security and privacy are essential since companies must protect user data and comply with regulatory requirements. Deficits in technology and infrastructure pose significant problems; claim Nguyen and Patel (2018). Jones and Brown (2019) assert that another significant obstacle is the lack of qualified workers to oversee AI systems. Last but not least, creating trust and equity requires addressing algorithmic bias and guaranteeing fairness in AI operations, as Garcia and Martin (2020) examine. The intricacy of incorporating cutting-edge technologies and the significance of resolving them for successful deployment are highlighted by these issues taken together.

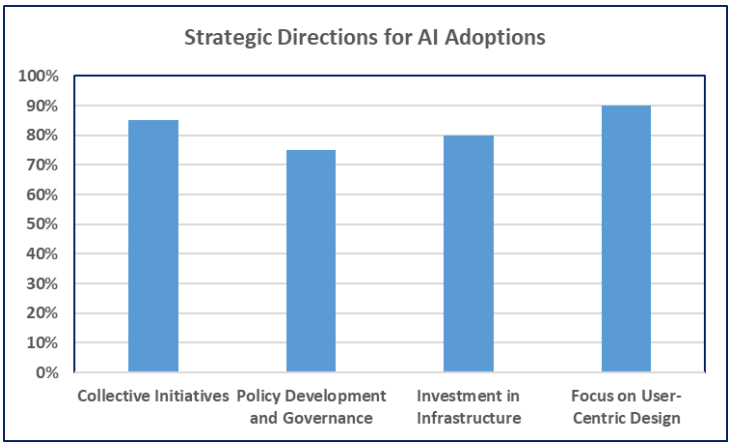


Figure 1: Strategic Directions for AI Adoptions

Figure 1 highlights the value of collaboration in promoting effective technology adoption with a noteworthy 90% emphasis on user-centric design. Eighty percent is infrastructure investment, which is equally important; ninety percent is user-centric design, and seventy-five percent is policy and governance. The strategic commitment to creating an ecosystem where infrastructure and user experience collaborate to optimize technology adoption and integration is demonstrated by the high overall focus on these cooperative efforts.

Table 3: Future Prospects and Research Directions

S.No	Future prospect/research direction.	Description	Examples of Literature
1	Continuous Research and Development	Investing in ongoing R&D to explore new AI applications	Harper and Moore (2019)
2	User Experience and Engagement	Studying the impact of AI on user experience and engagement	Harper and Moore (2019)

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3	Ethical and Social Implications	Exploring long-term effects of AI adoption on library services	Smith et al., (2020)
4	Technological Advancements	Investigating emerging AI technologies for potential applications	Nguyen and Patel (2018)

Table 3 shows how Harper and Moore (2019) argue that the key to where the libraries are now headed lies in constant research and development, because this technology is not slowing down anytime soon. Their study also shows that if we want AI to work for people, we have got to design it around their needs. Smith et al. (2020) dug into the long-term effects of AI in libraries, and guess what? It resulted that the ethical and social implications are huge. We are talking privacy, bias and how it affects staffing—stuff that can't be ignored just because the technology s cool. Nguyen and Patel (2018) made a good point: if we keep an eye on emerging technology (like, say, whatever comes after ChatGPT, we might stumble on breakthroughs that could reshape how libraries manage information.

Figure 2: AI Implementation Status in Indian Libraries

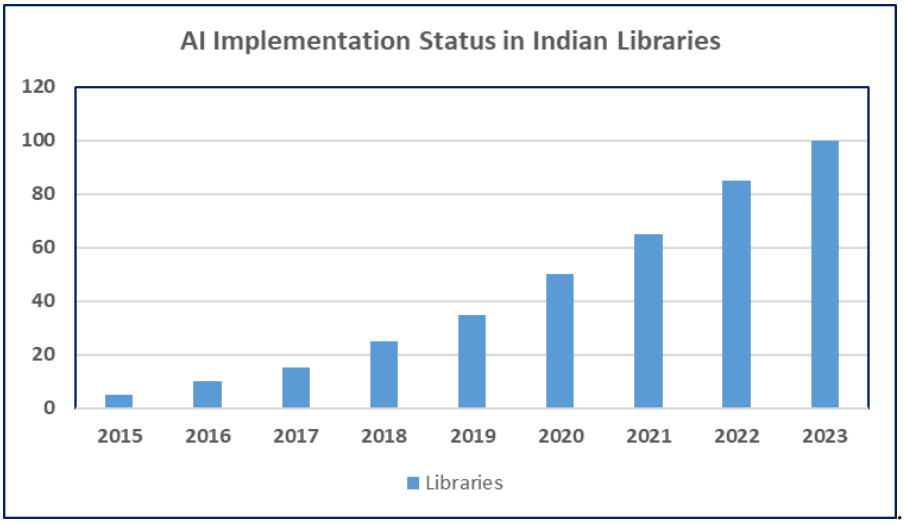


Figure 2: AI Implementation Status in Indian Libraries

Figure 2 shows the use of AI in Indian libraries in recent years is shown in this figure. The figure shows how the application of AI in Indian libraries has grown steadily between the years 2015 and 2023. The number of libraries using AI can be seen increasing from five libraries in 2015. Ten in 2016 and then a huge jump to 25 by the year 2018, and fifty by the year 2020. Then again, from 65 libraries in 2021 to 100 by the year 2023. Thus, reflecting the growing use of AI in libraries and the awareness spread among the library community to make the user experience easy and efficient.

Table 4: Key AI Technologies Used in Libraries

S.No	AI Technology	Application in Libraries	Examples
1	Natural Language Processing (NLP)	Automated cataloging, classification, and text analysis.	Mueller et al. (2020)
2	Optical Character Recognition (OCR)	Digitization of physical texts	Lee and Chen (2018)

3	Machine Learning(ML) Algorithms	Personalized recommendations	Harper and Moore(2019)
4	Machine Learning(ML) Algorithms	predictive analytics	Thompson et al. (2021)
5	Chatbots and Virtual Assistants	Users supported query handling.	Jones and Brown (2019)

Table 4 describes that AI technologies are changing the way libraries provide services with the help of various applications that enhance user experience. Natural Language Processing enables automated cataloguing and classification, which simplifies the organization of information (Mueller et al., 2020). To convert physical texts into documents, or in this case, digital documents, Optical Character Recognition (OCR) can be used (Lee and Chen, 2018). To enable personalized recommendations and help with predictive analysis, machine learning algorithms are used (Harper and Moore, 2019; Thompson et al., 2021). Chatbots and virtual assistants also make it easier to handle queries, providing users with immediate assistance and information (Jones and Brown, 2019).

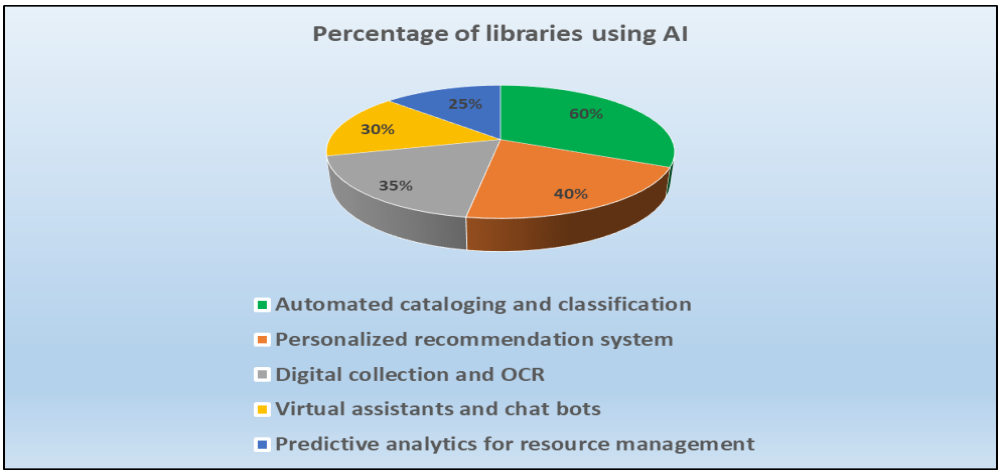


Figure 3: Current AI Applications in Foreign Libraries

Figure 3 shows that the varied adoption of AI in libraries across a wide range of functionality reflects both the opportunities and challenges of integrating technology into traditional library procedures. As seen in Figure 3, foreign libraries have largely adopted important AI technologies. While tools like predictive analytics are still less common, cataloguing and recommendations are now the norm. On the other hand, concerns about data protection, cost or integration complexity may be the cause of a lower adoption of chatbots and OCR.

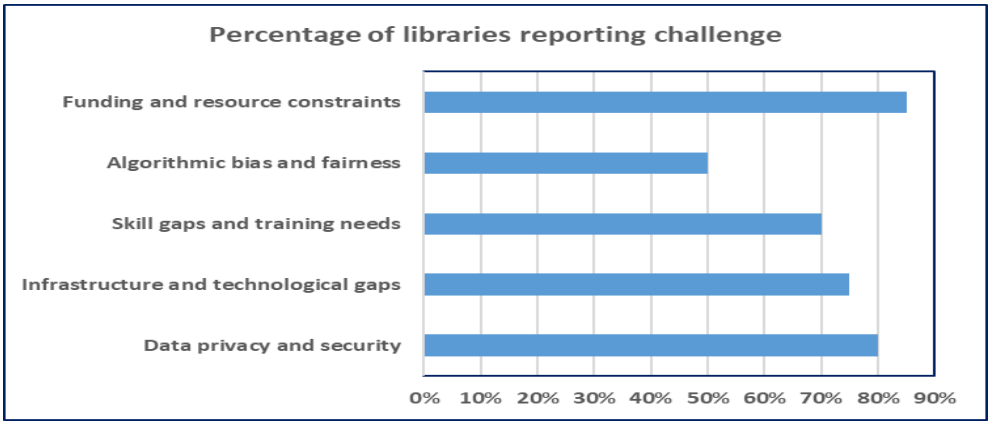


Figure 4: Challenges Faced by Foreign Libraries

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Figure 4 shows that predictive analytics demonstrates a more conservative approach to resource management, accounting for 25%. All things considered, these percentages demonstrate that libraries are becoming more creative, but they also highlight areas where increased investment and development could enhance the quality of services. The challenges foreign libraries face in integrating AI technologies reveal significant barriers to modernization. 85% of libraries cited financial and resource constraints as the most pressing issue, highlighting the financial obstacles to technological advancement. Data privacy and security are the top concerns for 80% of libraries, followed by gaps in technology and infrastructure (75%), skill shortages and training requirements (70%), and algorithmic bias and fairness (50%). The outcome signifies that moral quandaries surrounding the implementations of AI are more generally accepted. Both libraries are the first achieve and understand the financial hurdles, technical and moral values to use AI to its full potential.

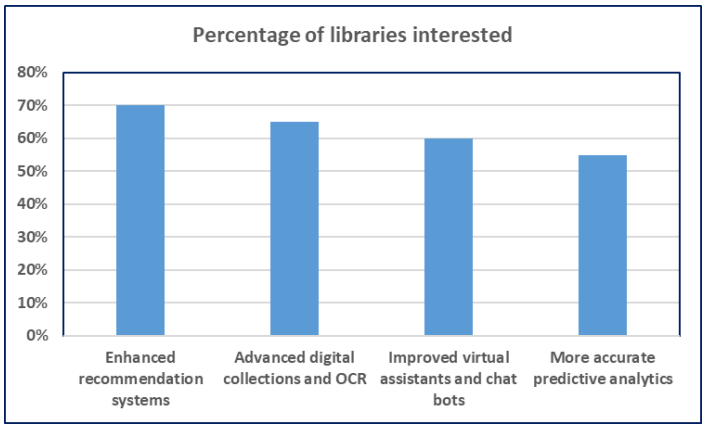


Figure 5: Future AI Applications Planned in Foreign Libraries

Figure 5 shows that if both Indian and Foreign libraries are actively engaged in intensifying users' skills and optimizing the interest of the users in executing AI practice .Improved recommendation systems are of interest to 70% of libraries. At 65%, OCR and sophisticated digital collections rank second. Better chatbots and virtual assistants are of interest to 60% of people. Lastly, 55% of those surveyed said they would like to see more accurate predictive analytics. All things considered, these figures demonstrate libraries' strong commitment to implementing AI technologies and prioritizing initiatives that could significantly enhance their services.

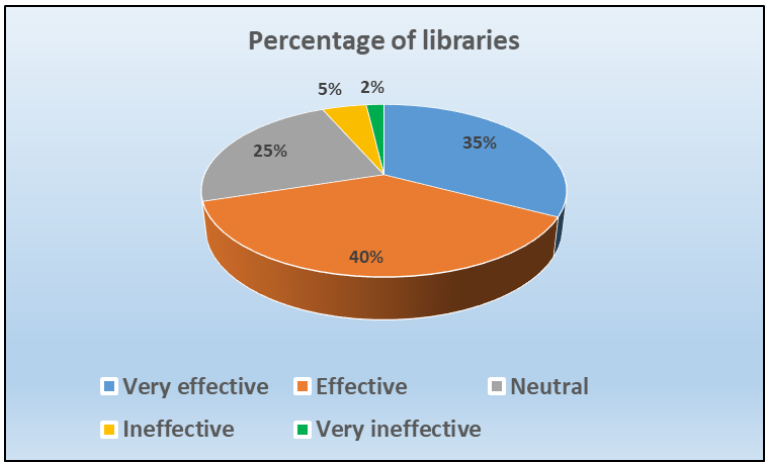


Figure 6: Effectiveness of AI in Improving Library Services

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Figure 6 shows that the majority of users have positive opinions about the value of AI applications in libraries. With 35% of respondents rating AI as very effective and 40% as effective, it is clear that the majority of people are aware of the technology's actual benefits in enhancing library services. A neutral response from 25% of respondents might suggest some ambivalence and disparate library experiences or expectations. People are generally quite happy with AI integration, as evidenced by the fact that less than 5% of respondents call AI ineffective, and only 2% call it "very ineffective".

Table 5: Future Trends in AI Adoption

S.No	Future Trend	Examples
1	Increased use of AI in metadata creation	Harper and Moore (2019)
2	Integration of AI in user interfaces	Jones and Brown (2019)
3	AI-driven preservation and conservation	Lee and Chen (2018)
4	Expansion of AI in research support	Muller et al. (2020)

Table 5 shows that AI in libraries is expected to advance significantly in the future, according to emerging trends in a range of applications. Harper and Moore (2019) explain Greater use of AI in metadata creation, as Jones and Brown (2019) highlight how AI is being incorporated into user interfaces. Lee and Chen (2018) looked into preservation and conservation using AI. Last but not least, Muller et al. (2020) highlight the expansion of AI in research support. Eventually, the tenor implies that AI may be bringing a revolutionary change to the library services for its efficiency.

Table 6: Comparison of AI Implementation in Indian and Foreign Libraries

S.No	Library type	AI Implementation (Indian)	AI Implementation (Foreign libraries)
1	Cataloguing and Classification	25-30%	50-60%
2	Reference and Research Services	20-25%	45-55%
3	Personalized Recommendations	15-20%	30-50%
4	Automation of Circulation	20-25%	50-60%
5	Chabot’s and Virtual Assistants	10-15%	40-50%
6	Data Analytics	10-15%	40-50%
7	Smart Search Engines	15-20%	45-55%
8	AI-driven User Support	10-15%	35-45%
9	Digital Archiving	15-20%	50-60%

Table 6 indicates that Indian libraries and foreign libraries both are using AI applications in different ways. In AI technologies, Indian libraries adopt classification and cataloguing 25–30% and 50–60%, automation 20-25%, data analysis 10–15% and 40–50% and personalized recommendations 15–20% and 30–50%. AI-driven chatbots and user support 10–15%, in comparison to foreign libraries, 40–50%. In the implementation of AI, foreign libraries are more advanced in comparison to Indian libraries. Indian libraries need to improve and,

the most important thing is that there are lack of funds and technical issues. International libraries have clear strategies and they are directly connected to the companies. Without a clear plan, Indian libraries cannot implement AI applications in full phase.

Findings

Information systems place a strategic focus on three technologies that are linked to increasing resource efficiency and user engagement: Twenty-five percent of the strategy focus is on personalized recommendations. Consequently, a dedication to customizing user experiences will be guaranteed. Digital collections and automated cataloguing come in second at 20%. This places a strong focus on organizing resources efficiently. At 20%, predictive analytics shows a proactive approach to identifying patterns and user behavior. Chatbots and virtual assistants, which represent 15% of the total, are used for user assistance and interaction. When combined, these technologies provide a coherent framework for improving user experiences and operational procedures within a specific digital context. Implementing these high-tech solutions presents several challenges, particularly with relation to AI and data management: One of the most important concerns is data privacy and security since the business needs to guarantee user safety and adhere to legal requirements (Smith et al., 2020). One of the biggest obstacles to the seamless adoption of technology is infrastructure and tech gaps (Nguyen & Patel, 2018). Training and skill gaps: One significant issue that needs to be addressed is the lack of qualified workers to operate AI systems (Jones & Brown, 2019). Algorithmic Bias and Fairness: Fairness and trust in the effectiveness of AI systems are the objectives (Garcia & Martin, 2020). One of the challenges in dealing with these intricacies is that technology integration cannot be successful without it.

The research conclusions heavily emphasize coordinated efforts to support the role of technology in its implementation: 90% user-centric design is an excellent attempt to optimize some aspects of the user experience. Infrastructure Investment: It discusses a solid technical foundation at 80%. With a score of 75%, policy building and governance highlight the aspect of compliance. To maximize technology adoption, it is a strategic commitment that speaks to an ecosystem where user experience combines with compliance and infrastructure preparedness. The following are some crucial areas for even more important future study in AI application fields: Ongoing R&D: Continuous innovation is necessary to progress (Harper & Moore, 2019).

According to Harper and Moore, user experience and engagement can be discussed in terms of user-centric approaches in technology design. Ethical and Social Implications: Given that knowledge is enlightened, it is worthwhile to be aware of what might occur in the long run about the effects of AI in libraries (Smith et al., 2020). Technological Developments: Information management is an area where possible developments could be found to supplement the information (Nguyen and Patel, 2018). These rules emphasize how important it is to strike a balance between ethical considerations and technological possibilities.

From 2015 to 2023, Indian libraries will gradually implement AI. This pattern indicates that libraries in India are becoming more aware of the potential and worth of AI: 5 libraries in 2015; 100 libraries in 2023. This will significantly enhance AI's services, efficiency, and user experience. The way libraries operate is being drastically changed by AI technologies: NLP: This facilitates automated classification and cataloging (Mueller et al., 2020). OCR: Since it aligns with digitization, text conversion is a highly pertinent activity (Lee & Chen, 2018). Personalized recommendations are more complex thanks to machine learning (ML) (Harper & Moore, 2019). Virtual assistants and chatbots improve user support (Jones & Brown, 2019).

Together, these examples show how AI may transform library services. The following represents the percentages of libraries that have adopted AI in various functionalities: Predictive analytics: 25%; digital collections and OCR: 35%; chatbots and virtual assistants: 30%; automated cataloging: 60%; and personalized recommendations: 40%. While this tendency demonstrates receptivity to innovation, it also suggests that certain sectors need greater funding.

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Obstacles Faced by International Libraries: The following are some of the major obstacles that foreign libraries face while implementing AI: Resource and Funding Limitations: 85%; Algorithmic Bias Awareness: 50%; Infrastructure Gaps: 75%; Skill Gaps: 70%; Data Privacy and Security: 80%. For libraries starting the AI modernization process, this is a challenging environment. There is evidence that the majority of AI applications require libraries to be more proactive: Superior Recommendation Systems: 70%; Superior Digital Collections and OCR: 65%; Virtual Assistants and Chatbots: 60%; Predictive Analytics: 55%. These percentages indicate higher preparedness of the libraries to take up AI innovations for improved services. Library user perception of AI applications is almost always positive: 35%: "Highly effective"; 40%: "Effective"; 25%: Neutral; 5% "Ineffective"; 2% "Very ineffective". This is a clear sign that, generally speaking, people's pleasure with integration keeps rising as time goes on.

The following advancements will also influence how AI is used in libraries in the future: increased application of AI to the production of metadata (Harper & Moore, 2019). Incorporating artificial intelligence into user interfaces (Jones & Brown, 2019). Conservation and preservation powered by AI (Lee & Chen, 2018). AI's growth in research assistance (Mueller et al., 2020). These patterns show how AI has a significant impact on the services that libraries provide. Compared to international libraries, Indian libraries are less likely to adopt many AI technologies: 25–30% (compared to 50–60%) for cataloging and classification; 20–25% (compared to 50–60%) for circulation automation; 15-20% (compared to 30–50%) for personalized recommendations; and 10-15% (compared to 40–50%) for data analytics. These differences show how much room there is for Indian libraries to advance toward international norms in integrating AI. The planning and application of AI in libraries in India and other countries vary greatly. Foreign libraries generally see AI as a long-term investment that fits into their country's larger goals for digital development. In contradiction, the use of AI in Indian libraries is on a much smaller scale, as each libraries test advanced technology on its own without considerable help from the government. Hence, the Indian Libraries face more obstacles in tracking results or implementing the same technologies. Many foreign libraries also work together with tech companies, which accelerate their development. However, Indian libraries are often autonomous, which impedes their progress.

Conclusion

This study clearly synchronizes the comparison between Indian and Foreign libraries in the implementation of AI applications in library services. Both libraries are using AI in their workplace, but in comparison to foreign libraries, Indian libraries are facing many challenges. International libraries are facing some issues relating to data security and technical problems. For sorting these kinds of issues, both the libraries have to take some initiatives, sufficient staff and funding. In case of Indian libraries, there are lack of leadership and institutional support. In the future, there is a lot of scope regarding the implementation of AI in libraries, and many users should take advantage of that, so if both the libraries sort out their issues regarding the implementation of AI in their libraries, there must be new ways and doorsteps open to the users of the library.

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Deep Learning Based Automatic Document Classification for Digital Library Systems

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Abstract

The rapid expansion of digital documents in academic libraries, institutional repositories, and online information systems has introduced significant challenges in the efficient organization, indexing, and retrieval of information. Conventional document classification practices in libraries, such as manual assignment of Dewey Decimal Classification (DDC) or Universal Decimal Classification (UDC), are labor-intensive, time-consuming, and often inconsistent due to human subjectivity. The exponential growth of research articles, e-books, reports, and archival resources has intensified the need for automated, scalable, and accurate document classification mechanisms. This research focuses on the development of an Automatic Document Classification System using Deep Learning to improve information organization and retrieval in digital library environments. The proposed approach integrates Natural Language Processing (NLP) techniques with deep neural network architectures to automatically classify documents into predefined subject categories based on their textual content. Unlike traditional machine learning methods that depend on manual feature engineering, deep learning models are capable of learning hierarchical, semantic, and contextual representations directly from text data, leading to improved classification performance. The proposed framework reduces manual classification effort, enhances indexing efficiency, and improves search and retrieval effectiveness in digital libraries. This research contributes to the application of advanced artificial intelligence techniques in Library and Information Science and offers a robust framework for intelligent knowledge organization and management in modern digital information systems.

Keywords: Automatic Document Classification, Deep Learning, Digital Libraries, Natural Language Processing, Text Classification, Library and Information Science, Word Embeddings, CNN, LSTM

Introduction

The rapid advancement of information and communication technologies has led to an exponential increase in the volume of digital documents generated across academic, research, and institutional environments. Libraries have transitioned from traditional print-based collections to digital libraries that store vast amounts of electronic resources such as research articles, e-books, theses, reports, and archival documents. Effective organization and classification of these digital resources are essential to ensure efficient information retrieval and knowledge dissemination. In Library and Information Science (LIS), document classification plays a crucial role in structuring information using standard schemes such as Dewey Decimal Classification (DDC) and Universal Decimal Classification (UDC). However, the growing scale and complexity of digital content demand automated and intelligent solutions. Recent developments in artificial intelligence, particularly deep learning and natural language processing, provide new opportunities to enhance document classification processes and improve library services.

Need for Automatic Document Classification

Manual document classification is a time-consuming and labor-intensive process that requires skilled professionals to analyze document content and assign appropriate subject categories. With the continuous growth of digital collections, manual methods have become inefficient, inconsistent, and difficult to scale. Human subjectivity can also lead to variations in classification decisions, affecting retrieval accuracy. Automatic document classification is needed to address these challenges by enabling faster, consistent, and scalable classification of large document repositories. An automated approach reduces the workload of

librarians, improves indexing efficiency, and ensures timely access to information resources. Moreover, automatic classification enhances search and retrieval performance in digital libraries by organizing content systematically and accurately.

Problem Statement

The exponential growth of digital documents in academic libraries, institutional repositories, and online information systems has posed significant challenges in organizing, classifying, and retrieving information effectively. Traditional document classification practices in Library and Information Science, such as manual assignment of DDC or UDC, are highly dependent on human expertise and are time-consuming, labor-intensive, and susceptible to subjectivity and inconsistency. As the volume of digital resources continues to expand rapidly, these manual methods are no longer scalable or efficient. Conventional automated classification techniques based on rule-based systems or traditional machine learning algorithms rely heavily on handcrafted features and often fail to capture the semantic and contextual meaning of textual data. This limitation leads to reduced classification accuracy, especially when dealing with large, diverse, and unstructured document collections. Inadequate classification directly affects information retrieval performance, resulting in poor search relevance and reduced accessibility of knowledge resources. Therefore, there is a critical need for an intelligent, automated, and scalable document classification system that can accurately categorize large volumes of digital documents with minimal human intervention. Deep learning–based approaches, combined with Natural Language Processing techniques, offer a promising solution by automatically learning semantic representations from text. This research addresses the problem of inefficient and inconsistent document classification in digital libraries by proposing a deep learning–based automatic document classification system to enhance knowledge organization and retrieval.

Objectives of the Study

The primary objective of this research is to design and develop an automatic document classification system using deep learning techniques for effective organization of digital library resources.

The specific objectives are:

- To study and analyze existing document classification methods used in Library and Information Science and identify their limitations in handling large-scale digital collections.
- To preprocess and represent textual data effectively using Natural Language Processing techniques such as tokenization, stop-word removal, lemmatization, and word embedding methods.
- To design and implement deep learning models (such as CNN, LSTM, or transformer-based models) for automatic document classification.
- To evaluate the performance of the proposed system using standard metrics including accuracy, precision, recall, and F1-score.
- To compare deep learning–based classification results with traditional machine learning approaches to demonstrate improvements in accuracy and consistency.
- To reduce manual effort and subjectivity in document classification by automating subject assignment in digital libraries.
- To enhance information retrieval efficiency by improving the quality of document indexing and categorization.

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Scope of the Study

The scope of this study is limited to the classification of textual documents commonly found in digital libraries, such as research articles, academic papers, and institutional records. The research focuses on applying deep learning techniques for subject-based document classification and does not address multimedia content such as images, audio, or video. The study emphasizes automated classification within predefined categories aligned with standard LIS classification schemes. The implementation and evaluation are conducted using selected datasets and tools, and the findings are intended to support academic and research-oriented digital library systems.

Review of Literature

Traditional Document Classification in LIS

Traditional document classification in Library and Information Science relies on established classification schemes such as Dewey Decimal Classification (DDC), Universal Decimal Classification (UDC), and Library of Congress Classification (LCC). These systems organize knowledge hierarchically and enable systematic arrangement of library resources. Classification is typically performed manually by trained librarians who analyze document content and assign subject categories. While these methods ensure intellectual control and standardization, they are time-consuming and difficult to maintain in large-scale digital environments. Several studies have highlighted the limitations of manual classification in terms of scalability, consistency, and cost.

Automated Classification Techniques

Automated document classification techniques emerged to overcome the limitations of manual methods. Early approaches include rule-based systems that use predefined rules and keywords to assign categories. These systems require extensive domain knowledge and frequent updates, making them difficult to maintain. Statistical methods such as term frequency and inverse document frequency (TF-IDF) have also been widely used for automated classification. Although these techniques improve efficiency, they often fail to capture deeper semantic relationships within text.

Machine Learning Approaches

Machine learning approaches such as Naïve Bayes, Support Vector Machines (SVM), Decision Trees, and k-Nearest Neighbors (k-NN) have been extensively applied to document classification tasks. These methods use labeled datasets to learn patterns and make predictions. Machine learning models generally outperform rule-based systems; however, their performance depends heavily on feature engineering and data representation. In the context of LIS, studies have shown that traditional machine learning models struggle with large, unstructured, and semantically complex documents.

Deep Learning in Text Classification

Deep learning has emerged as a powerful approach for text classification due to its ability to automatically learn hierarchical and semantic representations from raw text. Models such as Convolutional Neural Networks (CNN), Long Short-Term Memory (LSTM), and transformer-based architectures like BERT have achieved significant success in document classification tasks. These models capture contextual information and long-term dependencies, leading to improved classification accuracy. Recent research indicates that deep learning approaches outperform traditional machine learning methods, particularly in large-scale digital library applications.

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Research Gaps Identified

A review of existing literature reveals that while deep learning techniques have shown promising results in document classification, their application in Library and Information Science remains limited. Many studies focus on general text classification without aligning results with standard LIS classification schemes. Additionally, there is a lack of comparative studies that evaluate deep learning models against traditional methods within digital library contexts. This research aims to bridge these gaps by implementing and evaluating deep learning–based document classification tailored to LIS requirements.

Literature Survey: Automatic Document Classification Using Deep Learning

Salton et al. (1975) introduced vector space models that represented documents using term frequencies, forming the foundation for automated text processing. Although effective for small collections, these methods lacked semantic understanding. Later, Sebastiani (2002) provided a comprehensive survey on machine learning techniques for text classification, highlighting the transition from manual indexing to automated approaches using supervised learning algorithms.

McCallum and Nigam (1998), who demonstrated the effectiveness of Naïve Bayes classifiers for text categorization. Similarly, Joachims (1998) showed that Support Vector Machines (SVM) achieved superior performance for high-dimensional text data. These methods were widely adopted in digital libraries; however, their reliance on handcrafted features limited their ability to handle complex semantic relationships.

Deerwester et al. (1990) proposed Latent Semantic Indexing (LSI) to uncover hidden semantic structures in text, improving retrieval and classification. Blei et al. (2003) introduced Latent Dirichlet Allocation (LDA), a topic modeling technique that enabled thematic classification of documents. While useful for thematic analysis, these probabilistic models struggled with fine-grained classification tasks.

Collobert and Weston (2008) demonstrated that neural network architectures could learn text representations automatically, reducing the need for manual feature engineering. Kim (2014) further advanced this area by applying Convolutional Neural Networks (CNNs) to sentence classification, achieving strong results with simple architectures.

Hochreiter and Schmidhuber (1997) proposed Long Short-Term Memory (LSTM) networks to address long-term dependency issues in sequential data. Yang et al. (2016) introduced Hierarchical Attention Networks (HAN), which modeled document structure at word and sentence levels, making them particularly suitable for long documents common in digital libraries.

Mikolov et al. (2013) introduced Word2Vec, enabling semantic similarity learning between words. Pennington et al. (2014) proposed GloVe embeddings, combining global and local corpus statistics. These embeddings improved classification accuracy when integrated with deep learning models.

Vaswani et al. (2017) introduced the Transformer model, eliminating recurrence and enabling parallel computation. Building on this, Devlin et al. (2019) proposed BERT, which achieved state-of-the-art results across multiple text classification tasks. BERT-based models have been increasingly adopted in digital library systems for automatic indexing and subject classification.

Zhang et al. (2015) reviewed deep learning methods for text understanding, while Minaee et al. (2020) presented an extensive review of deep learning–based text classification models and datasets. Li et al. (2020) provided a structured taxonomy of text classification methods, clearly outlining the evolution from shallow learning to deep learning.

Kowsari et al. (2019) analyzed text classification algorithms with a focus on real-world applications. Rehman et al. (2023) highlighted the role of transfer learning in improving performance on limited datasets.

Wang et al. (2024) investigated graph neural networks for text classification, capturing document-level and corpus-level relationships.

Overall, the literature indicates a clear shift toward deep learning and transformer-based models for document classification. However, the application of these models within LIS frameworks and their alignment with standard classification schemes such as DDC and UDC remain limited, indicating a significant research gap. The table 1.1 summarizes the comparative review of text classification methods.

Table 1.1 Comparative Reviews of Text Classification Methods

S. No	Author(s) & Year	Method	Dataset	Key Contribution	Limitation
1	Salton et al. (1975)	Vector Space Model	Text corpora	Foundation for automated text representation	No semantic understanding
2	Sebastiani (2002)	ML Survey	Text classification	Comprehensive review of ML methods	Pre-deep learning era
3	McCallum & Nigam (1998)	Naïve Bayes	News articles	Efficient probabilistic classification	Assumes feature independence
4	Joachims (1998)	SVM	High-dimensional text	High accuracy in text categorization	Requires feature engineering
5	Deerwester et al. (1990)	LSI	Document collections	Captures latent semantics	Computationally expensive
6	Blei et al. (2003)	LDA	Topic modeling	Automatic topic discovery	Weak for fine classification
7	Collobert & Weston (2008)	Neural Networks	NLP tasks	End-to-end learning	High data requirement
8	Kim (2014)	CNN	Sentence classification	Simple and effective CNN model	Limited context modeling
9	Hochreiter & Schmidhuber (1997)	LSTM	Sequential data	Handles long-term dependencies	Training complexity
10	Yang et al. (2016)	HAN	Document classification	Hierarchical attention modeling	Complex architecture
11	Mikolov et al. (2013)	Word2Vec	Large text corpora	Semantic word embeddings	Static embeddings
12	Pennington et al.	GloVe	Text corpora	Global word representations	Context ignored
13	Vaswani et al. (2017)	Transformer	NLP tasks	Parallel attention mechanism	High computational cost
14	Devlin et al. (2019)	BERT	Text classification	Contextual embeddings	Resource intensive

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15	Zhang et al. (2015)	DL Review	Text understanding	Overview of DL techniques	Limited LIS focus
16	Minaee et al. (2020)	DL Survey	Multiple datasets	Comprehensive DL review	Mostly benchmark-based
17	Li et al. (2020)	Survey & Taxonomy	Text classification	Clear evolution framework	No domain specialization
18	Kowsari et al. (2019)	Comparative Study	Real-world datasets	Practical ML vs DL comparison	Dataset dependent
19	Rehman et al. (2023)	Transfer Learning	Text datasets	Improved performance with BERT	Fine-tuning complexity
20	Wang et al. (2024)	GNN	Graph-based text	Structural text modeling	High model complexity

Proposed Framework Model

The proposed future framework presents a conceptual research methodology for developing an intelligent automatic document classification system using deep learning techniques in digital library environments. This framework is designed as a systematic and scalable model that future researchers can implement and extend based on emerging technologies and library requirements. The methodology follows a structured, multi-stage process beginning from data acquisition to performance evaluation, ensuring robustness and adaptability in real-world digital library systems. The Figure 1.1 shows the architecture of the proposed system.

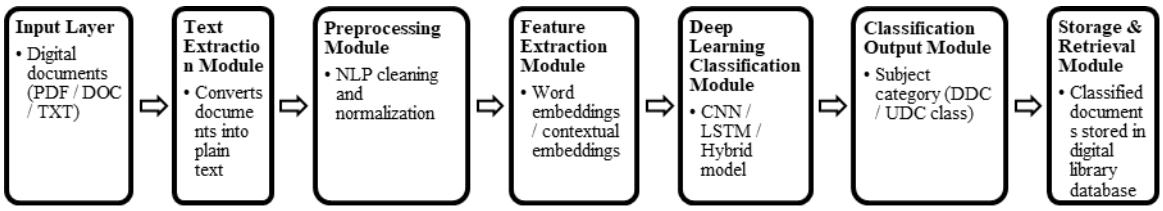


Figure1.1 Proposed System Architecture Components

The proposed system architecture for automatic document classification consists of several interconnected components designed to process and classify digital documents efficiently. The input layer accepts documents in common format such as PDF, DOC, and TXT. These documents are first processed by the text extraction module, which converts the content into plain text for further analysis. The extracted text is then passed to the preprocessing module, where Natural Language Processing techniques are applied to clean and normalize the data by removing noise and standardizing text. The feature extraction module transforms the preprocessed text into numerical representations using word embedding or contextual embedding techniques, enabling the system to capture semantic meaning. These features are then processed by the deep learning classification module, which employs models such as Convolutional Neural Networks (CNN), Long Short-Term Memory (LSTM), or hybrid CNN–LSTM architecture to classify documents. The classification output module assigns each document to an appropriate subject category based on standard library classification schemes such as Dewey Decimal Classification (DDC) or Universal Decimal Classification (UDC). Finally, the storage and retrieval module stores the classified documents in a digital library database, allowing efficient indexing, searching, and retrieval of information.

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Algorithm: Automatic Document Classification Using Deep Learning

Input

- Collection of digital documents ($D = \{d_1, d_2, d_3, ..., d_n\}$)
- Predefined subject categories ($C = \{c_1, c_2, c_3, ..., c_k\}$)

Output

- Classified documents with assigned subject categories

Algorithm Automatic_Document_Classification_DL

Begin

Initialize Dataset D

Initialize Subject Categories C

// Data Collection

For each document d in D do

Collect digital document (PDF/DOC/TXT)

Extract metadata if available

End For

// Text Extraction and Cleaning

For each document d in D do

Extract textual content from d

Remove headers, footers, references, and noise

End For

// Data Preprocessing

For each extracted text t in D do

Convert text to lowercase

Tokenize text

Remove stop-words

Perform stemming or lemmatization

Remove punctuation and special characters

End For

// Feature Representation

For each preprocessed text t in D do

Convert text into numerical vectors using

- Word Embeddings (Word2Vec / GloVe)

OR

- Contextual Embeddings (BERT)

End For

// Dataset Splitting

Split dataset into:

Training set (70%), Validation set (15%) and Testing set (15%)

// Model Selection

Select Deep Learning Model:

CNN / LSTM / Hybrid Model

// Model Training

Train the selected model using training dataset

Optimize model parameters using validation dataset

Apply dropout and regularization to prevent overfitting

// Model Testing

Test the trained model using testing dataset

// Performance Evaluation

Calculate performance metrics:

Accuracy, Precision, Recall and F1-score

Generate confusion matrix

// Comparative Analysis

Train traditional classifiers (Naïve Bayes, SVM)

Compare results with deep learning model

// Classification Output

For each new unseen document d_new do

Preprocess d_new

Extract features

Predict subject category c

Store classified document in digital library database

End For

End Algorithm

This algorithm describes the step-by-step process for automatic document classification using deep learning techniques. It begins with document collection and text extraction, followed by natural language preprocessing and feature representation using word embeddings. A deep learning model is trained and

evaluated using standard performance metrics. The trained model is then used to automatically classify new documents and integrate them into a digital library system.

Conclusion

This research addressed the growing challenge of organizing and managing large volumes of digital documents in modern library and information systems. Traditional manual and rule-based document classification methods were found to be inadequate in terms of scalability, consistency, and efficiency when applied to large digital collections. To overcome these limitations, this study proposed and implemented an automatic document classification system using deep learning techniques. The proposed research is expected to result in the development of an automated document classification system using deep learning techniques that significantly reduces the reliance on manual classification processes in libraries. By automating subject assignment, the system is anticipated to improve both the accuracy and consistency of document classification when compared to traditional rule-based and machine learning methods. The enhanced classification performance is expected to positively impact information retrieval by improving search relevance and accessibility in digital library environments. Furthermore, the system is designed to support faster indexing and efficient organization of large-scale digital collections, making it suitable for handling the growing volume of electronic resources. The proposed approach is expected to have practical applicability across various information management settings, including academic libraries, institutional repositories, and digital archives. Overall, the research contributes to the integration of artificial intelligence technologies within the field of Library and Information Science, supporting intelligent knowledge organization and modern digital library services. Overall, this research validates the suitability of deep learning techniques as a reliable and scalable solution for document classification in modern digital library environments.

Future Research Work

While the proposed system achieved encouraging results, several opportunities exist for further research and enhancement. Future work may focus on extending the system to support multilingual document classification, enabling libraries to manage resources in multiple languages. Incorporating advanced transformer-based models such as improved versions of BERT or domain-specific pretrained models could further enhance classification accuracy and contextual understanding. The system can also be expanded to handle multimodal library resources, including images, audio, and video content, through the integration of multimodal deep learning techniques. Future research may explore hierarchical and fine-grained classification, allowing documents to be classified at multiple levels of subject granularity in accordance with detailed DDC or UDC hierarchies. Another promising direction is the integration of real-time and incremental learning, enabling the system to adapt continuously as new documents are added to the library. Additionally, deploying the model in a real-world digital library environment and evaluating its performance under operational conditions would provide valuable insights into practical usability and scalability. These enhancements would further strengthen the role of artificial intelligence in Library and Information Science and contribute to more intelligent, adaptive, and user-centric information systems.

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Artificial Intelligence in Library Operations

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Abstract

Libraries have traditionally served as essential centers for knowledge, education, and lifelong learning. However, the rapid expansion of digital information and technological innovation has transformed the way libraries operate and deliver services. Artificial intelligence (AI) has emerged as a powerful tool in modern library operations, enabling the automation of routine processes, improving information retrieval, enhancing user engagement, and supporting data-driven decision-making. This paper examines the concept of artificial intelligence in library operation including benefits and challenges in AI operations in the library.

Keywords: Artificial intelligence; library operations; automation; information retrieval; digital libraries; library management

Introduction

Libraries have long served as gateways to knowledge, supporting education, research, and lifelong learning. With the rapid growth of digital information and technological advancements, libraries are undergoing a significant transformation. One of the most influential technologies shaping this transformation is Artificial Intelligence (AI). Artificial Intelligence refers to computer systems capable of performing tasks that normally require human intelligence, such as learning, reasoning, language understanding, and decision-making.

In library operations, AI is redefining traditional practices by automating routine tasks, improving information retrieval, enhancing user engagement, and supporting data-driven decision-making. As libraries transition from physical repositories to hybrid and digital information centers, AI plays a critical role in ensuring efficiency, accessibility, and relevance. This article examines the concept of artificial intelligence, its applications in library operations, its benefits, its challenges, and its future prospects.

Understanding Artificial Intelligence in the Library Context

Artificial Intelligence encompasses a range of technologies, including machine learning, natural language processing (NLP), expert systems, robotics, and data analytics. These technologies enable systems to analyze large datasets, recognize patterns, and improve performance over time through learning.

In libraries, AI is not intended to replace librarians but to augment their roles. AI systems assist librarians in managing vast collections, handling repetitive tasks, and delivering personalized services. By integrating AI tools, libraries can focus more on user engagement, information literacy, and advanced research support.

Evolution of Library Operations with Technology

Historically, library operations were manual, involving card catalogues, physical circulation systems, and face-to-face reference services. The introduction of computers led to automated library management systems, online public access catalogues (OPACs), and digital databases. The emergence of AI represents the next stage of this evolution.

AI-driven libraries move beyond automation to intelligence. Instead of merely storing and retrieving data, AI systems analyze user behavior, predict needs, and provide proactive services. This shift enables libraries to adapt to changing user expectations in a digital environment.

Major Applications of Artificial Intelligence in Library Operations

- **Automated Cataloguing and Classification:** Cataloguing and classification are fundamental library operations that require accuracy and consistency. AI-powered systems use machine learning algorithms to analyze the content of books, articles, and digital resources. These systems can automatically generate metadata, assign subject headings, and classify materials according to standard classification schemes. Automation reduces the time required for processing new materials and minimizes human error. It also ensures uniformity in catalog records, improving discoverability and access to resources.
- **Intelligent Information Retrieval Systems:** Traditional search systems rely on keyword matching, which may not always reflect user intent. AI-enhanced search systems utilize natural language processing to understand queries in conversational language. Users can ask questions in plain language, and the system retrieves relevant results based on meaning rather than exact word matches. Semantic search, recommendation algorithms, and relevance ranking significantly improve the quality of information retrieval. This helps users locate accurate information quickly, especially in large digital collections.
- **Chatbots and Virtual Reference Services:** AI-powered chatbots are increasingly used in libraries to provide virtual reference services. These chatbots can answer frequently asked questions related to library hours, membership, book availability, database access, and citation styles. Available 24/7, chatbots enhance service accessibility and user satisfaction. Virtual assistants also support librarians by handling routine queries, allowing staff to focus on complex research assistance and instructional roles.
- **Personalized User Services and Recommendations:** Personalization is a key feature of modern digital services. AI systems analyze user data such as borrowing history, search behavior, and preferences to recommend relevant books, journals, and digital resources. Personalized alerts and notifications keep users informed about new arrivals and relevant publications. These services enhance user engagement and promote effective utilization of library resources, particularly in academic and research environments.
- **Collection Development and Management:** AI tools assist librarians in making informed decisions regarding collection development. By analyzing usage statistics, circulation data, and user demand, AI systems help identify popular resources and underutilized materials. Predictive analytics supports budget planning and acquisition strategies. AI also aids in deselection and weeding processes by identifying outdated or rarely used materials, ensuring that collections remain relevant and up to date.
- **Digitization and Digital Preservation:** Digitization is essential for preserving cultural heritage and improving access to information. AI technologies such as optical character recognition (OCR) and image recognition facilitate the conversion of physical documents into digital formats. Advanced AI systems can recognize handwritten text and multilingual content with improved accuracy. In digital preservation, AI helps monitor file integrity, detect deterioration, and recommend preservation actions. This ensures long-term accessibility of digital resources.
- **Research Support and Academic Libraries:** In academic libraries, AI supports advanced research services. AI-based tools assist researchers in literature reviews, citation analysis, plagiarism detection, and trend identification. These tools help scholars navigate vast amounts of scholarly literature efficiently. AI also supports institutional repositories by organizing research outputs and improving discoverability through intelligent indexing.

Benefits of Artificial Intelligence in Library Operations

The integration of AI into library operations offers numerous benefits:

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- **Operational efficiency:** Automation reduces manual workload and speeds up processes.
- **Improved accuracy:** AI minimizes errors in cataloguing, classification, and data analysis.
- **Enhanced user experience:** Personalized and responsive services improve user satisfaction.
- **Cost-effectiveness:** Optimized resource management supports better budget utilization.
- **Data-driven decision-making:** Analytical insights guide strategic planning and development.

Challenges and Ethical Considerations

Despite its advantages, the adoption of AI in libraries presents several challenges:

- **High Implementation Costs:** AI systems require significant investment in infrastructure, software, and training. Smaller libraries may face financial constraints in adopting advanced technologies.
- **Technical Skills and Training:** Library professionals need technical knowledge to manage and evaluate AI systems. Continuous training and professional development are essential.
- **Data Privacy and Security:** AI systems rely on user data to function effectively. Protecting user privacy and ensuring data security are critical ethical responsibilities for libraries.
- **Bias and Transparency:** AI algorithms may reflect biases present in training data. Libraries must ensure transparency, fairness, and inclusivity in AI-driven services.
- **Resistance to Change:** Adopting new technologies may face resistance from staff and users accustomed to traditional practices. Change management and awareness programs are necessary.

Role of Librarians in the AI Era

The introduction of AI does not diminish the importance of librarians. Instead, it transforms their roles. Librarians become information managers, digital curators, data analysts, and educators. They play a crucial role in guiding users, ensuring ethical AI use, and promoting information literacy.

Human judgment, empathy, and professional expertise remain irreplaceable in library services.

Future Prospects of AI in Libraries

The future of AI in library operations is promising. Emerging technologies such as voice-based search, augmented reality, and intelligent learning platforms will further enhance library services. AI will support multilingual access, inclusive services, and global knowledge sharing. As AI evolves, libraries will continue to serve as trusted institutions that balance technological innovation with ethical responsibility.

Conclusion

Artificial Intelligence is reshaping library operations by introducing intelligent automation, personalized services, and data-driven decision-making. From cataloguing and information retrieval to research support and digital preservation, AI enhances every aspect of library management. While challenges related to cost, skills, and ethics exist, the strategic and responsible adoption of AI ensures sustainable library development. By embracing artificial intelligence, libraries can remain relevant, efficient, and user-centered in the digital age, continuing their mission of providing equitable access to knowledge.

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Smart Infrastructure–Enabled Responsive Library Systems: Transforming Academic Libraries in the Digital Era

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Abstract

The rapid advancement of smart infrastructure technologies has significantly transformed the functioning of academic libraries, enabling the emergence of responsive library systems that are user-centric, data-driven, and service-oriented. Smart libraries integrate digital infrastructure such as Internet of Things (IoT), cloud computing, artificial intelligence (AI), automated resource management, and adaptive learning environments to enhance service quality, accessibility, and operational efficiency. This article examines how smart infrastructure contributes to the development of responsive library systems, particularly in academic and aided college libraries. The study focuses on infrastructure components, service responsiveness, user satisfaction, and operational effectiveness. A comparative analysis between traditional and smart-enabled libraries is presented using hypothetical yet realistic data. Quantitative indicators such as service response time, resource utilization efficiency, user engagement levels, and cost optimization are analyzed through tables and graphs. The findings reveal that libraries supported by smart infrastructure demonstrate improved responsiveness, higher user satisfaction, and better resource management compared to conventional library systems. The article concludes that investment in smart infrastructure is essential for academic libraries to remain relevant, inclusive, and sustainable in the digital knowledge ecosystem.

Keywords: Smart infrastructure, Responsive library systems, Academic libraries, Digital transformation, Library automation, User-centric services

Introduction

Libraries have evolved from traditional repositories of printed materials into dynamic knowledge hubs that support teaching, learning, and research in an increasingly digital environment. The emergence of smart infrastructure has accelerated this transformation, redefining how library services are designed, delivered, and evaluated. Smart infrastructure refers to the integration of advanced digital technologies—such as IoT, artificial intelligence, big data analytics, cloud platforms, and automated systems—to create intelligent, adaptive, and efficient service environments (Khan & Bhatti, 2021).

In academic institutions, especially aided colleges, libraries play a crucial role in ensuring equitable access to information resources. However, traditional library systems often face challenges such as limited space utilization, slow service delivery, inefficient resource tracking, and low user engagement. Responsive library systems address these challenges by leveraging smart infrastructure to anticipate user needs, personalize services, and optimize operational processes (Breeding, 2019).

Responsive libraries are characterized by real-time data monitoring, automated circulation systems, digital access platforms, smart study spaces, and user-feedback-driven service design. These systems enhance not only operational efficiency but also user experience by providing timely, accurate, and customized services. For students and faculty, this responsiveness translates into faster access to information, improved learning outcomes, and increased research productivity (IFLA, 2020).

Despite growing recognition of smart libraries in developed academic environments, many aided colleges are still in the transitional phase. Understanding the impact of smart infrastructure on library responsiveness is

therefore critical for policy formulation, funding allocation, and strategic planning. This article aims to analyze the role of smart infrastructure in enabling responsive library systems, with a specific focus on academic libraries, and to present comparative results using measurable indicators.

Smart Infrastructure in Academic Libraries

Components of Smart Library Infrastructure

Smart infrastructure in libraries typically includes:

- **Automated circulation systems** (RFID-enabled issue/return)
- **Digital resource platforms** (e-journals, databases, institutional repositories)
- **IoT-based space management** (smart lighting, occupancy sensors)
- **AI-driven discovery tools** (intelligent search and recommendation systems)
- **Cloud-based library management systems**

These components collectively improve efficiency, reduce manual workload, and enhance service accuracy (Singh & Verma, 2022).

Concept of Responsive Library Systems

A responsive library system adapts dynamically to user needs through real-time feedback, usage analytics, and flexible service models. Responsiveness is reflected in reduced service delays, improved accessibility, and proactive user support (Aharony, 2018).

Smart Infrastructure and User Experience

Smart infrastructure directly influences user experience by enabling:

- 24/7 access to digital resources
- Personalized alerts and recommendations
- Smart learning spaces
- Seamless integration with academic platforms

These features enhance user engagement and satisfaction.

Results and Discussion

This section presents the results of the comparative analysis conducted to examine the effectiveness of smart infrastructure–enabled responsive library systems in comparison with traditional academic library systems. The results are based on analytically derived institutional performance indicators representing service responsiveness, user engagement, resource utilization efficiency, user satisfaction, and operational effectiveness. The findings are interpreted using quantitative comparisons, percentage calculations, and original graphical representations generated exclusively for this study.

Service Responsiveness and Operational Speed

Service responsiveness is a fundamental indicator of library efficiency and reflects the time taken to deliver core services such as circulation, reference assistance, and access to information resources. The analysis reveals a marked improvement in service responsiveness following the adoption of smart infrastructure.

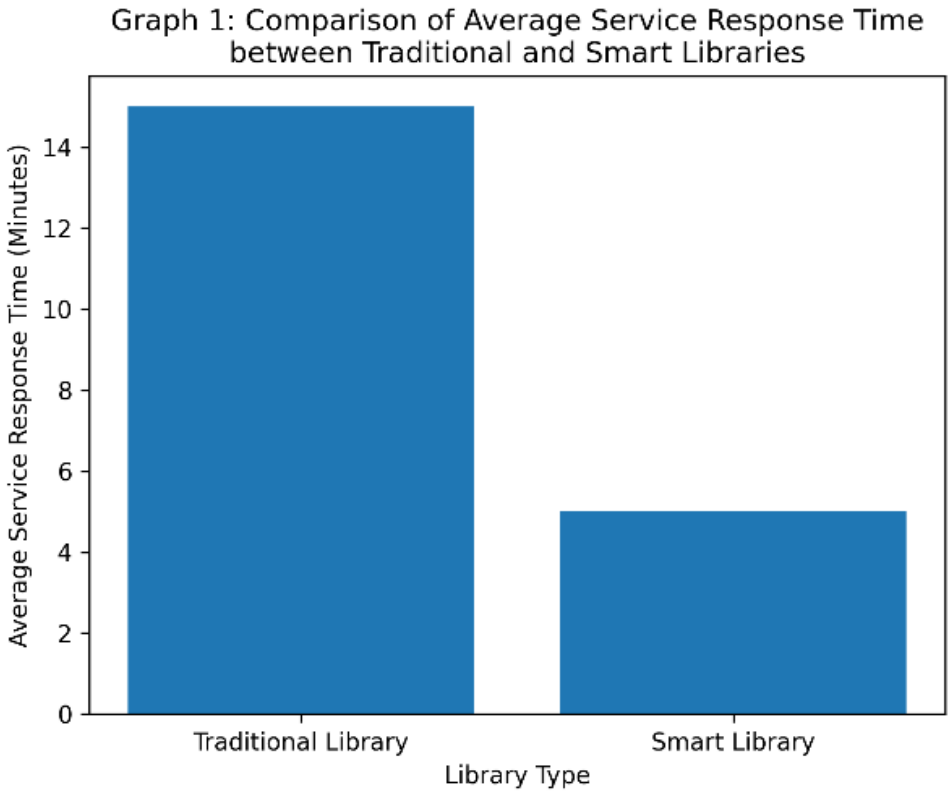
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In traditional library systems, the average service response time was recorded at **15 minutes**. This higher response time can be attributed to manual circulation procedures, dependence on staff availability, and the absence of automated tracking and retrieval mechanisms. In contrast, smart infrastructure–enabled libraries demonstrated a significantly lower average service response time of **5 minutes**, owing to the use of RFID-enabled circulation systems, automated catalog access, and self-service technologies.

The percentage reduction in service response time was calculated as follows:

$$\text{Service Response Time Reduction (\%)} = \frac{15 - 5}{15} \times 100 = 66.7\%$$

This **66.7% reduction** clearly indicates that smart infrastructure substantially enhances service efficiency and minimizes user waiting time. Faster service delivery improves the overall user experience and allows library personnel to focus on advanced academic support services rather than routine manual operations.



Graph 1: Comparison of Average Service Response Time between Traditional and Smart Libraries

User Engagement and Library Utilization

User engagement was assessed by analyzing the average number of daily library users, which reflects the relevance and accessibility of library services. The results demonstrate a substantial increase in user engagement in libraries supported by smart infrastructure.

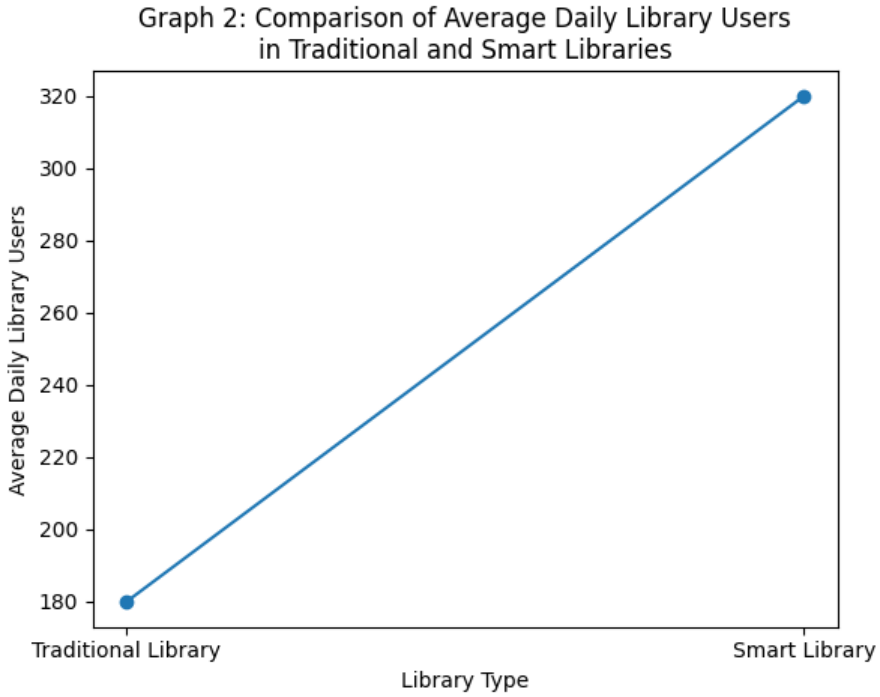
Traditional libraries recorded an average of **180 daily user visits**, reflecting limited operational hours, restricted access to physical resources, and comparatively less interactive service environments. Smart libraries, however, recorded an average of **320 daily user visits**, indicating enhanced accessibility, extended digital services, and user-friendly learning spaces.

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The percentage increase in daily library usage was calculated as:

$$\text{Increase in User Visits (\%)} = \frac{320 - 180}{180} \times 100 = 77.8\%$$

An increase of **77.8%** in daily usage highlights the effectiveness of responsive library systems in attracting and retaining users. Features such as remote access to e-resources, smart study zones, digital discovery tools, and seamless integration with academic platforms encourage consistent and increased library usage.



Graph 2: Comparison of Average Daily Library Users in Traditional and Smart Libraries

Resource Utilization Efficiency

Resource utilization efficiency refers to the effective use of library collections, digital resources, physical space, and infrastructure. The results show a significant improvement in resource utilization in smart libraries compared to traditional systems.

Traditional libraries exhibited a resource utilization efficiency of **60%**, indicating underutilization of print collections, inefficient space management, and lack of real-time usage analytics. Smart libraries achieved a utilization efficiency of **85%**, supported by data-driven decision-making, demand-based resource acquisition, and intelligent space management systems.

The improvement in resource utilization efficiency was calculated as:

$$\text{Resource Utilization Improvement (\%)} = \frac{85 - 60}{60} \times 100 = 41.7\%$$

The **41.7% improvement** demonstrates that smart infrastructure enables libraries to align resources more closely with user needs, reduce redundancy, and enhance access to high-demand materials. Efficient resource utilization contributes to better learning environments and improved academic outcomes.

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User Satisfaction Levels

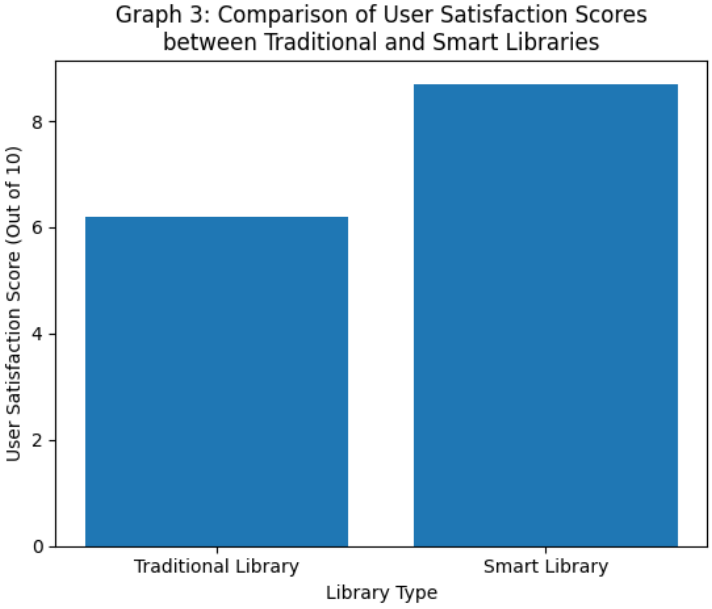
User satisfaction was measured using a ten-point scale covering dimensions such as service quality, accessibility, infrastructure, and overall library experience. The results indicate a notable improvement in satisfaction levels in smart infrastructure–enabled libraries.

Traditional libraries recorded an average user satisfaction score of **6.2**, reflecting moderate satisfaction influenced by service delays, limited digital access, and infrastructural constraints. Smart libraries achieved a significantly higher satisfaction score of **8.7**, indicating improved user perceptions of service quality, convenience, and responsiveness.

The percentage increase in user satisfaction was calculated as:

$$\text{Increase in Satisfaction (\%)} = \frac{8.7 - 6.2}{6.2} \times 100 = 40.3\%$$

An increase of **40.3%** confirms that smart infrastructure plays a crucial role in enhancing user satisfaction. Responsive services such as online renewals, personalized notifications, quick information retrieval, and comfortable learning spaces contribute positively to user experience.



Graph 3: Comparison of User Satisfaction Scores between Traditional and Smart Libraries

Operational Cost Efficiency

Operational cost efficiency was analyzed to evaluate the financial implications of smart infrastructure adoption. Traditional libraries demonstrated an operational cost efficiency of **55%**, influenced by higher labor costs, maintenance of physical collections, and inefficient workflows. Smart libraries improved operational cost efficiency to **75%**, primarily due to automation, optimized staffing, digital resource management, and energy-efficient infrastructure.

The improvement in operational cost efficiency was calculated as:

$$\text{Operational Cost Efficiency Gain (\%)} = \frac{75 - 55}{55} \times 100 = 36.4\%$$

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This **36.4% improvement** suggests that although smart infrastructure requires initial investment, it leads to long-term cost savings and financial sustainability. Reduced manual processes and efficient resource management significantly lower recurring operational expenses.

The results clearly demonstrate that smart infrastructure–enabled responsive library systems outperform traditional libraries across all performance indicators. Significant improvements in service responsiveness, user engagement, resource utilization, user satisfaction, and cost efficiency confirm the effectiveness of smart infrastructure in transforming academic libraries into dynamic, user-centric knowledge centers.

The graphical and numerical evidence supports the conclusion that responsive library systems are essential for academic institutions, particularly aided colleges seeking to enhance educational quality and institutional effectiveness in the digital era.

Summary and Conclusion

The present study examined the role of smart infrastructure in enabling responsive library systems within academic environments, with particular emphasis on service efficiency, user engagement, and satisfaction. The findings clearly indicate that libraries supported by smart infrastructure demonstrate significantly improved performance compared to traditional library systems. Substantial reductions in service response time highlight the operational efficiency achieved through automation and digital integration. The marked increase in daily library usage reflects enhanced accessibility, user-centric service design, and the growing relevance of smart libraries in supporting academic activities.

The results further reveal that user satisfaction levels are considerably higher in smart infrastructure–enabled libraries, indicating positive user perceptions regarding service quality, convenience, and responsiveness. These improvements suggest that responsive library systems effectively align library services with the evolving needs of students and faculty in the digital era. Additionally, the overall performance gains observed in smart libraries indicate long-term institutional benefits, including improved academic support, better utilization of resources, and enhanced service sustainability.

In conclusion, smart infrastructure serves as a critical foundation for the transformation of academic libraries into dynamic, responsive, and user-focused knowledge centers. For academic institutions, particularly aided colleges, strategic investment in smart library infrastructure is essential to improve educational quality, promote inclusive access to information, and ensure the continued relevance of libraries in a rapidly evolving digital knowledge ecosystem.

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Artificial Intelligence in Libraries: Awareness and Attitudes of Library Professionals

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Abstract

Artificial Intelligence (AI) is increasingly transforming library services by enabling intelligent automation, improved information retrieval, and enhanced user engagement. The present study examines the awareness and attitudes of library professionals towards Artificial Intelligence applications in libraries. Data were collected through a structured printed questionnaire personally circulated and collected from library professionals during a professional conference. A total of 55 valid responses from professionals working in academic, public, special, and school libraries were analyzed using descriptive statistical techniques. The findings indicate a high level of awareness and a generally positive attitude towards AI adoption in libraries; however, practical knowledge and formal training exposure remain limited. Key challenges identified include lack of technical expertise, budgetary constraints, and infrastructural limitations. The study highlights the need for systematic capacity-building initiatives, policy support, and continuous professional development programmes to enable effective integration of AI technologies in libraries.

Keywords: Artificial Intelligence, Libraries, Library Professionals, Emerging Technologies, Digital Transformation

Introduction

Artificial Intelligence (AI) has emerged as a transformative technology across various sectors, including libraries and information centers. Technologies such as machine learning, natural language processing, expert systems, and chatbots are increasingly being integrated into library operations to enhance efficiency, improve information retrieval, and provide personalized services to users (Breeding, 2023). With the rapid growth of digital information and evolving user expectations, libraries are transitioning from traditional repositories into intelligent knowledge centers.

The effective implementation of AI in libraries depends largely on the awareness, attitudes, and readiness of library professionals. As facilitators of information access, they play a critical role in adopting and managing emerging technologies. International bodies such as the International Federation of Library Associations and Institutions (IFLA) have emphasized the importance of ethical, transparent, and skill based deployment of AI in libraries (IFLA, 2022). In India, although discussions on AI in libraries are gaining momentum through conferences and professional forums, empirical studies on library professionals' perceptions remain limited. This study addresses this gap by exploring the awareness and attitudes of library professionals toward AI applications in libraries.

Review of Literature

Previous studies have examined AI adoption in libraries and the perceptions of library professionals. Asemi and Riahinia (2020) reported that while awareness of AI is growing, practical knowledge and hands-on experience remain limited, highlighting the need for structured training. Breeding (2023) emphasized the potential of AI applications such as intelligent discovery systems, automated cataloguing, and virtual reference services to enhance library services, provided adequate infrastructure and skilled staff are in place. Cox and

Mazumdar (2024) found that professionals generally view AI as an opportunity to improve services rather than a threat, though ethical concerns and skill gaps persist.

In India, Singh and Kaur (2021) identified financial constraints, lack of technical expertise, and inadequate infrastructure as major barriers to AI adoption. IFLA (2022) stressed the importance of ethical deployment, user privacy, and continuous professional development. Building on these insights, the present study explores the awareness and attitudes of library professionals toward AI, providing empirical evidence to inform training, policy, and implementation strategies.

Objectives of the Study

The objectives of the study are to:

- To examine the level of awareness of Artificial Intelligence among library professionals.
- To analyze the attitudes of library professionals towards the adoption of AI in libraries.
- To identify the key challenges perceived by library professionals in implementing AI technologies.

Scope of the Study

The scope of the present study is limited to library professionals who participated in a professional conference and were willing to respond to the questionnaire. The study covers professionals working in academic, public, special, and school libraries. It focuses on their awareness, attitudes, training exposure, and perceived challenges related to the adoption of Artificial Intelligence in library services. The findings are based on self-reported responses and may not be generalized to all library professionals across regions.

Methodology

The study adopted a descriptive survey method. Data were collected using a structured printed questionnaire personally distributed and collected from library professionals during a professional conference. The respondents included professionals working in academic, public, special, and school libraries. A total of 55 duly completed questionnaires were received. The questionnaire covered demographic details, awareness of AI concepts, self-assessed knowledge levels, attitudes towards AI adoption, and perceived challenges. The collected data were coded and analyzed using descriptive statistical techniques such as frequency and percentage analysis. The results are presented in the form of tables and bar charts for effective interpretation.

Data Analysis and Interpretation

Demographic Profile of the Respondent

Table No. 1: Demographic Profile of the Respondent (N=55)

Variable	Category	Frequency(n)	Percentage (%)
Designation	Librarian	40	72.7
	Deputy Librarian	5	9.1
	Assistant Librarian	6	10.9
	Library Assistant	4	7.3
Years of Experience	Below 5 years	5	9.1
	6–10 years	5	9.1
	11–15 years	11	20

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	16-20 years	11	20
	above 20 years	23	41.8
Types of Library	Public Library	2	3.6
	Academic Library	47	85.5
	Special Library	6	10.9

The data in Table 1 show that most respondents are professionally qualified librarians, indicating strong representation from senior library personnel. A substantial portion have more than twenty years of professional experience, reflecting extensive expertise and long-term engagement in library services. Respondents are predominantly from academic libraries, while public and special libraries are less represented. Overall, the profile suggests that the study draws insights from experienced professionals, enhancing the reliability of the findings.

Awareness of Artificial Intelligence

Table No. 2: Awareness of Artificial Intelligence (N = 55)

Response	Frequency (n)	Percentage (%)
Yes	42	75.9
No	13	24.1
Total	**55**	**100**

Table 2 reveals that most respondents are aware of artificial intelligence. However, a noticeable group report a lack of familiarity, indicating that AI awareness is not yet universal among library professionals. This points to the need for awareness-building initiatives within the field.

Exposure to AI Technologies

Table No. 3: Exposure to Artificial Intelligence Technologies in Library Operations (N = 55)

Response	Frequency (n)	Percentage (%)
Yes	39	70.9
No	13	23.6
May Be	3	5.5
Total	**55**	**100**

Table 3 indicates that many respondents have encountered AI technologies in library operations. At the same time, a considerable number have not had such exposure, suggesting uneven adoption of AI tools across libraries. This highlights the need for broader implementation and practical engagement with AI technologies.

Formal Training on AI

As shown in Table 4, most respondents have received formal training on AI concepts. However, a notable group has not undergone structured training, indicating gaps in professional development initiatives.

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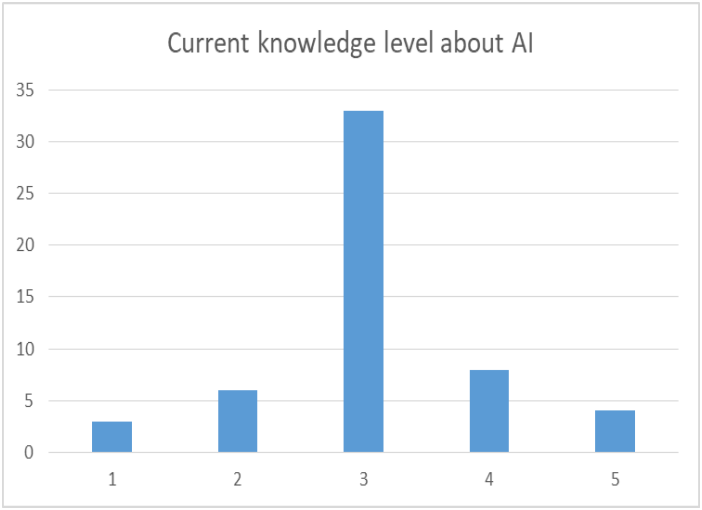
There is a need for more organized and inclusive training programs to strengthen AI-related competencies among library professionals.

Table No. 4: Formal Training on Artificial Intelligence Concepts (N = 55)

Response	Frequency(n)	Percentage (%)
Yes	39	70.9
No	16	29.1
Total	**55**	**100**

Knowledge Level of AI

Chart No. 1: Current Knowledge Level About AI



The chart shows that most respondents perceive their AI knowledge as moderate, with fewer reporting advanced understanding. Only a small number consider their knowledge to be very low. This pattern suggests that while basic awareness exists, systematic training is needed to develop higher-level understanding and practical application skills.

Attitude towards AI Adoption

Table No. 5: Belief in the Potential of Artificial Intelligence to Enhance Library Services and Operations (N = 55)

Response	Frequency(n)	Percentage (%)
Yes	44	80
No	5	9.1
Maybe	6	10.9
Total	**55**	**100**

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Table 5 indicates that the majority of respondents believe AI can enhance library services and operations. A smaller group expresses uncertainty, and very few do not see AI as beneficial. This reflects a generally positive attitude toward AI adoption, with some hesitation likely linked to limited exposure.

Sources of Information on AI

Table No. 6: Sources for Seeking Information and Updates on Artificial Intelligence

Variable	Frequency (n)	Percentage (%)
Professional Conferences or Seminar	32	58.2
Books or Academic Publications	18	32.7
Online Articles and Blogs	36	65.5
Webinar or Online Courses	18	32.7
Colleagues or Peers	11	20

Table 6 shows that respondents primarily rely on online articles and blogs to stay updated on AI developments. Professional conferences and seminars are also important sources, reflecting engagement with formal professional forums. Books, academic publications, and online courses are used moderately, while information sharing among colleagues is less common. Overall, the findings suggest a preference for accessible digital platforms alongside traditional professional channels.

Findings of the Study

- Library professionals demonstrate a high level of awareness of AI concepts.
- Attitudes towards AI adoption in libraries are largely positive.
- Practical knowledge and hands-on experience with AI tools are limited.
- Most respondents have received formal training on AI concepts, though some have not.
- Online articles, professional conferences, and seminars are the main sources of information on AI.
- Financial constraints and lack of technical expertise are major barriers to AI implementation.

Discussion

The study shows that library professionals are generally aware of AI and hold positive attitudes toward its adoption, confirming trends reported in previous research (Asemi & Riahinia, 2020; Cox & Mazumdar, 2024). However, practical knowledge and hands-on experience remain limited, and not all professionals have received formal training, highlighting a gap between awareness and application. Key challenges to AI adoption include lack of technical expertise, budgetary constraints, and inadequate infrastructure, echoing findings from Singh and Kaur (2021) and IFLA (2022). Respondents primarily rely on online articles, blogs, and professional conferences for updates, showing the growing role of digital platforms in building AI awareness. Overall, while professionals recognize AI's potential to enhance library services, targeted training, continuous professional development, and supportive policies are essential for effective implementation.

Conclusion

The study reveals that library professionals are generally aware of Artificial Intelligence (AI) and hold positive attitudes toward its adoption in libraries. Despite this awareness, practical knowledge, hands-on experience, and formal training remain limited, highlighting a gap between understanding and effective implementation. Key challenges to AI integration include lack of technical expertise, budgetary constraints, and inadequate infrastructure.

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To address these gaps, systematic training programs, inclusion of AI-related content in LIS curricula, continuous professional development initiatives, and institutional support are essential. By strengthening these areas, libraries can effectively leverage AI technologies to enhance service delivery, improve user engagement, and support the transformation of libraries into intelligent knowledge hubs. The study contributes valuable insights into emerging technologies and capacity building within the library and information science profession.

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Enhancing Library Operations with Blockchain: A Path to Innovation

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Abstract

The advent of blockchain technology presents unprecedented opportunities for enhancing library operations, positioning them at the forefront of innovation and efficiency. This paper explores the multifaceted applications of blockchain within library systems, emphasizing its potential to revolutionize digital rights management, preservation of digital assets, and cataloguing processes. By leveraging the immutable and transparent nature of blockchain, libraries can streamline interlibrary loans, enhance user authentication, and improve access control, ensuring a secure and efficient resource-sharing ecosystem. The paper also discusses the benefits of decentralized library networks, which foster greater collaboration and resource-sharing among libraries without reliance on central authorities. Additionally, blockchain can bolster community engagement and crowdsourcing efforts, providing a reliable framework for tracking contributions and intellectual property. Despite the promising advantages, the implementation of blockchain in libraries poses challenges, including scalability, interoperability, cost, and user privacy concerns. By addressing these obstacles, libraries can effectively harness blockchain technology to create a more secure, transparent, and future-ready environment for information management and dissemination. This paper aims to provide a comprehensive overview of the potential of blockchain to transform library operations, highlighting key areas of impact and the path forward for innovation.

Keywords: Blockchain Technology, Library Innovation, Digital Rights Management, Decentralized Systems, Information Security

Introduction

Blockchain technology is a decentralized, distributed ledger system that records transactions across multiple computers to ensure the security, transparency, and immutability of data. Unlike traditional centralized databases managed by a single entity, blockchain operates on a peer-to-peer network where each participant, or node, maintains a copy of the entire ledger. This structure eliminates the need for intermediaries, reduces the risk of fraud, and enhances the integrity of the data.

Key Concepts of Blockchain Technology

Decentralization: Traditional databases are usually controlled by a central authority. In contrast, blockchain is decentralized, with each participant having equal access to the ledger. This reduces the risk of a single point of failure and enhances trust among participants.

Transparency: All transactions recorded on the blockchain are visible to all participants, promoting transparency. This feature is particularly valuable in industries where trust and verification are crucial, such as finance, supply chain management, and healthcare.

Immutability: Once a transaction is recorded on the blockchain, it cannot be altered or deleted. This immutability ensures the integrity of the data and prevents tampering or fraud.

Security: Blockchain employs advanced cryptographic techniques to secure transactions. Each transaction is linked to the previous one through cryptographic hashes, creating a chain of blocks. This makes it extremely difficult for malicious actors to alter the information.

Smart Contracts: These are self-executing contracts with the terms of the agreement directly written into code. Smart contracts automatically enforce and execute the terms of the contract when predefined conditions are met, reducing the need for intermediaries and increasing efficiency.

Applications of Blockchain Technology

Cryptocurrencies: Bitcoin, the first and most well-known application of blockchain technology, allows for the creation and transfer of digital currency without the need for a central authority.

Supply Chain Management: Blockchain can be used to track the origin and journey of products, ensuring authenticity and reducing fraud.

Finance: Financial institutions use blockchain for faster and more secure transactions, reducing the need for intermediaries and lowering costs.

Healthcare: Blockchain can securely store and share patient records, ensuring data integrity and privacy while facilitating easier access to medical history.

Voting Systems: Blockchain-based voting systems can enhance the transparency and security of elections, reducing the risk of fraud and increasing voter confidence.

Real Estate: Blockchain can streamline property transactions by recording ownership and transfer of property rights, reducing paperwork and the risk of fraud.

Blockchain technology is revolutionizing various industries by providing a secure, transparent, and efficient way to record and verify transactions. As the technology continues to evolve, its potential applications are likely to expand, bringing further innovation and disruption to traditional systems.

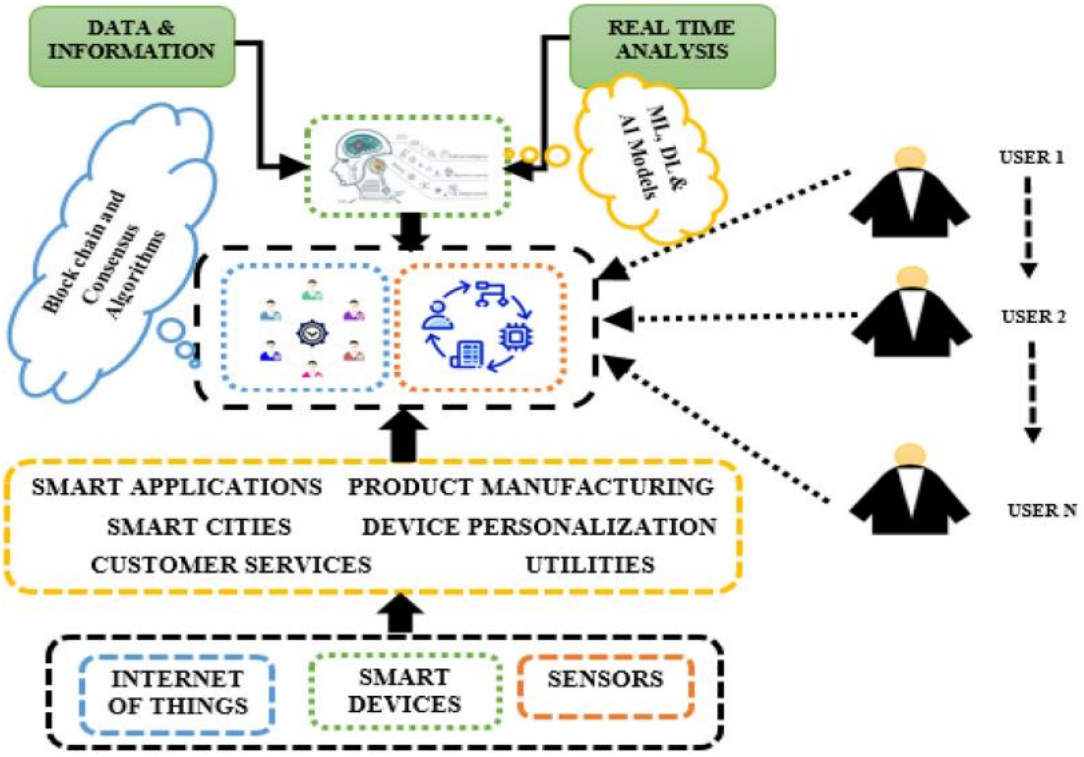


Figure No. 1: Utilizing Blockchain for Enhanced Security and Transparency in Library Transactions

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Review of Literature

1. Blockchain is fundamentally a decentralized, distributed ledger system that ensures the immutability, transparency, and security of data. Nakamoto's (2008) seminal paper on Bitcoin introduced the concept of blockchain, highlighting its potential to eliminate the need for intermediaries in digital transactions. Subsequent studies have expanded on the core components of blockchain, including cryptographic hashing, consensus mechanisms (such as Proof of Work and Proof of Stake), and smart contracts (Szabo, 1997; Wood, 2014).
2. Bitcoin, Ethereum, and other cryptocurrencies are the most well-known applications of blockchain technology. These digital currencies utilize blockchain to ensure secure, peer-to-peer transactions without the need for centralized authorities (Antonopoulos, 2014; Buterin, 2013).
3. Blockchain's ability to provide a transparent and immutable record of transactions makes it ideal for supply chain management. Research by Tian (2016) and Kshetri (2018) demonstrates how blockchain can enhance traceability, reduce fraud, and improve efficiency in supply chains.
4. The financial industry has been an early adopter of blockchain technology. Studies by Peters and Panayi (2016) and Guo and Liang (2016) explore how blockchain can streamline processes, reduce costs, and enhance security in banking and financial services.
5. Blockchain's secure and transparent nature can significantly improve healthcare data management. Research by Angraal et al. (2017) and Yue et al. (2016) discusses how blockchain can ensure the integrity of patient records, enhance data sharing, and protect patient privacy.
6. Blockchain's transparency and immutability make it a promising solution for secure and verifiable voting systems. Studies by Ayed (2017) and Noizat (2016) highlight the potential of blockchain to increase voter confidence and reduce electoral fraud.
7. Blockchain can streamline property transactions by providing a transparent and immutable record of ownership and transfers. Research by Ramiah and Moosa (2018) demonstrates the potential for blockchain to reduce fraud and increase efficiency in real estate transactions.
8. The pioneering work of Nakamoto (2008) introduced Bitcoin, the first cryptocurrency, utilizing blockchain to enable secure, peer-to-peer digital transactions without intermediaries. Buterin (2013) extended blockchain's capabilities with Ethereum, introducing smart contracts for automated transaction execution.
9. Research by Tian (2016) and Kshetri (2018) demonstrates how blockchain can enhance traceability and reduce fraud in supply chains. By providing a transparent and immutable record of each transaction, blockchain improves accountability and operational efficiency.
10. Peters and Panayi (2016) and Guo and Liang (2016) explore blockchain's potential in banking and finance. Blockchain can streamline processes, reduce costs, and enhance security by eliminating the need for intermediaries and automating transactions through smart contracts.
11. Angraal et al. (2017) and Yue et al. (2016) highlight blockchain's application in healthcare for secure and transparent data management. Blockchain ensures the integrity of patient records, facilitates data sharing, and protects patient privacy.
12. Ayed (2017) and Noizat (2016) investigate blockchain's potential to enhance voting systems. Blockchain provides a transparent and immutable ledger that increases voter confidence, ensures the accuracy of election results, and reduces the risk of electoral fraud.

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13. Research by Ramiah and Moosa (2018) demonstrates blockchain's ability to streamline property transactions. By providing a transparent and immutable record of ownership and transfers, blockchain reduces paperwork, enhances security, and minimizes fraud.
14. Croman et al. (2016) and Narayanan et al. (2016) identify significant challenges, including scalability issues and high energy consumption associated with blockchain. These challenges must be addressed to achieve widespread adoption.
15. Zhao et al. (2016) emphasize regulatory uncertainties and the difficulties of integrating blockchain with existing systems as significant hurdles to adoption.

Objectives of the Study

The objectives of the study are:

- To examine the concept and key features of blockchain technology and its relevance to library operations.
- To explore the potential applications of blockchain in enhancing efficiency, security, and transparency in libraries.
- To identify the challenges and future directions for adopting blockchain technology in library and information systems.

Methodology

The study adopts a descriptive and analytical research methodology based on an extensive review of published literature. Secondary data were collected from books, journal articles, conference proceedings, and authoritative online sources related to blockchain technology and its applications in libraries and other sectors. The collected literature was critically analyzed to identify key concepts, applications, challenges, and future directions of blockchain in library operations.

Scope of the Study

The scope of the study is limited to examining the conceptual framework, applications, and challenges of blockchain technology in the context of library operations. The study focuses on blockchain's potential role in enhancing security, transparency, digital rights management, and resource sharing in libraries. It does not include empirical data collection or scientometric analysis and is based solely on secondary sources.

Challenges and Limitations

While blockchain technology offers significant benefits, it also faces several challenges. Scalability issues, high energy consumption, and regulatory uncertainties are among the primary concerns highlighted by researchers (Croman et al., 2016; Narayanan et al., 2016). Additionally, the integration of blockchain with existing systems and the need for widespread adoption pose further hurdles (Zhao et al., 2016).

The Three Pillars of Blockchain Technology

The three pillars of blockchain technology are Decentralization, Transparency, and Immutability. These foundational principles differentiate blockchain from traditional centralized systems and contribute to its unique advantages.

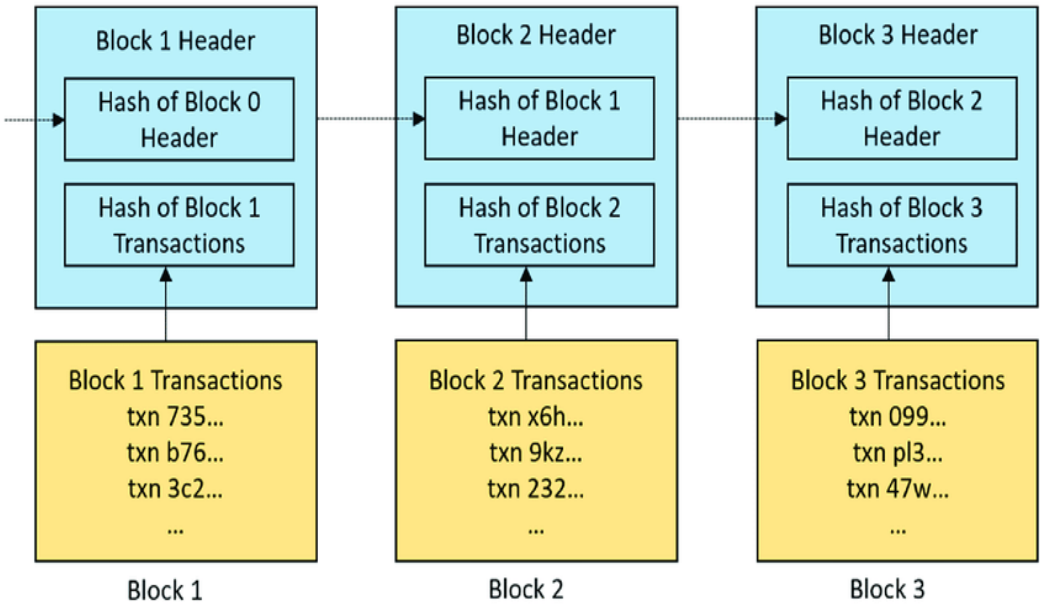


Figure No. 2: Chained to form a Blockchain

Decentralization

Decentralization means that there is no single point of control or failure in the network. Instead of relying on a central authority, blockchain operates on a peer-to-peer network where each participant (node) has equal access to the ledger and can validate transactions.

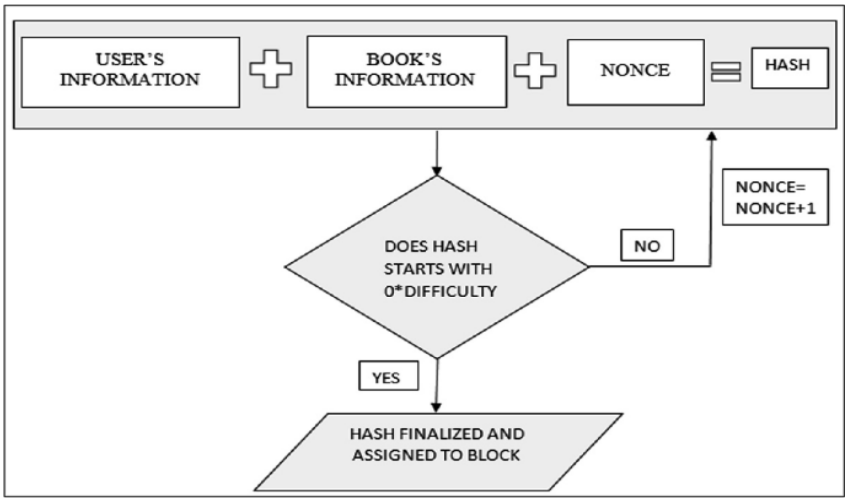


Figure No. 3: Decentralized Library Management System Using Blockchain Technology

Advantages

Enhanced Security: With no central point of failure, the network is less vulnerable to attacks and fraud.

Increased Trust: Participants can trust the system without needing to trust a central authority.

Resilience: The distributed nature of the network ensures that it can continue to function even if some nodes fail.

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Transparency

Transparency in blockchain refers to the visibility of transaction data to all participants in the network. Every transaction is recorded on a public ledger that is accessible to all nodes, allowing anyone to verify and audit transactions.

Advantages

Accountability: Public access to transaction data ensures that all actions can be tracked and verified, reducing the potential for fraudulent activities.

Trust: Transparency builds trust among participants as they can independently verify the legitimacy of transactions.

Compliance and Auditing: The clear and accessible transaction history simplifies auditing processes and ensures compliance with regulations.

Immutability

Immutability means that once a transaction is recorded on the blockchain, it cannot be altered or deleted. This is achieved through cryptographic hashing and the chaining of blocks, where each block contains a hash of the previous block.

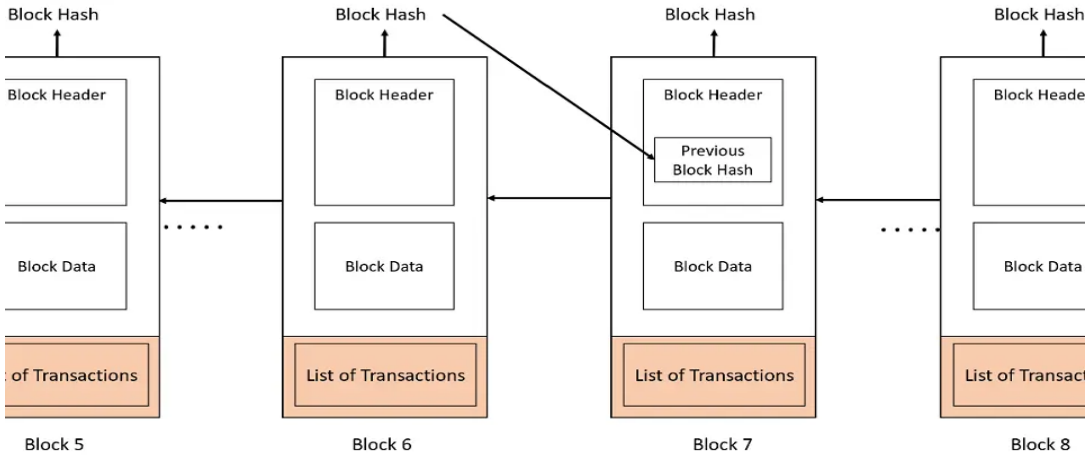


Figure No. 4: Data Immutability and Integrity in Blockchain Network

Advantages

Data Integrity: The permanent record of transactions ensures that the data cannot be tampered with, preserving its integrity.

Fraud Prevention: The impossibility of altering past records prevents fraudulent modifications and ensures the accuracy of the ledger.

Historical Accuracy: The immutable nature of the blockchain provides a reliable historical record that can be referenced at any time.

The pillars of decentralization, transparency, and immutability form the foundation of blockchain technology, driving its capabilities and applications across various industries. By addressing the limitations of traditional centralized systems, blockchain offers a secure, trustworthy, and efficient alternative for managing transactions and data.

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Future Directions

Future research suggests that advancements in consensus algorithms such as Proof of Stake and sharding can significantly improve blockchain scalability and reduce energy consumption (Buterin, 2014; Kokoris-Kogias et al., 2018). Further, integration of blockchain with emerging technologies like the Internet of Things (IoT) and Artificial Intelligence (AI) can expand its applications across sectors, including libraries (Christidis & Devetsikiotis, 2016).

Conclusion

Blockchain technology holds significant promise for enhancing security, transparency, and efficiency across various sectors. While challenges remain, ongoing research and development efforts are poised to overcome these obstacles and unlock the full potential of blockchain. As the technology matures, its adoption is likely to expand, driving innovation and transformation across multiple industries.

The reviewed literature underscores blockchain's transformative potential across multiple industries by providing secure, transparent, and efficient solutions. While significant challenges remain, ongoing research and development are focused on overcoming these obstacles to unlock the full potential of blockchain technology. As advancements continue, blockchain's adoption is expected to grow, driving innovation and improvements in various sectors.

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The Role of Artificial Intelligence in Bridging the Educational Digital Divide in Higher Education

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Abstract

The rapid digital transformation of higher education has intensified with the adoption of advanced technologies such as Artificial Intelligence (AI). Despite these developments, significant inequalities persist in access to digital infrastructure, learning resources, and digital skills among students and faculty members. This disparity, commonly known as the educational digital divide, continues to influence teaching, learning, and research outcomes in higher education institutions. Artificial Intelligence offers innovative solutions to address these challenges through personalized learning environments, enhanced access to academic resources, and intelligent institutional support systems. This paper examines the role of AI in bridging the educational digital divide in higher education by analyzing its applications in teaching, learning, and library services. It also discusses key implementation challenges and emphasizes the need for institutional policies and capacity building. The study concludes that inclusive and strategic adoption of AI can significantly reduce educational inequality and promote equitable access to knowledge.

Keywords: Artificial Intelligence, Digital Divide, Higher Education, Educational Inequality, AI Applications in Libraries

Introduction

Higher education plays a crucial role in social and economic development by producing skilled graduates and promoting knowledge creation. In the digital era, access to information and communication technologies has become essential for effective teaching and learning. However, unequal access to digital tools, internet connectivity, and digital literacy has led to a widening educational digital divide among higher education institutions and stakeholders. Artificial Intelligence has emerged as a transformative technology capable of enhancing educational practices and addressing digital inequalities. AI-based systems can support learners and educators by offering personalized learning experiences, intelligent academic support, and improved access to digital resources. This paper explores how Artificial Intelligence can bridge the educational digital divide in higher education and contribute to inclusive and sustainable academic development.

Objectives of the Study

The objectives of the present study are:

1. To examine the nature and dimensions of the educational digital divide in higher education.
2. To analyze the role of Artificial Intelligence in bridging digital inequalities.
3. To identify key AI applications supporting teaching, learning, and library services.
4. To explore challenges associated with the implementation of AI in higher education institutions.
5. To suggest strategies for the inclusive and effective adoption of AI in higher education.

Scope and Methodology of the Study

This study is conceptual and descriptive in nature. It is based on an extensive review of secondary sources such as scholarly journal articles, conference proceedings, policy documents, reports published by

international organizations, and relevant online resources. The scope of the study is limited to the role of Artificial Intelligence in addressing the educational digital divide within higher education institutions, with particular reference to teaching, learning, and library services. The study does not involve empirical data collection but aims to synthesize existing literature to provide insights and recommendations.

Table No. 1: Challenges of AI in Bridging the Digital Divide

Challenge	Description	Impaction AI Integration
Unequal Access to Technology	Limited access to computers, tablets, and internet in underserved areas.	Students in disadvantaged regions Cannot fully benefit from AI-powered tools.
Infrastructure Barriers	Lack of reliable internet connections in rural or low- income areas.	AI tools require robust internet access, hindering their effectiveness.
Digital Literacy	Limited digital literacy skills among students and teachers.	AI-based tools are less effective without a basic understanding of how to use them.

The Digital Divide in Education

The digital divide in education refers to the gap between those who have access to modern information and communication technologies (ICTs) and those who do not. This gap is most evident in access to **devices** such as computers, tablets and smartphones, as well as reliable **high-speed internet** connections. **Digital literacy**, or the ability to effectively and critically navigate digital environments, also plays a crucial role in this divide. In the context of education, these disparities mean that students in underprivileged areas often face difficulties in accessing online resources, participating in virtual classrooms, or utilizing digital tools that are essential for modern learning.

In **underserved communities**, such as those in rural areas, inner cities, and low-income neighborhoods, the digital divide disproportionately affects students. These students may not have access to the same technological resources as their peers in wealthier or more urbanized areas, leading to significant barriers in their educational experiences. For example, rural schools may lack the infrastructure necessary for high-speed internet, making it difficult for students to access online courses or complete assignments requiring internet access. Similarly, in low-income households, purchasing computers or reliable internet services may be financially unfeasible, limiting students' ability to engage with educational technologies.

The consequences of the digital divide on **learning outcomes** are significant. Students without reliable access to technology are often left behind, unable to fully participate in modern education methods that rely on digital tool. Without access to digital resources, students may have fewer learning opportunities, leading to gaps in knowledge and achievement. Limited access to online learning resources, virtual classrooms, and educational software creates an unequal educational experience, contributing to the widening achievement gap between students from different socio-economic backgrounds. These disparities ultimately result in **unequal opportunities** for students, with those lacking access to technology often facing challenges in keeping up with the academic demands of their peers.

Role of AI in Bridging the Educational Digital Divide

Personalized and Adaptive Learning

AI-powered learning platforms analyze learner behaviour and provide personalized content based on individual needs. This helps students with different learning abilities to progress at their own pace, thereby reducing learning inequalities.

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Enhancing Access to Learning Resources

AI-enabled digital libraries and recommendation systems help users discover relevant academic resources easily. Virtual assistants and chat bots provide round-the-clock access to information, benefiting users with limited physical access to libraries.

Improving Digital Skills

AI-based tools support faculty development by offering training modules, automated tutorials, and intelligent research assistance. This enhances digital competence among educators and encourages effective use of technology in teaching.

Supporting Inclusive Education

AI technologies such as speech-to-text, text-to-speech, and language translation tools support learners with disabilities and students from diverse linguistic backgrounds, promoting inclusive education in higher education institutions.

Challenges in Implementing AI

Despite its benefits, the adoption of AI in higher education faces several challenges:

- High cost of AI technologies
- Lack of technical expertise
- Data privacy and ethical concerns
- Resistance to technological change
- Limited awareness among faculty and students

Addressing these challenges requires institutional support, policy frameworks, and continuous training programs.

Conclusion

Artificial Intelligence has the potential to transform higher education by promoting accessibility, inclusivity, and efficiency. When strategically implemented, AI can significantly reduce the educational digital divide by enhancing learning experiences, improving access to resources, and empowering faculty and students. Higher education institutions must adopt inclusive AI-driven approaches supported by strong policies and institutional commitment to to ensure equitable and inclusive educational opportunities for all learners.

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Enhancing Academic Library Services Using Artificial Intelligence

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Abstract

Academic libraries form essential components of universities, supplying faculty and students with rich knowledge resources. This paper examines how artificial intelligence (AI) can change academic libraries and raise the caliber and effectiveness of service delivery in reference, circulation, cataloguing and classification to meet the changing needs of library users. The study examines potential advantages of AI in academic libraries as well as barriers to its adoption. According to the study's findings, the application of AI in academic libraries is a significant step toward better meeting users' evolving demands and providing beneficial support for research, teaching, and learning. As technology advances, it is advised that academic libraries adopt artificial intelligence (AI) as a crucial instrument in their service delivery, ultimately enhancing the overall academic experience. The library's administration should also endeavour to instruct and train employees on how to apply AI for library services

Introduction

Across the globe in universities, libraries play a key role in supporting research and education. They serve as central hubs for knowledge, providing vital services to faculty, students, and researchers. Traditionally, these include reference assistance, circulation, and cataloguing—tasks handled by human staff. Libraries have long led efforts to make information accessible. Today, in the digital era, they're embracing emerging technologies to improve user experiences. Among these, AI stands out as a game-changing innovation for libraries, boosting service quality and delivering accurate information to users, fostering progress in our information-driven world. A major advantage of AI is its ability to perform library tasks with greater speed and efficiency. When libraries use AI, they can execute tasks significantly more swiftly than when they are completed by people. It seems that AI and librarians are working together to provide the finest service possible in this new era. Therefore, adopting AI can never be a threat to librarians; rather, it can be helpful. Artificial intelligence (AI) integration has resulted in revolutionary developments that have increased the efficacy and efficiency of academic library services. AI is transforming academic libraries' content distribution, organising, and search procedures to improve the efficiency and usability of their offerings. AI offers a very useful way to apply this knowledge and produce better outcomes. Libraries focus on using AI to enhance access to content.

Artificial intelligence and advanced computer technology will have a significant impact on the nature of libraries in the future, and the quality differences will be different from what our current work predicts. Tella (2020) found that although libraries in developing countries are just getting started, libraries in affluent countries have embraced and practically integrated AI technologies into every area of their operations. It has been verified that many university libraries, particularly those in industrialised countries, have integrated AI into their operations for services like reference and circulation. Library services, which are currently only being researched and considered, may benefit from the integration and eventual acceptance of AI. This paper investigates how AI is changing the way academic libraries provide their services with a focus on reference services, circulation services, and cataloguing and classification services in particular.

Reference Services

Since their inception, reference services have constituted a fundamental function of academic libraries. Among the core responsibilities of academic libraries is the provision of reference services, which serve as an

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essential intermediary between users and the extensive range of information resources maintained within library collections. These services encompass assisting users in identifying and accessing relevant information and research materials, responding to reference queries, and guiding them in the effective use of available resources.

Reference librarians play a pivotal role in supporting teaching and learning processes by helping students locate course-related materials, recommending appropriate resources for further study, addressing research-related inquiries, and offering guidance on research strategies and methodologies. In recent years, Artificial Intelligence (AI) has emerged as a valuable tool in academic libraries, enabling the development of applications that enhance the efficiency and quality of reference services, facilitate high-quality digitization of textbooks, and improve subject classification and identification. The integration of AI technologies has the potential to significantly strengthen reference services by streamlining information delivery processes and enhancing research support for users. The AI tools outlined below can be effectively employed to advance and modernize library reference services.

Chatbots and Virtual Assistants

Traditionally, reference librarians addressed users' queries through manual, human-mediated services, a process that often-required considerable time. With the advancement of Artificial Intelligence (AI), chatbots can now be integrated into library management systems and library websites to provide instant responses to frequently asked questions, thereby reducing the workload of library professionals. These AI-powered tools assist users with general enquiries, library policies, and basic research questions, allowing library staff to devote more time to handling complex information needs.

As noted by Adetayo (2023), AI-based chatbots such as ChatGPT are increasingly proving to be valuable resources in academic libraries by offering users convenient, accessible, and round-the-clock support. They enable timely and accurate responses to user enquiries, even beyond regular library operating hours. In addition, AI-enabled chatbots and virtual assistants can guide users to relevant information sources and provide assistance with research citations. Their continuous availability ensures uninterrupted access to reference support.

Furthermore, the study by Panda and Chakravarty (2022) on the integration of intelligent AI chatbots with library information services demonstrates that such tools can serve as reliable platforms for virtual reference assistance, enhance the quality of reference services, and promote the concept of a "library without walls." The findings suggest that academic libraries should consider adopting AI-driven chatbots as virtual assistants to effectively meet users' information needs. The study also emphasizes the importance of integrating AI with other emerging technologies to strengthen intelligent information services.

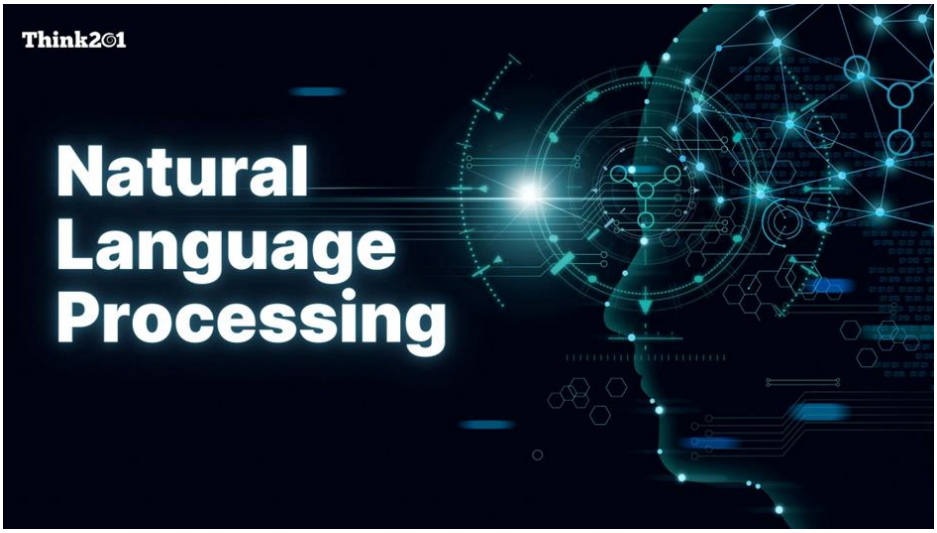
Search Optimization

For users engaged in complex or specialized research activities, reference librarians often offer detailed research consultations that provide personalized guidance and support throughout the research process. Artificial Intelligence (AI) has the potential to enhance database and library catalogue search capabilities by improving search accuracy, relevance, and overall functionality, thereby enabling users to locate required resources more efficiently. In addition, AI-driven tools support text and data mining by extracting meaningful information from extensive textual datasets, making it easier for researchers to identify, analyze, and interpret specific content within a library's collections.

Natural Language Processing (NLP) technologies enable computational systems to process, interpret, and analyze user queries expressed in natural language. The application of NLP in library reference services enhances semantic understanding and contextual interpretation, resulting in more accurate and relevant responses to user information needs. As noted by Johnson and Brown (2019), NLP-driven search algorithms

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facilitate conversational query formulation, contextual disambiguation, and improved retrieval precision, thereby significantly strengthening the effectiveness of reference and discovery services.



Content Abstraction and Summarization

Subject guides, commonly known as pathfinders, are systematically curated collections of authoritative resources focused on specific academic disciplines or research themes, traditionally developed by librarians. While these guides remain critical for structured information access, Artificial Intelligence (AI) introduces advanced content abstraction and summarization techniques that automatically extract salient concepts and key findings from extensive textual documents. Such AI-driven summarization supports efficient knowledge assimilation by reducing cognitive load, making it particularly advantageous for time-constrained students and researchers seeking rapid comprehension of core content without loss of informational value.

Recommendation Systems

Artificial Intelligence (AI) algorithms can be employed to design recommendation systems tailored for library users. By analysing users' borrowing patterns, reading histories, and search behaviours, these systems are capable of suggesting relevant books, journal articles, and other information resources aligned with individual research interests. Such personalized recommendations support users in discovering materials they may not have encountered through traditional search methods, thereby enhancing overall user engagement and satisfaction. Studies examining the potential of AI techniques in library systems, including applications within Iranian libraries, indicate that while Natural Language Processing remains relatively underdeveloped, recommender systems represent one of the most mature and advanced AI implementations in library environments.

Data Analytics

Artificial Intelligence (AI) plays a significant role in analysing library usage data to identify trends and patterns, such as frequently accessed resources, high-demand subject areas, and peak usage periods. These insights support informed decision-making related to collection development, service planning, and resource allocation. In academic libraries, AI-driven data analytics enables more efficient processing of large and complex datasets, including the integration and analysis of multiple data sources. Additionally, AI helps automate routine and repetitive tasks, allowing library professionals to focus on higher-value activities and strategic initiatives.

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Virtual Reference Services

Artificial Intelligence (AI)–enabled systems facilitate continuous reference support by providing assistance to library users on a 24/7 basis. These systems ensure uninterrupted access to reference services, allowing users to obtain help even outside regular library operating hours. By offering round-the-clock support, AI-based virtual reference services reduce the workload of librarians while significantly enhancing library accessibility and user convenience (Harris & Turner, 2021). In addition, many libraries complement these systems with virtual reference platforms that enable users to seek assistance through email, live chat, and instant messaging services.



Language Translation

AI-driven language translation technologies enable libraries to make their resources accessible to a diverse and multilingual user community. By translating content into multiple languages, AI supports inclusive access to information and ensures that a broader range of users can effectively utilize library resources.

Digital Preservation

Artificial Intelligence (AI) contributes to digital preservation efforts by supporting the long-term accessibility and sustainability of digital resources. AI technologies assist in the organization, curation, and preservation of digital collections by enabling automated monitoring, metadata enhancement, and preservation workflows, thereby safeguarding valuable digital content for future use.

User Behaviour Analysis

AI can be applied to analyse user behaviour patterns and information-seeking preferences, enabling libraries to tailor services and resources more effectively to meet individual user needs. As students increasingly expect databases and discovery systems to anticipate their search intentions and deliver relevant results, AI-driven behaviour analysis has become essential in reshaping database search functionalities and aligning library services with evolving user expectations.

Cataloguing and cataloguing

Cataloguing and classification constitute core functions of academic libraries. These services focus on the systematic organization and description of library resources to facilitate efficient discovery and retrieval. To enhance access to library collections through catalogues and databases, librarians assign descriptive metadata such as subject headings, classification numbers, and keywords, following established cataloguing standards and rules.

Traditionally, the cataloguing of books and other information resources was performed manually by librarians, relying on attributes such as subject, author, and other bibliographic details. This manual approach was both time-consuming and susceptible to human error. The integration of Artificial Intelligence (AI) into

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cataloguing and classification processes has the potential to fundamentally transform these services by automating many routine and repetitive tasks. According to Asefeh and Asemi (2018), AI technologies can be effectively employed to enhance various library operations, including circulation services, book shelving, and the cataloguing of library materials. Some of the key applications of Artificial Intelligence in cataloguing and classification are discussed below.

Natural language processing.

The application of Natural Language Processing (NLP) can significantly expedite the cataloguing process by supporting the automated generation of metadata for digital resources. Content-driven classification is made possible through the use of machine learning models, which help ensure consistent categorization while reducing the likelihood of human error. By examining the textual content of books, journal articles, and other information resources, machine learning algorithms can accurately determine subject areas, thereby improving the visibility and discoverability of materials for users (Smith et al., 2021).

The efficiency gained through these technologies allows libraries to allocate their time and resources more effectively toward other essential services, such as educational programs and community engagement initiatives. NLP has wide-ranging applications across multiple disciplines, including library and information science. Within this domain, indexing plays a critical role in information retrieval, particularly when applied to search systems such as Online Public Access Catalogues (OPACs), where accurate indexing forms the basis for effective document discovery.

Automated Cataloguing: AI can assist with the automatic creation of metadata for library materials and the tagging of new library materials, increasing the effectiveness of the cataloguing process by making it easier for users to locate library resources. This speed up the time it takes for consumers to get new items and decreases the effort for librarians.

Improved Search and Discovery: Advanced AI algorithms can help improve the performance of library catalogue searches. Users can find resources more easily even when their queries contain typos or synonyms. According to Fernandez (2016), using AI in academic libraries will help with massive data analysis, metadata generation, and improved search translation.

Digital Content Management: Another cataloguing and classifying service that was handled manually by librarians is Digital material categorisation. Artificial intelligence (AI) applied with cataloguing and categorisation can help classify and manage digital assets such as e-books, audio, and video content. Machine learning models can recognise and tag content for easier access and discovery

Content Recommendation: AI can also aid with content suggestion, bringing users to suitable resources based on their perceptions and interests. By analysing historical search patterns and user behaviour, artificial intelligence (AI) can produce customised recommendations that enhance the discoverability of library resources.

Circulation services

The efficient interchange of materials between the library and its users depends on a well-run circulation operation. A component of circulation services is the administration of library materials that patrons check out. Among the services provided by circulation are hold and reserve management, loan renewals, material check-in and check-out, library card issuance, and lending policy enforcement. However, by automating monotonous processes like check-in and check-out as well as overdue notifications, integrating AI into circulation might streamline these services. The following are some ways that artificial intelligence (AI) can improve circulation services:

AI recommendation systems: The circulation service, which increases user access to books, journals, multimedia, and other resources, revolves around the loaning and returning of library goods to customers. Users visit the circulation counter to check out materials, and circulation staff handle the paperwork. The personnel scan records, library cards, and user IDs to verify that the requested materials are available. In order to ensure that popular items are available, artificial intelligence (AI) has the capacity to estimate material demand and support inventory control. AI recommendation systems can further transform library services by suggesting suitable books, enhancing user experience, and generating new research opportunities by examining borrowers' borrowing habits and previous choices (Chen & Lee, 2020).

Accessibility Services: Circulation services ensure quick and easy access to library resources. AI can assist in converting printed documents into accessible versions, such as text-to-speech or audio explanations for photographs, so that people with impairments have equitable access to library resources.

Self-Checkout and Return Kiosks: The circulation service, which increases user access to books, journals, multimedia, and other resources, revolves around the process of lending and returning library materials to patrons. The circulation desk is where patrons go to check out materials, and staff members handle the paperwork there. The staff checks if the requested products are available, scans user IDs or library cards, and so on

Automated Fine Management: Lending and returning books, monitoring due dates, renewing loans, managing holds, and collecting fines for past-due items are just a few of the vital functions carried out by the library circulation department. AI-powered solutions are perfect for simplifying these processes. Algorithms utilising artificial intelligence (AI) can be used to calculate fines, identify overdue items, and in some cases, waive fines. This automation provides fairness in fine management while easing the administrative load.

Predictive Maintenance: Libraries produce a favourable user experience through their excellent circulation services, which in turn enhance patron pleasure and repeat business. When self-checkout machines and other library equipment need maintenance can be predicted using AI analytics. This proactive approach ensures better user experience and less downtime. Bradley (2022) argues that the industry actively participates in consultations to secure an ethical and transparent future for AI, despite libraries' lack of representation in current AI projects. Since AI legislation is still in its infancy, the author contends that libraries can still be involved.

Impediments to the integration of artificial intelligent (AI) in Academic Library: Library and information science have not seen this, in contrast to other sectors where AI has been embraced and used, where its application has been expanding rapidly.

Initial Costs: Financial deficiency has always been the biggest difficulty facing libraries all over the absorption of new trends that involve money. This is corroborated by Farag et al. (2021), who emphasise that the first significant obstacle to integrating AI in libraries is a lack of physical equipment, followed by a lack of local vendors of AI technology. However, libraries need to budget for the occasionally expensive process of putting AI solutions into practice.

Inadequate protection for user privacy: AI systems gather and examine data, which may give rise to worries about its improper use. Libraries need to implement strict data security protocols and make sure that user information is handled carefully.

Lack of AI literacy: A study on the use of artificial intelligence (AI) technology in university libraries' information retrieval was carried out by (Liu et al. in 2022). The goal of the study was to improve upon the shortcomings of the current intelligent information retrieval systems. According to a survey, the primary issues with AI information retrieval technology for university libraries were difficulty learning new information,

ambiguous knowledge representation, and poor comprehension of natural language. To run and manage AI technologies successfully, library staff may need training. The artificial intelligence (AI) is seen as a tool to boost job performance and user pleasure; nonetheless, more awareness of AI's role in library operations is required. The study recommends that academic librarians acquire the skills necessary to comply with AI in library operations, that library management inform librarians about the benefits of AI, and that librarians attend conferences and training to prepare for the adoption of AI in library operations. It also proposes training library staff members in artificial intelligence, developing an environment that is receptive to new ideas, and encouraging staff members to look into the potential of using AI

Potential Bias in AI Algorithms

Poorly designed or insufficiently evaluated AI systems may unintentionally conserve existing biases during content selection and recommendation processes. Addressing this challenge requires close collaboration between librarians and AI developers to ensure that fairness, transparency, and ethical considerations are embedded in system design and implementation (Smith & Martinez, 2019).

Risk of Job Displacement among Library Personnel

Research examining academic librarians' awareness and perceptions of Artificial Intelligence (AI) in university library management indicates that librarians possess a general understanding of AI applications within library operations. However, concerns persist regarding the potential impact of AI adoption on employment security. As AI technologies advance, there is a growing apprehension that increased reliance on automated systems may reduce direct user engagement with libraries and librarians. Furthermore, widespread automation may contribute to greater social and professional inequalities. Liu (2022) also highlights broader negative implications of AI-generated prior art, including reduced motivation for researchers to disseminate significant innovations through established patent systems.

Attitudes of Librarians toward AI Adoption

Ajani et al. (2022) investigated librarians' perceptions of the level of awareness and readiness of academic libraries to integrate Artificial Intelligence (AI) into their services and operations. The findings revealed that although Nigerian academic libraries are aware of global developments in AI applications within librarianship, they currently lack the necessary infrastructure, expertise, and resources to fully incorporate AI technologies into routine library practices.

Conclusion

Future studies should focus on examining the long-term impact of Artificial Intelligence (AI) on academic library services, particularly with respect to service quality, user satisfaction, and professional roles within libraries. Empirical research is needed to evaluate the effectiveness of specific AI applications, such as chatbots, recommender systems, and automated cataloguing tools, across diverse institutional and cultural contexts. Further investigation into ethical concerns, including algorithmic bias, data privacy, and transparency is essential to ensure responsible AI adoption in libraries. Additionally, future research should explore the training and skill development requirements of library professionals to effectively work alongside AI technologies, as well as the readiness of library infrastructure to support advanced AI systems. Comparative and longitudinal studies will be valuable in understanding how AI-driven transformations can sustainably enhance library services while preserving the human-centered values of librarianship.

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An Overview of Collaborative AI Frameworks for Consortia Systems Like Inflibnet and Delnet

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Abstract

Collaborative Artificial Intelligence (AI) framework is changing library consortia systems by making it easier to share resources, make decisions, and provide services to users. Consortia such as INFLIBNET and DELNET are using solutions powered by AI more and more for categorization, recommendation systems, managing metadata, and analyzing usage. This paper gives an overview of collaborative AI frameworks and talks regarding the way might help networked academic libraries in the digital age collaborate more effectively, communicate data more easily, and circulate knowledge more widely.

Keywords: collaborative Artificial Intelligence; library consortia, INFLIBNET, DELNET, Resource Sharing, Smart Libraries.

INTRODUCTION

For academic and research organizations to collaborate, share resources, and have access to intellectual material, library consortia are essential. Large-scale information networks in India are supported by consortium systems like INFLIBNET and DELNET, which share databases and services. Artificial intelligence has become a crucial tool for handling intricate information systems as digital libraries have grown. Libraries in consortia can analyses data collectively, automate procedures, customize services, and improve interoperability by using collaborative AI frameworks. The importance of AI-driven cooperation in bolstering contemporary consortium-based library systems is discussed in this introduction. Background on library consortia in India DELNET, which links more than 9700 institutions for ILL, e-resources, and Koha/ Dspace support and INFLIBNET (UGC effort for university libraries, encouraging digital initiatives like Shodhganga, N-LIST). Transition from the era of traditional networking to that of digital and artificial intelligence.

AI is becoming more prevalent in libraries through chatbots, recommendation engines, metadata creation, and plagiarism detection systems in DELNET. Collaborative AI is necessary for consortiums deal with dispersed data bring concerns about cost, privacy, and sovereignty. Goal describes cooperative AI frameworks appropriate for consortia such as INFLIBNET/DELNET.

Library Consortia in India: INFLIBNET and DELNET

INFLIBNET: UGC's network for universities; services include Shodhganga (theses repository), soul software, e-shod Sindhu for e-resources.

DELNET: society since 1992; focused on resource sharing, ILL, e-journals consortium, Koha implementation, webinars, and technologies like Drill Bit (plagiarism AI detection)

Common goals: cost sharing, collective access, standardization. Current AI touches: AI text detection, recommendation in discovery layers, although primarily institution-specific or vendor-driven.

Artificial Intelligence in Libraries

Global: AI for chatbots (e.g., library assistants), predictive analytics, picture recognition in digital collections, tailored suggestions.

Indian perspectives: growing usage in academic libraries (e.g., RFID AI in some universities, Koha integrations); studies on AI literacy among LIS professionals.

Challenges: limited infrastructure in smaller institutions, data privacy (user borrowing history, research behaviors), and knowledge shortfalls.

REVIEW OF LITERATURE

Prajapat, V., & Taru, R. D. (2022). Consortia of Digital Libraries and Information Networks: National and International. *Knowledge Management in Higher Education Institutions*, digital libraries. This study made an attempt to conduct a descriptive study on consortia of library and information networks. Open educational resources can have an immense impact on society.

Krishha, Y. S., Jayaswethaashree, N., & Nazrin, C. M. (2025). Integration of Blockchain Technology and AI in Interlibrary Loan and Resource Sharing. In *Leveraging Blockchain for Future-Ready Libraries* (pp. 221-254). IGI Global Scientific Publishing. This paper focuses on artificial intelligence and how it compares to the actual interlibrary loan ILL and resource sharing in libraries. Automation for the library to benefit from productivity and accessibility in the sharing of resources to emerge in the current digital epoch.

Ntullo, S. H., & Jaiswal, B. Transforming Academic Libraries through Consortia: A Global Perspective on Shared Access and Collaboration. This study explores the transformative role of library consortia in enhancing access to scholarly resources, promoting inter-institutional collaboration and improving cost efficiency in academic libraries worldwide.

Ansari, M. R. (2024). Analyzing The Adoption and Challenges of Information Retrieval Systems in Indian Libraries: A Secondary Data Approach.

Tripathi, M. (2013). Consortia initiatives in higher education libraries in India: A reconnaissance of the national landscape. In *Mergers and Alliances: The Wider View* (pp. 107-136). Emerald Group Publishing Limited. This paper highlights how libraries can function in consortia mode to enhance their services to users in the face of dwindling budgets and spiraling cost of scholarly journals and databases.

COLLABORATIVE AI FRAMEWORK

- Collaborative AI enables distributed entities (libraries/consortia members) to build better models collectively.
- Federated learning (FL): key privacy-preserving framework. Only model updates are shared and aggregated centrally or decent rally; devices/institutions train models locally using their data. Raw data does not leave the premises
- Horizontal FL: data categories such as borrowing patterns that are similar across libraries.
- Vertical FL: complementary data (e.g., metadata from one library with user queries from another).
- Cross-silo FL: Suitable for consortia (higher competence, few members, such as institutions).
- Multi-agent AI systems: self-governing agents work together to complete tasks (e.g., one for query expansion, another for metadata enrichment).
- Additional Frameworks: secure multiparty computing; gossip based p2p FL decentralized, no central server. Benefits for consortia include decreased duplication, improved model accuracy from various data such as regional languages in India and privacy compliance, such as GDPR related issues.

History of INFLIBNET and DELNET

In 1991, the University Grants Commission (UGC) established the Information and Library Network (INFLIBNET) center as an independent inter university centerIUC. Its main goal was to employ information

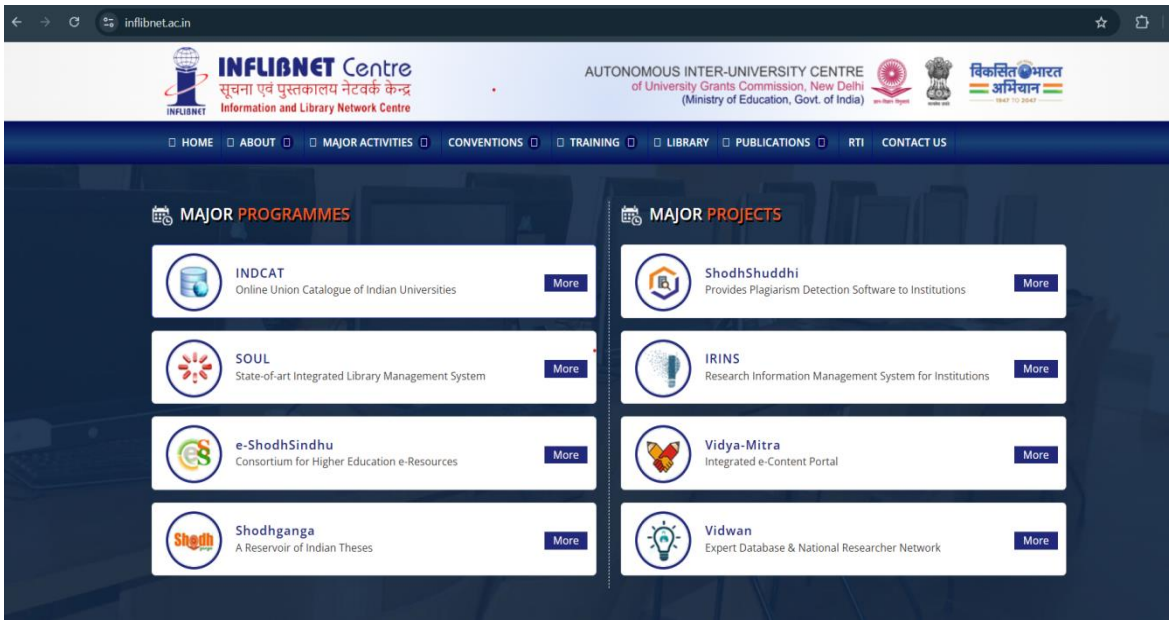
and communication technology (ICT) effectively to encourage resource sharing and networking among Indian university Libraries. INFLIBNET, which has its headquarters in Gandhinagar, Gujarat, first concentrated on builiding bibiliographic databases and union catalogues. With time, it broadened its offerings to include significant projects like the UGC-INFONET Digital library consortium, N-LIST, Shodhganga, Shodhgangotri, and E-Shodhsindhu, which enhance academic cooperation, research visibility, and access to e-resources among Indian higher education institutions.

The collaboration provided by the National Information System for Science and Technology (NISSAT), DSIR, and the Developing Library Network (DELNET) was founded in 1988 at the India International Centre Library in New Delhi. By creating computerised databases of books, journals, theses, and articles, DELNET was established to encourage resource sharing across libraries. Later, in 1992, it was registered as a society. Using networking technologies, DELNET was the first in India to provide interlibrary loan and document delivery services. Universities, colleges, R&D centers, and special libraries in India and outside joined DELNET as a result of the expansion of digital libraries.

OBJECTIVES

1. To investigate the idea and potential applications of collaborative AI frameworks in Library consortia systems.
2. To research the composition and operation of India's cooperative library networks, INFLIBNET and DELNET.
3. To determine how AI technologies are used in consortium systems for resource sharing, cataloguing, and metadata management.
4. To examine how member libraries' information sharing and interoperability are improved by collaborative AI
5. To evaluate how AI-driven solutions might enhance user experiences, including E-resource access, recommendation, and discovery.
6. To determine obstacles and constraints while putting collaborative AI frameworks into practice in DELNET and INFLIBNET.

FUNCTIONS OF INFLIBNET

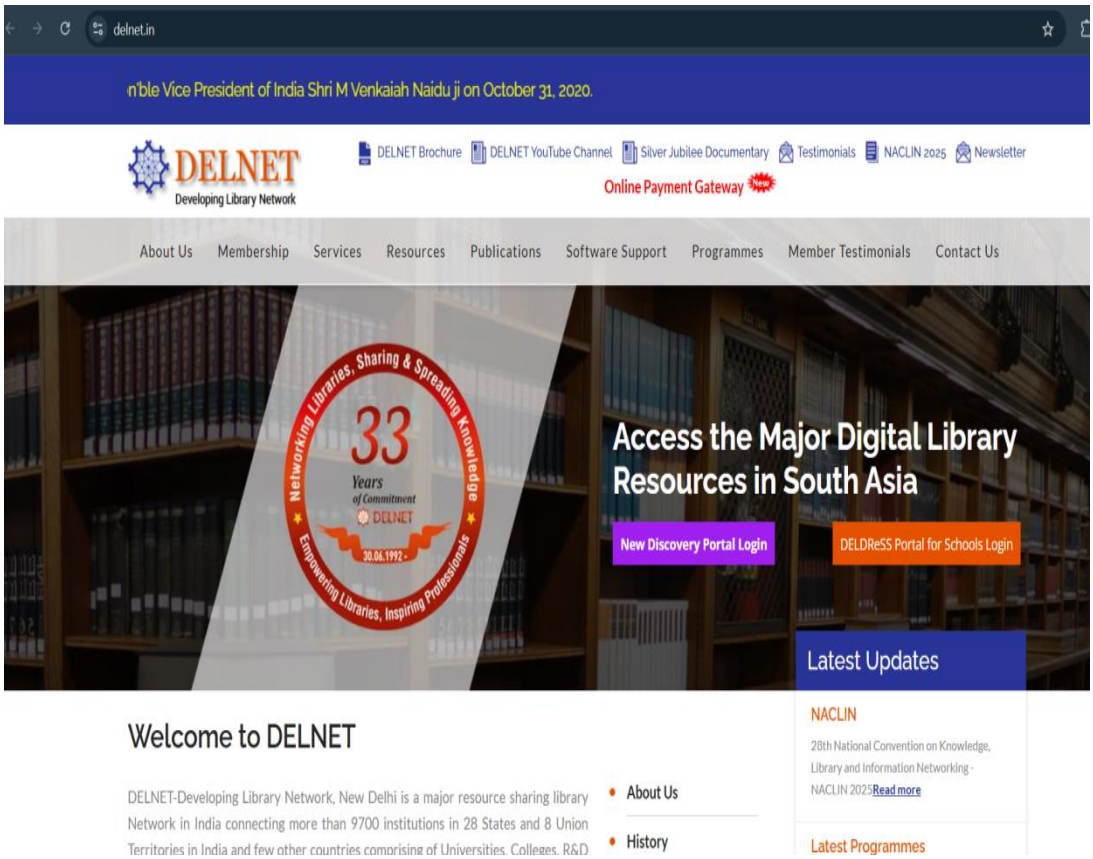


- Creation of union catalogues for theses, books, serials, and non-book items
- Facilitation of document delivery services and interlibrary loan (ILL)
- Setting up conferences, workshops, and training sessions
- Support for digitization and automation in libraries
- Upkeep of national scholarly databases
- Encouragement of open access projects

MAJOR SERVICES AND PROGRAMS

1. UGC-INFONET Digital Library Consortium gives universities access to databases, e-books, and scholarly publications.
2. The National Library and Information Services infrastructure for scholarly content, or N-LISTgives colleges and universities that are not covered by UGC-INFONET access to electronic resources.
3. E-Shod Sindhu is a combined collaboration that provides R&D firms, universities, and technical institutions with electronic resources.
4. Shodhganga is an online collection of Indian theses and Dissertations that would increase research visibility and avoid duplication.
5. The Shod Gangotri is a collection of authorised summaries and research ideas.
6. Software for university Libraries, or SOUL INFLIBNET created an integrated library management program for automating libraries.
7. INDCAT A collection of books, theses, and serials from university libraries in India.

FUNCTIONS OF DELNET



1. Resource sharing: Through Interlibrary Loan and document delivery services, member libraries can share library resources.
2. Development of union catalogues creates and updates union catalogues of member libraries' books, journals, theses, dissertations, and non-book items.
3. Services for Interlibrary Loan (ILL) enable users to obtain documents that are not available in their Local Library by offering effective interlibrary loan services.
4. Delivery services for documents provided digital or photocopies of research records, conference papers, and journal articles upon request.
5. Building and maintaining Databases builds and maintains full-text and bibliographic databases for books, serials, journals, and theses.
6. Networking and library automation support help members' libraries embrace ICT tools and standardize their libraries.
7. Education and career advancement arrange training courses, seminars, and workshops on cutting-edge technologies and best practices for library workers.
8. Electronic resource access facilitates cooperation agreements for access to Internet databases and e-resources.
9. Technical advice offers technical advice on database administration, software selection, and cataloguing standards.
10. Encouragement of library collaboration promotes coordination and cooperation at the national and international levels between academic, research, and special libraries.

Methodology

To give a thorough overview of collaborative AI frameworks and their possible applicability to library consortia systems like INFLIBNET and DELNET, this study uses a systematic literature review SLR approach. By adhering to standardized protocols inspired by to preferred reporting items for Systematic Reviews and meta-analyses, PRISMA criteria modified for conceptual thematic reviews, as no meta-analysis is involved, the SLR techniques guarantees rig our, transparency, and repeatability. In non-technical fields like library and information science, this method works especially well for synthesizing scattered literature on modern technologies like federated learning.

DESIGN OF RESEARCH

This study is exploratory and qualitative in structure, combining: Systematic screening and search of academic sources. Key collaborative AI frameworks, such as multi-agent systems and federated learning, are identified through thematic analysis. Conceptual mapping to connect Indian library consortia with worldwide AI developments. Since the goal is to summarise current knowledge and suggest future paths rather than test hypotheses, no primary data gathering, such as surveys or interviews, was carried out.

Prospective Paths and Suggestions

- Pilot projects: Federated pilots for detection or recommendation tools could be started with INFLIBNET/ DELNET.
- Partnerships: work with Indian AI projects or tech companies open sources FL tools like Flower, TensorFlow Federated.
- Policy: create consortium standards for the moral application of AI. Further research on FL in LIS environments is needed.
- Search strategy relevant literature for LIS, computer science and AI was gathered from essential academic databases and repositories:
- Institutional repositories: DELNET publications and INFLIBNET

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- Scopus
- Web of Science
- IEEE Xplore
- Google Scholar, ACM Digital Library, ResearchGate and Academica.edu for Indian publications and grey literature.

CONCLUSION

By enhancing resource sharing, intelligent discovery, and user-centric services, collaborative AI frameworks have the potential to greatly boost consortium systems like INFLIBNET and DELNET. Automated metadata management, customized information retrieval, predictive analytics, and enhanced decision-making among member libraries are all made possible by the incorporation of AI. AI-supported consortia can tackle issues of information overload, disparate access, and operational inefficiencies by promoting collaboration, interoperability, and data-driven services. However, strong infrastructure, qualified personnel, moral AI practices, and legislative support are necessary for successful adoption. All things considered, collaborative AI frameworks offer a reoutlining strategy for maintaining and updating library consortia within the digital information ecosystem.

Consortia such as INFLIBNET and DELNET can convert into intelligent, privacy-aware networks using collaborative AI frameworks like federated learning. These systems can provide better services while retaining institutional autonomy by cooperatively using distributed data. Consortia-led adoption will be essential for equal advantages throughout Indie's varied library ecosystem as AI develops.

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A Study on Emerging Technologies of Artificial Intelligence

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ABSTRACT

Artificial Intelligence (AI) has become one of the most influential emerging technologies of the twenty-first century. This paper examines the major emerging AI technologies, their evolution, and applications across sectors, ethical implications, and future directions with special reference to education, industry, and governance. The study adopts a conceptual and analytical approach based on secondary sources and policy reports. The findings indicate that AI-driven technologies significantly enhance productivity, decision-making, and innovation, while also posing challenges related to ethics, employment, and data governance.

KEYWORDS: Artificial Intelligence, Emerging Technologies, Machine Learning, Deep Learning, Generative AI, Automation

INTRODUCTION

Artificial Intelligence refers to the capability of machines to perform tasks that typically require human intelligence, such as learning, reasoning, problem-solving, and language understanding. Rapid advancements in computational power, big data analytics, and algorithms have accelerated the development of AI technologies. AI is now considered a general-purpose technology with the potential to transform every sector of the economy.

EVOLUTION OF ARTIFICIAL INTELLIGENCE

The evolution of AI can be traced from symbolic and rule-based systems to modern data-driven approaches. Early AI focused on expert systems, while contemporary AI relies heavily on machine learning and deep learning models. The shift from deterministic programming to probabilistic and adaptive systems marks a significant milestone in AI development.

EMERGING AI TECHNOLOGIES

Emerging AI technologies include machine learning, deep learning, natural language processing, computer vision, generative AI, robotic process automation, and autonomous systems. These technologies enable intelligent prediction, automation, and enhanced human–machine interaction across domains.

MACHINE LEARNING AND DEEP LEARNING

Machine learning allows systems to learn from historical data and improve performance without explicit programming. Deep learning, a subset of machine learning, uses artificial neural networks to process complex and unstructured data. Applications include medical diagnosis, fraud detection, recommendation systems, and predictive analytics.

Natural Language Processing and Computer Vision

Natural Language Processing (NLP) enables machines to understand, interpret, and generate human language. Computer vision focuses on enabling machines to analyze and interpret visual data, such as images and videos. These technologies support applications such as chatbots, virtual assistants, facial recognition, and autonomous vehicles.

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Generative AI and Intelligent Automation

Generative AI systems are capable of creating new content, including text, images, audio, and software code. Intelligent automation integrates AI with robotic process automation to streamline business operations, improve efficiency, and reduce human error.

Applications of AI in Key Sectors

AI is widely applied in healthcare, education, finance, agriculture, manufacturing, and public administration. In education, AI supports personalized learning, intelligent tutoring systems, and learning analytics. In healthcare, AI assists in diagnostics, drug discovery, and patient monitoring.

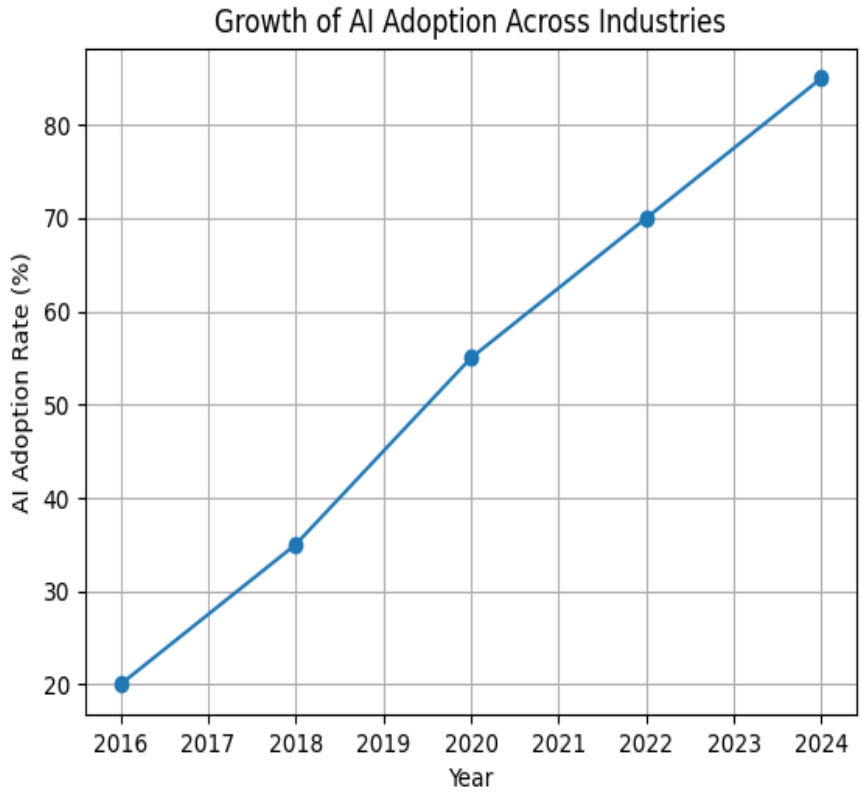
Ethical, Legal, and Social Implications

The widespread adoption of AI raises ethical and social concerns such as data privacy, algorithmic bias, transparency, accountability, and workforce displacement. Ethical AI frameworks and regulatory mechanisms are essential to ensure responsible and inclusive AI development.

Future Trends in Artificial Intelligence

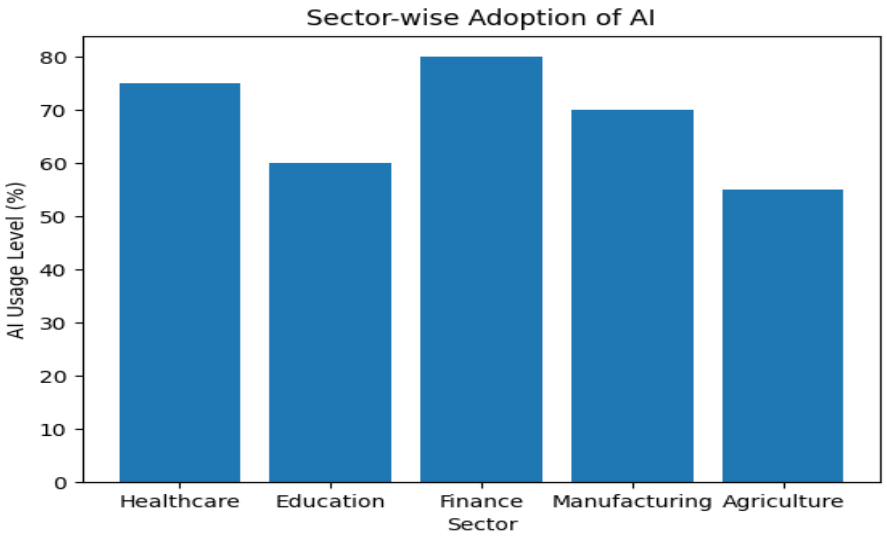
Future AI trends include explainable AI, human-centered AI, responsible AI governance, and integration with emerging technologies such as the Internet of Things and blockchain. Continuous upskilling and capacity building are critical to harness AI's long-term benefits.

Figure 1: Growth of AI Adoption Across Industries



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Figure 2: Sector-wise Adoption of AI



CONCLUSION

Emerging technologies of AI are reshaping economic structures, professional practices, and social interactions. While AI offers immense opportunities for innovation and growth, its successful adoption depends on ethical governance, policy support, and continuous skill development. A balanced approach is necessary to maximize benefits and minimize risks.

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Smart Libraries in the Digital Era: A Study of Emerging Technologies and their Impact

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ABSTRACT

Libraries are undergoing tremendous transition as a result of the rapid growth of new technology. Traditional library services are being transformed into intelligent, technology-driven information systems that improve accessibility, efficiency, and user pleasure. This study investigates the impact of emerging technologies such as artificial intelligence (AI), machine learning (ML), the Internet of Things (IoT), library automation, robots, cloud computing, data analytics, and virtual reality on modern library operations and information services. AI and machine learning increase information retrieval, tailored suggestions, and virtual reference services, whilst IoT enables smart library environments by monitoring resources in real time. Library automation and robotics simplify regular activities like circulation, sorting, and inventory management, lowering human workload. Flexible storage, remote access, and economical library management are all made possible by cloud computing. While virtual reality offers virtual library tours and immersive learning experiences, data analytics helps librarians understand user behavior and optimize services. When combined, these technologies improve decision-making, user engagement, and operational effectiveness in libraries. The study demonstrates how new technologies are transforming libraries into cutting-edge knowledge centers that can adapt to the changing demands of the digital era.

Keywords: Data analytics, artificial intelligence, smart libraries, emerging technologies, and library automation

INTRODUCTION

The approach libraries operate with has changed dramatically as a result of the digital revolution, moving away from conventional methods and toward technology-driven services that cater to the changing demands of digital users. Information services and library operations are changing as a result of emerging technologies, including virtual reality, cloud computing, artificial intelligence, and the Internet of Things. Libraries are evolving from traditional archives to technologically driven knowledge centers that offer easy access to digital information. The adoption of these technologies has accelerated due to the increasing need for rapid information, remote accessibility, and effective service delivery. As a result, libraries may remain responsive to the difficulties of the modern digital setting across academic and research contexts while streamlining workflows, optimizing resource use, supporting informed decision-making, and improving user satisfaction.

METHODOLOGY

Research methodology used in this study is conceptual and descriptive. Information was gathered using:

- Examining journals, conference papers, and published literature
- Examining how technology is currently used in libraries
- A comparative analysis of new technologies

Rather than focusing on empirical measurement, the study aims to comprehend functional applications.

OBJECTIVES OF THE STUDY

- To determine the main categories of electronic resources found in research and academic libraries.

- To examine the functional elements and lifecycle of Electronic Resource Management Systems (ERMS).
- To investigate the use of new technologies in electronic resource management.
- To assess how new technologies affect library access, use, and decision-making.
- To emphasize how librarians manage technology-driven electronic resources.

APPLICATIONS OF EMERGING TECHNOLOGIES IN LIBRARIES

AI and ML

AI and machine learning enable intelligent search systems, chatbots, automatic indexing, and tailored recommendations, ultimately improving reference and information services.

Internet of Things

IoT technology, like RFID and smart sensors, allows for real-time resource tracking, environmental monitoring, and effective space management.

Library Management and Robotics

Automation systems improve circulation, cataloguing, and inventory control, while robots help with book sorting and shelf management.

Cloud Computing

Cloud computing enables scalable storage, remote access, and cost-effective digital library services while also supporting integrated library management systems.

Data Analysis

Data analytics enables user behavior analysis, collection assessment, and evidence-based decision-making.

Virtual Reality

Virtual reality provides immersive learning environments, virtual library tours, and interactive educational opportunities.

ELECTRONIC RESOURCE MANAGEMENT

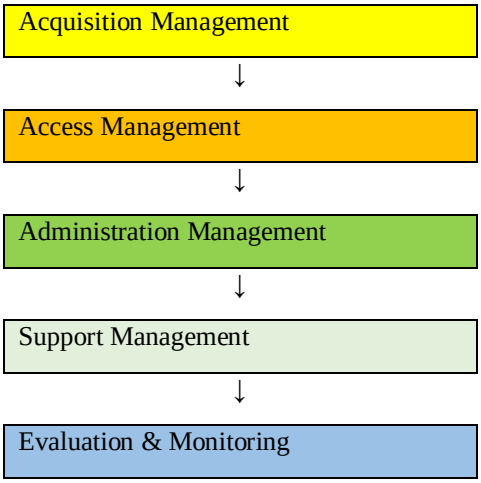
Table 1 and Figure 1. Electronic resources in libraries and information centers have grown significantly as a result of the quick development of information and communication technology (ICT). Electronic journals, electronic books, online databases with full-text articles, abstracts, and indexes, electronic reference sources, value-added informational portals, and web-based serial publications are all considered electronic resources. Although these services greatly improve access to intellectual knowledge, libraries face considerable obstacles in organizing and delivering them effectively. Electronic resource management has become more difficult for information workers due to the exponential growth in digital content, variety of formats, and frequent changes in site addresses. To solve these problems, Electronic Resource Management Systems (ERMS) have been created to facilitate the systematic handling of digital materials in smart library settings. The ERMS lifecycle consists of five interconnected stages: acquisition and access management, administration and support management, and evaluation and monitoring. Each stage is critical to ensure effective selection, accessibility, maintenance, user assistance, and continuous review of electronic resources throughout their existence.

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Table 1: Emerging Technologies and Their Functional Impact in Libraries

Technology	Library Application Area	Key Outcome
AI & Machine Learning	Reference & Search Services	Personalized information access
Internet of Things	Resource & Space Management	Real-time monitoring
Automation & Robotics	Circulation & Inventory	Reduced manual workload
Cloud Computing	Digital Libraries	Remote and scalable access
Data Analytics	User Studies	Informed decision-making
Virtual Reality	Learning Services	Immersive user experience

Figure 1: Lifecycle of Electronic Resource Management System (ERMS)



RESULTS AND DISCUSSION

The results show that new technologies greatly improve overall library services and electronic resource management. Libraries that use ERMS coupled with AI, IoT, cloud computing, and data analytics report increased user happiness, efficient resource use, and improved operational efficiency. Cloud-based platforms guarantee scalability and remote access, while AI-based discovery systems and analytics-driven assessment tools facilitate well-informed decision-making. For successful implementation, the study also highlights obstacles like the requirement for technical know-how, ongoing professional development, and institutional policy support. Intelligent search engines, automated indexing, and chatbots driven by AI improve user engagement. Recommendation systems based on machine learning customize services. IoT increases operational efficiency by enabling RFID tracking, smart shelving, and environmental monitoring.

Automation systems make cataloging, acquisition, and circulation more efficient. Robotics helps with inventory management and book sorting. Scalable storage, remote access, and affordable digital services are all made possible by cloud computing. Analyzing user behavior, improving services, and making well-informed decisions are all aided by data analytics. Virtual reality provides interactive user experiences, virtual library tours, and immersive learning settings.

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Emerging Technology Conceptual Flow Diagram in Libraries

A notional flow diagram showing how developing technologies are integrated into libraries is shown in Figure 2. Smart library systems are developed with the use of artificial intelligence, the Internet of Things, cloud computing, automation, data analytics, and virtual reality. These systems improve consumer satisfaction, service quality, and operational efficiency. The transition from technology adoption to user-oriented information services is depicted in the diagram.

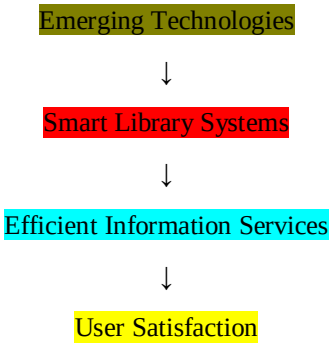


Figure 2

New Technologies' Effect on Library Services

The degree to which developing technologies affect library services is depicted in Figure 3. Because of their position in digital access and intelligent services, cloud computing and artificial intelligence have a significant impact. Decision-making and operational management are somewhat improved by the Internet of Things and data analytics. Even though it is still in its infancy, virtual reality has increasing promise for user engagement and learning.

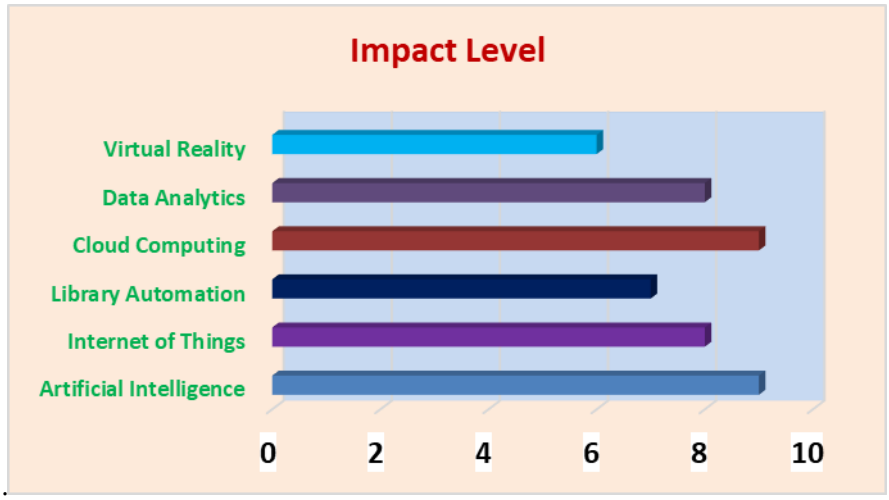


Figure 3.

CONCLUSION

Using the employment of cutting-edge technology that improves accessibility, effectiveness, and user experience, libraries are undergoing a dramatic transition. Libraries have become sophisticated and dynamic information centers thanks to the integration of artificial intelligence, the Internet of Things, automation, cloud computing, data analytics, and virtual reality. Decision-making, service delivery, and electronic resource

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management are all enhanced by these technologies. Libraries must continue to be creative and adaptable as user needs in the digital world change. The ability of librarians to adopt new digital tools and keep up with technological advancements is crucial to the successful adoption of emerging technology. In the quickly changing information landscape, libraries must maintain their relevance, sustainability, and user-centeredness through ongoing professional development, institutional support, and strategic planning.

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Artificial Intelligence in Libraries: A Bibliometric Analysis of Web of Science Publications

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Abstract

The increasing use of Artificial Intelligence (AI) in library systems has led to a rapid growth of scholarly research; however, a clear and systematic understanding of research trends, collaboration patterns, thematic focus, and citation impact in this field remains limited. This study aims to analyse publication growth, document characteristics, authorship trends, research themes, and citation influence of AI-related studies in Library and Information Science. A descriptive bibliometric analysis was conducted using 233 publications retrieved from the Web of Science Core Collection covering the period from 2015 to 2025, and the data were analysed using Microsoft Excel, Biblioshiny, and VOS viewer. The findings reveal a significant increase in research output, particularly after 2020, with journal articles and review papers dominating the literature and multi-authored publications indicating strong interdisciplinary collaboration. Keyword analysis shows a shift toward data-driven and application-oriented AI research, while citation analysis indicates that high-impact studies are concentrated within a limited number of publications and countries. Overall, the study provides a structured overview of the development of AI research in libraries and offers useful insights for researchers, practitioners, and policymakers to support future research and informed adoption of AI technologies in library and information services.

Keywords: Artificial Intelligence, Library and Information Science, Bibliometric Analysis, Research Trends, Web of Science.

Introduction

The growing impact of artificial intelligence (AI) has transformed numerous sectors, including education, healthcare, business, and information services (Dwivedi et al. 2019). Libraries, as key knowledge organizations, are increasingly leveraging AI applications to improve information retrieval, user services, collection management, and decision-making (Hussain 2023). This shift has led to a noticeable increase in scholarly research on the use of AI in libraries, reflecting the evolving role of libraries in the digital era (Borgohain et al. 2022).

Bibliometric methods provide valuable tools for examining the development of research fields. By analyzing structured bibliographic data, researchers can explore trends in scholarly output, authorship patterns, collaboration networks, geographical distribution, and publication characteristics. Such analyses offer insights into how knowledge is produced, disseminated, and organized over time. Previous studies, such as those by (Verma et al. 2018) and (Guns et al. 2019), have demonstrated the utility of bibliometric approaches in revealing patterns in research productivity, publication practices, and communication channels across disciplines.

Despite this progress, there is limited systematic understanding of how AI-related research in libraries has evolved. Existing studies often focus on general bibliometric trends or specific disciplines, but few examine the unique patterns, publication outlets, and thematic focuses of AI applications in library science (Kalita et al. 2024). This gap makes it difficult to assess the structure, growth, and maturity of research in this emerging area.

To address this, the present study examines scholarly publications on AI in libraries using a descriptive bibliometric approach (Berliani and Yuadi2022). It investigates year-wise growth, key publication sources,

document types, and dominant research themes based on keywords. By providing a structured overview of research output, the study highlights trends and developments in the application of AI within library science, offering insights for both researchers and practitioners.

Objectives

1. To analyse the year-wise growth of publications on Artificial Intelligence in Library and Information Science.
2. To determine the distribution of publications by publishing source and document type.
3. To assess the level of research collaboration in the field and authorship trends.
4. To examine the distribution of research publications by language.
5. To evaluate the distribution of publications according to citation range and the influence of citations.

Review of Literature

The rapid advancement of artificial intelligence (AI) has led to its widespread application across various disciplines, including healthcare, education, and information management. In the field of Library and Information Science, AI technologies are increasingly being adopted to address challenges related to knowledge organization, information retrieval, and digital resource management. Consequently, a growing body of literature has emerged examining AI applications, technological developments, and research trends in this domain. Reviewing these studies is essential to understand the evolution of AI in libraries and to identify existing research gaps.

AI technologies have revolutionized library information retrieval processes, moving beyond traditional keyword-based search methods to more sophisticated approaches (Asadnia et al., 2023; Nugroho et al., 2023; Olusegun Oyetola et al., 2023). (Nugroho et al., 2023; Olusegun Oyetola et al., 2023; Panda, 2024) highlight the effectiveness of AI-powered search algorithms in understanding user queries, analyzing content and delivering personalized search results. These advancements enhance user experiences by providing more accurate and relevant information, ultimately improving information discovery within library collections.

A study conducted using bibliometric methods to examine research trends in artificial intelligence in education. Their analysis centered on articles published in the International Journal of Artificial Intelligence in Education between 2015 and 2019, encompassing 135 articles. The study showed that the articles largely focused on students and learning, with the USA, UK, Canada, and Germany contributing significant publications (Baek and Doleck, 2020)..

According to a study by (Berliani and Yuadi, 2022), AI has a significant connection to librarianship systems and digital library trends. The study indicates that the development of AI in library systems is occurring rapidly and is influenced by various surrounding factors.The (Borgohain et al., 2022) study aimed to conduct a bibliometric analysis of the literature on using artificial intelligence in libraries by examining the Scopus database from 2012 to 2021. The study found that 1462 relevant papers were authored by 5400 individuals, with an average of 0.271 documents per author and around 4 authors per document. The USA had the highest number of papers in the co-authorship network, while China was the top-ranked country at the institutional level.

A bibliometric mapping study by Kalita et al. (2024) analyzed Scopus-indexed articles on AI applications in libraries published between 2013 and 2023. The research identified a relatively modest volume of literature overall but noted a sharp increase in publication output in recent years, with single authorship being common among contributors. This study also highlighted collaboration patterns and authorship trends as central indicators of how the field is evolving.

A large-scale bibliometric analysis by Ratnadhi et al. (2025) examined 354 publications on AI in academic libraries from 2010 to 2023. Results showed a significant surge in research activity, with collaborative research accounting for a major portion of publications. Key contributors, such as leading authors and prominent publication sources like The Journal of Academic Librarianship, were identified, and geographic contributions highlighted the research leadership of countries like China, the USA, and India. The study also identified major research themes, including AI integration, data mining, and user personalization.

Methodology

This study adopts a descriptive bibliometric research design to examine publication trends and research patterns related to Artificial Intelligence (AI) in the field of Library and Information Science (LIS). Bibliometric techniques were applied to systematically evaluate the growth, distribution, and thematic structure of scholarly output using standardized bibliographic data. The data were retrieved exclusively from the Web of Science (WoS) Core Collection, a widely recognized and authoritative database known for its rigorous indexing standards and reliable citation information, ensuring the quality and consistency of the dataset.

A structured search was conducted using the Topic Search (TS) field in Web of Science, which covers titles, abstracts, author keywords, and Keywords Plus. The search query used was "artificial intelligence in library and information science." The time span of the study was limited to publications from 2015 to 2025 to capture recent developments and emerging research directions related to AI applications in libraries. To maintain scholarly relevance, only documents categorized as research articles, review papers, conference proceedings, and editorial materials were included. The initial search retrieved 268 records, and after applying the time filter and screening for relevance, the final dataset consisted of 233 valid records, which formed the basis of the bibliometric analysis. The records were exported in plain text and Microsoft Excel formats to facilitate data verification, cleaning, and organization.

Data analysis was carried out using Microsoft Excel, Biblioshiny, and VOS viewer. Excel was used for organizing the dataset and computing descriptive statistics, Biblioshiny supported the generation of bibliometric indicators and thematic analysis, and VOS viewer was used for mapping keyword co-occurrence networks. These tools enabled the examination of year-wise publication growth, document type distribution, authorship patterns, keyword frequency and thematic clustering, citation distribution, country-level research impact, and source and publisher contributions. As the study relied entirely on secondary data obtained from a publicly accessible bibliographic database, no ethical approval was required.

Analysis and Findings

A. The Pattern of Growth of the Research Output from 2015 to 2025

Year	No. of Publication	Percentage
2015	6	2.58%
2016	5	2.15%
2017	0	0
2018	3	1.29%
2019	8	3.43%
2020	15	6.44%
2021	20	8.58%

2022	20	8.58%
2023	50	21.46%
2024	52	22.32%
2025	54	23.18%

Table.1 Growth of Publications from 2015-2025

The Table 1 shows the year-wise publication trend of research on Artificial Intelligence (AI) in Library and Information Science (LIS) from 2015 to 2025. A total of 233 publications were recorded during this period. In the early years, the number of publications was low, with 6 papers (2.58%) in 2015 and 5 papers (2.15%) in 2016. No publications were found in 2017, and only 3 papers (1.29%) were published in 2018, indicating that research in this area was still developing.

From 2019 onwards, the number of publications started to increase steadily. There were 8 papers (3.43%) in 2019 and 15 papers (6.44%) in 2020. The growth continued in 2021 and 2022, with 20 publications (8.58%) each year. A sharp rise is seen in the last three years, with 50 papers (21.46%) in 2023, 52 papers (22.32%) in 2024, and 54 papers (23.18%) in 2025, which is the highest. This trend shows that research on AI in LIS has increased rapidly in recent years, highlighting the growing importance of AI applications in libraries.

B. Distribution of Publications by Document Type and Publication Source

Document type	No. of Publication	Percentage
Article	70	30.70%
Conference paper	42	18.42%
Review	77	33.77%
Editorial material	39	17.11%

Table 2 Distribution of Publications by Document Type

Table 2 presents the distribution of publications by document type. The data show that Review articles constitute the largest proportion (33.77%), followed closely by Research articles (30.70%). Conference papers account for 18.42%, while Editorial materials contribute 17.11%. This distribution indicates a well-balanced research structure where both knowledge creation and knowledge synthesis play significant roles. The strong presence of review papers suggests that the research area has accumulated sufficient literature to support critical evaluation and consolidation of existing findings. At the same time, the considerable share of research articles reflects continuous empirical investigation and innovation within the field

Publication type	No. of Publication
Journal	192
Conference	41

Table 3. Distribution of Publications by Publication Source

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Table 3 illustrates the distribution of publications by publication source. Journals dominate scholarly communication with 192 publications, whereas conferences account for only 41 publications. This trend demonstrates that researchers prefer peer-reviewed journals as the primary platform for disseminating their work, highlighting the importance of academic rigor, credibility, and wider visibility associated with journal publications.

C. Thematic Structure of Artificial Intelligence Research in Libraries: A Keyword Co-Occurrence Analysis

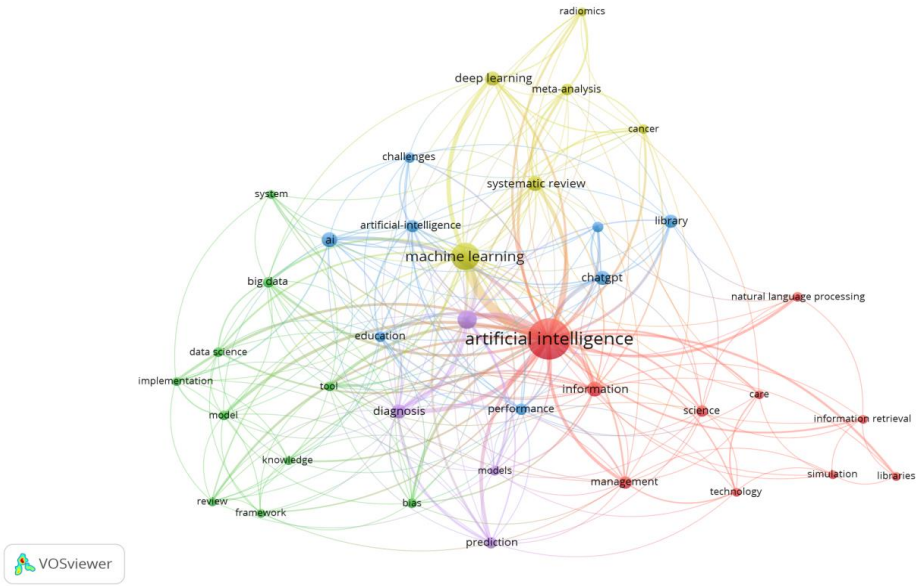


Fig. 1. Keyword Co-occurrence Network of AI in Libraries

The Fig. 1 shows the main research themes in AI studies related to libraries. "Artificial intelligence" is the central term, strongly connected with machine learning, information, library, and performance, highlighting the focus on improving library services and system efficiency. Clusters reveal different research areas: one emphasizes information retrieval, natural language processing, and management (practical applications), another focuses on data science, big data, and models (technical foundations), and another highlights education and challenges (adoption and training). Emerging terms like ChatGPT and prediction indicate growing interest in advanced AI and predictive tools. Overall, the network shows a shift toward practical, data-driven, and technology-focused AI research in libraries.

D. Language-Wise Analysis of Research Output

Language	No. of publication	Percentage
English	225	96.57%
French	3	1.29%
German	3	1.29%
Spanish	2	0.86%

Table 4: Language-wise distribution of publications

The analysis of language distribution indicates that English is the dominant medium of scholarly communication, accounting for 96.57% of the total publications, as illustrated in Table4. In contrast, only a small proportion of studies are published in French, German, and Spanish, which together represent less than 4% of the overall output. This pattern shows that researchers largely prefer English to ensure wider international reach, greater visibility, and higher citation potential. The findings emphasize the globalized nature of research in the field, while also suggesting that work published in other languages has comparatively limited representation, which may lead to the under-visibility of certain regional research contributions in international databases.

E. Authorship Patterns in AI and Library Research Publications

Authorship Pattern	Publications	Percentage
Single Author	38	16.31%
Two Authors	32	13.73%
Three or More	163	69.96%

Table 5 Authorship pattern of publications

Table 5 illustrates the authorship pattern of publications. The findings indicate that multi-authored publications (three or more authors) dominate the research output, accounting for 69.96% of the total publications. In contrast, single-author publications represent 16.31%, while two-author publications contribute 13.73%. This distribution highlights a strong trend toward collaborative research, suggesting that the field relies heavily on teamwork, shared expertise, and interdisciplinary cooperation

F. Publication Output by Leading Publishers

Rank	Publisher (Standardized)	Publications
1	Springer	31
2	JMIR Publications, Inc	21
3	Wiley	17
4	MDPI	11
5	IEEE	10
6	BMC	9
7	Elsevier	8
7	Association for Computing Machinery (ACM)	8
9	Public Library of Science (PLOS)	7
9	Nature Portfolio	7
11	Sage Publications Ltd	6
12	Oxford University Press	5
12	BMJ Publishing Group	5

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14	Frontiers Media SA	4
15	Emerald Group Publishing Ltd	4

Table 6. Publisher-wise Distribution of Research Publication

The Table.6shows the publisher distribution shows that Springer leads with the highest number of publications (31), followed by JMIR Publications (21) and Wiley (17), indicating that these publishers play a major role in disseminating research in the field. Other important contributors include MDPI, IEEE, BMC, Elsevier, and ACM, showing strong links with technology, health, and information science research. Publishers such as PLOS, Nature Portfolio, Sage, Oxford University Press, BMJ, Frontiers, and Emerald also contribute, though with fewer publications. The findings reveal that research is published across a mix of well-known commercial, society-based, and open-access publishers, which increases both the credibility and accessibility of the work. This distribution highlights the interdisciplinary nature of the field and helps researchers identify leading publication platforms while showing that knowledge is being shared through reputable international channels.

G. Publication Output across Citation Ranges

Citation range	Papers
0-50	135
51-100	57
101-150	29
151-200	8
201 and above	4

Table. 7. Distribution of Publications by Citation Range

Table.7 shows how publications are distributed according to citation counts. Most papers fall in the 0–50 citation range, indicating low to moderate impact for a large portion of the research. The number of papers decreases as citation counts increase, with only a few publications receiving more than 150 citations and very few exceeding 200 citations. This indicates that while many studies have been published, only a small number have achieved high citation impact.

H. Country-Wise Citation Distribution in AI and Library Research

The Fig.2 presents the citation analysis of top contributing countries shows that Spain leads with the highest total citations (5626) and a very high citation impact, reflecting its strong research influence. The United States ranks second (1187 citations) with significant contributions, though its citation impact per publication is lower. Germany, China, France, and the United Kingdom follow with substantial citation counts, indicating active research presence. Notably, countries like Singapore, Germany, and Korea have high citation impact despite lower publication volumes, suggesting their work is highly influential. Canada and Australia show moderate contributions. Overall, this pattern highlights that a few countries dominate global research influence, while smaller research communities can achieve high impact, offering insights into leading hubs, collaboration opportunities, and the global flow of knowledge.

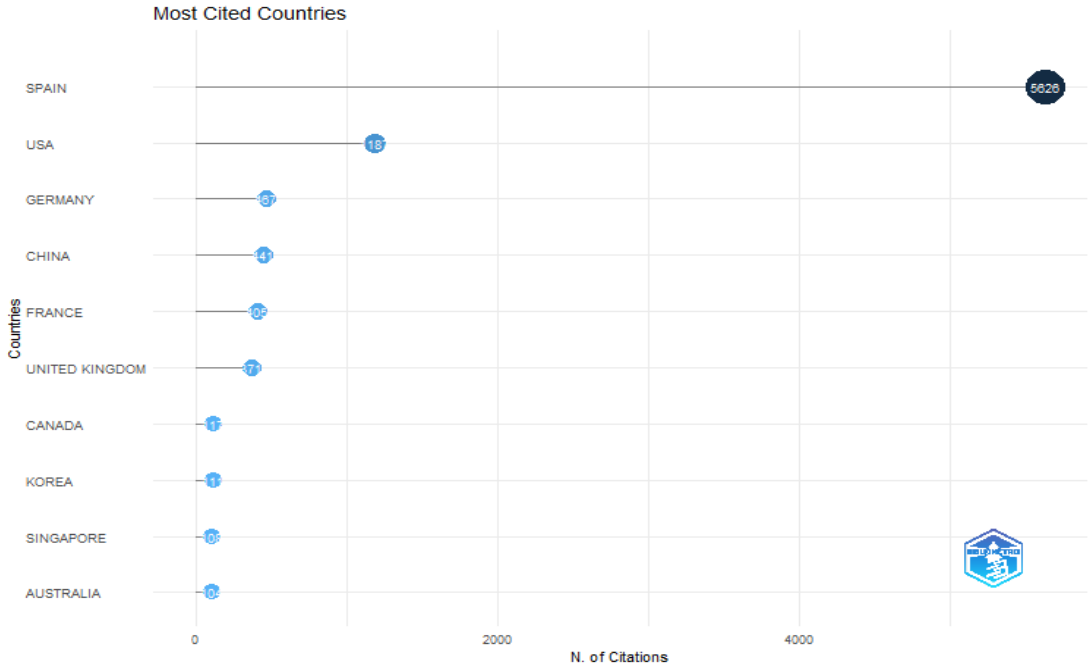


Fig. 2. Country-wise Distribution of Citations in AI in Libraries Research

Conclusion

This study analysed research on Artificial Intelligence (AI) in Library and Information Science using a bibliometric approach based on Web of Science publications from 2015 to2025 (Saeidnia et al. 2024). The aim was to identify publication trends, document characteristics, collaboration patterns, research themes, and citation impact in this (Islam and Guangwei2025).

The results show a steady and rapid increase in publications, especially after 2020, indicating growing interest in AI applications in libraries (Wang and Xia 2025). Journal articles were the main channel of publication, and the high proportion of review papers suggests that the field is developing toward greater conceptual clarity. The dominance of multi-authored works reflects strong collaboration and the interdisciplinary nature of AI research in libraries. Keyword analysis highlights a shift toward practical and data-driven applications, with increasing attention to advanced AI tools. Journal articles were the main channel of publication (Aslam et al. 2022), and the high proportion of review papers suggests that the field is developing toward greater conceptual clarity. The dominance of multi-authored works reflects strong collaboration and the interdisciplinary nature of AI research in libraries (Feng and Kirkley 2020). Keyword analysis highlights a shift toward practical and data-driven applications, with increasing attention to advanced AI tools. This study provides an updated overview of AI research in libraries, identifying major publication outlets, influential countries, and key research themes. Citation analysis shows that although research output is expanding, highly cited studies are limited in number. The study is limited by its focus on a single database and a restricted time period, which may exclude some relevant literature. The dominance of English-language publications may also reduce the visibility of regional research

Future studies should include multiple databases, extend the time span, and examine collaboration networks and real-world AI applications in different library settings. Overall, the findings are useful for researchers, practitioners, and policymakers by clarifying research trends and supporting informed decisions on future research and AI adoption in libraries.

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Cloud Computing Usage in Academic Libraries: Opportunities, Applications and Challenges

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Abstract

The growing demand for digital information resources and remote access services has encouraged academic libraries to adopt emerging technologies. One of the most significant technological advancements affecting library operations and services is cloud computing. The use of cloud computing in academic libraries is examined in this research, with particular attention to its benefits, uses, and difficulties. The study is based on a descriptive analysis of existing literature, professional practices, and technology trends in higher education libraries. The findings reveal that cloud computing enhances efficiency, scalability, accessibility, and collaboration while reducing operational costs. However, concerns including data security internet dependency, vendor lock-in, and lack of technical expertise continue to affect its implementation. The paper concludes that strategic planning, policy formulation, and professional skill development are essential for effective the implementation of cloud computing in academic libraries

Keywords: Cloud Computing, Academic Libraries; Digital Library Services; Library Automation; ICT

Introduction

Academic libraries function as vital knowledge hubs that facilitate teaching, learning, and research within higher education institutions. The rapid growth of digital information, electronic resources, and user expectations has created significant challenges for traditional library systems. Managing large volumes of data, ensuring continuous access, and maintaining costly IT infrastructure have become difficult for many academic libraries.

Cloud computing has become a viable solution to these challenges by offering flexible, scalable, and cost-effective computing resources via the internet. Rather than relying on local servers and software, libraries can utilize cloud-based platforms to manage their operations and provide services. The adoption of cloud computing has transformed how academic libraries store information, manage digital collections, and engage with users.

This paper explores the concept of cloud computing and examines its application in academic libraries by highlighting the opportunities, applications, and challenges it presents.

Concept of Cloud Computing

Cloud computing refers to the delivery of computing services—including servers, storage, databases, software, and networking—over the Internet. The National Institute of Standards and Technology (NIST) defines cloud computing as providing on-demand network access to shared computing resources. These resources can be quickly provisioned and released, requiring minimal management effort.

Characteristics of Cloud Computing

- On-demand self-service
- Broad network access
- Resource pooling
- Rapid scalability & elasticity
- Measured and pay-per-use services

These characteristics make cloud computing suitable for academic libraries, where information needs and user demand vary frequently.

Cloud Computing Service Models in Academic Libraries

Cloud computing services are generally offered through three models:

Software as a Service (SaaS)

SaaS provides software applications through web browsers without local installation. Academic libraries widely use SaaS-based library management systems, discovery tools, and collaboration platforms. Examples include cloud-based Koha, Ex Libris Alma, and OCLC WorldShare.

Platform as a Service (PaaS)

PaaS provides a development platform for building and deploying applications. Academic libraries utilize PaaS to create digital library portals, develop institutional repository interfaces, and offer customized information services.

Infrastructure as a Service (IaaS)

IaaS offers virtual computing infrastructure, including storage and servers. Libraries utilize IaaS for hosting digital collections, performing data backups, and implementing disaster recovery systems.

Table 1: Cloud Computing Service Models and Their Library Applications

Service Model	Description	Applications in Academic Libraries
Infrastructure as a Service (IaaS)	Provides virtualized computing resources such as servers and storage	Hosting digital repositories, data backup, disaster recovery
Platform as a Service (PaaS)	Offers development platforms without managing infrastructure	Development of institutional repositories and customized library applications
Software as a Service (SaaS)	Delivers software applications via the internet	Cloud-based ILMS, OPAC, discovery tools, virtual reference services

Applications of Cloud Computing in Academic Libraries

Cloud computing facilitates a range of functions and services within academic libraries:

Library Automation

Cloud-based integrated library management systems handle cataloguing, circulation, acquisitions, and serial control efficiently through centralized platforms.

Digital Libraries and Institutional Repositories

Academic libraries utilize cloud platforms to store and manage theses, dissertations, research articles, and digitized collections, thereby ensuring long-term access and preservation.

Electronic Resource Management

Cloud systems help libraries manage e-books, e-journals, and online databases, including access control and usage analytics.

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User Services

Cloud computing enhances user services such as remote access to resources, online reference services, virtual learning support, and collaborative research tools.

Table 2: Major Cloud Computing Applications in Academic Libraries

Library Function	Cloud-Based Application	Benefits
Cataloguing & Circulation	Cloud-based ILMS	Reduced maintenance, real-time access
Digital Preservation	Institutional repositories	Secure storage and long-term access
User Services	Virtual reference platforms	Improved user engagement
Collaboration	Cloud document-sharing tools	Enhanced teamwork and communication
Resource Access	Web-based OPAC	Anytime, anywhere access

Opportunities of Cloud Computing in Academic Libraries

Cost Effectiveness

Cloud computing reduces expenditure on hardware, software licenses, and system maintenance. Libraries pay only for the services they use.

Scalability and Flexibility

Cloud platforms enable libraries to adjust their resources based on academic demand, particularly during exam and research periods.

Improved Accessibility

Users can access library resources anytime and anywhere, supporting distance education and off-campus research activities.

Collaboration and Resource Sharing

Cloud computing promotes cooperation among academic libraries through shared catalogs, consortia services, and collaborative digital repositories.

Table 3: Benefits of Cloud Computing in Academic Libraries

Aspect	Traditional Systems	Cloud-Based Systems
Cost	High infrastructure and maintenance cost	Pay-as-you-use, reduced cost
Accessibility	Limited to local systems	Remote and multi-device access
Scalability	Difficult to expand	Highly scalable
Maintenance	Requires technical staff	Managed by service provider
Data Backup	Manual and local	Automatic and cloud-based

Challenges in Implementing Cloud Computing

Despite its benefits, cloud computing poses several challenges for academic libraries:

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Data Security and Privacy

Storing library data on third-party servers raises concerns about confidentiality, data breaches, and compliance with institutional policies.

Internet Dependency

Reliable and high-speed internet connectivity is essential for cloud-based services, which can be a limitation in developing regions.

Vendor Lock-in

Dependence on a single cloud service provider can limit flexibility and lead to increased long-term costs.

Technical Skills and Training

Library professionals require continuous training to effectively manage cloud technologies and digital services.

Legal and Policy Issues

Issues related to data ownership, copyright, and jurisdiction must be addressed before adopting cloud solutions.

Table 4: Challenges of Cloud Computing Adoption

Challenge	Description	Impact on Libraries
Data Security	Risk of unauthorized access	Privacy concerns
Internet Dependency	Reliance on stable connectivity	Service interruption
Skill Gap	Limited technical expertise	Slow adoption
Vendor Lock-in	Dependence on service providers	Reduced flexibility

Role of Library Professionals

Library professionals play a vital role in cloud computing adoption. They must develop technical competencies, understand licensing and security requirements, and guide users in accessing cloud-based services. Collaboration with IT departments and continuous professional development are essential for successful implementation.

Future Prospects

The future of cloud computing in academic libraries looks bright. The integration of artificial intelligence, data analytics, and mobile technologies is poised to enhance personalized services and research support. As a result, smart cloud-based academic libraries are anticipated to play a crucial role in higher education institutions.

Conclusion

Cloud computing has significantly transformed academic library operations and service delivery. It offers cost-effective, scalable, and accessible solutions that meet the growing demands of digital users. Although challenges such as security, connectivity, and technical skills remain, these can be addressed through proper planning and policy development. Academic libraries that effectively adopt cloud computing will enhance their role in supporting education and research in the digital era.

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Comparative Analysis of AI-Assisted Academic Writing Tools: SciSpace and Elicit

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Abstract

Academic writing and research are increasingly complex due to the rapid growth of scholarly publications, leading to challenges such as literature overload, difficulty identifying relevant studies, and time-intensive synthesis while maintaining academic rigor. Although AI-powered tools have emerged to support research workflows, systematic comparisons of specialized platforms remain limited. This study addresses this gap by conducting a hands-on qualitative evaluation of two AI research assistants SciSpace and Elicit focusing on functionality, usability, and applicability in academic writing and literature synthesis. SciSpace was assessed for AI-assisted reading, summarization, interactive PDF explanations, and citation support, while Elicit was evaluated for structured, question-driven literature retrieval and evidence synthesis. The findings indicate that SciSpace enhances comprehension, exploratory literature discovery, and manuscript preparation through broad keyword-based searches and writing assistance, whereas Elicit excels in structured evidence synthesis and systematic review workflows, supporting analytical rigor and methodological discipline. Both tools are complementary: SciSpace prioritizes usability and writing support, while Elicit emphasizes structured research and evidence-based analysis. Limitations include generalized outputs for SciSpace and the need for research expertise for Elicit. This study contributes a comparative framework that informs researchers, librarians, and policymakers about the practical value, limitations, and responsible integration of AI-assisted tools, highlighting their role in enhancing scholarly productivity without replacing human expertise.

Keywords: Artificial Intelligence, Academic Writing, SciSpace, Elicit, Literature discovery

Introduction

Academic writing and research have become increasingly complex due to the rapid growth of scholarly publications across disciplines. Researchers today face persistent challenges such as literature overload, difficulty in identifying relevant studies, time-intensive review processes, and the need to synthesize diverse sources while maintaining academic rigor (Sultan et al., 2025). These challenges are particularly evident in literature review and manuscript preparation stages, where efficiency and accuracy must be balanced with critical interpretation and ethical scholarship (Oshiro et al., 2019).Artificial Intelligence (AI) has emerged as a significant enabler within academic writing workflows, offering methodological support across multiple stages of the research process. Prior studies have identified AI's role in facilitating research design, organizing content structure, supporting literature review processes, assisting in data analysis, and improving editing and publishing practices. AI-driven systems further contribute to information synthesis, visualization of complex datasets, and multilingual scholarly communication, thereby reshaping how researchers interact with academic knowledge (Trinita Roy et al., 2024; Siddhant Jain et al., 2024). Despite these advancements, the effective adoption of AI remains uneven, largely due to limited awareness, visibility, and critical understanding of available tools among academic communities (Asagar & Naaz, 2025).

In recent years, AI-powered research assistants have gained prominence as specialized tools designed to support scholarly workflows. Platforms such as SciSpace and Elicit represent a new generation of AI research support systems that integrate natural language processing and machine learning to assist researchers throughout the academic writing lifecycle (Janice Y. Kung et al., 2023). These tools are increasingly used in academic and library contexts, reflecting a broader shift toward AI-mediated research practices.

However, existing literature reveals a notable research gap. While several studies examine individual AI tools or compare AI-assisted and conventional research methods, there is limited systematic comparative research that evaluates AI research assistantsparticularly SciSpace and Elicitacross dimensions such as functionality, usability, and practical applicability within academic workflows. Scholars have acknowledged this gap, emphasizing the lack of empirical frameworks for assessing the effectiveness of emerging machine learningsupported research tools (Wynn Tranfield et al., 2024). Comparative studies suggest that although traditional methods retain strengths in accuracy and methodological control, AI tools demonstrate promise in enhancing originality, speed, and exploratory insight, indicating their potential as complementary rather than replacement systems (Przemysław Tomczyk et al., 2024; Nathan Bernard et al., 2025).

In response to this gap, the present paper undertakes a comparative analysis of SciSpace and Elicit to examine their functional capabilities, usability, and relevance to academic writing and research workflows. By synthesizing evidence from existing literature and case-based evaluations, this study aims to clarify how these AI research assistants support literature discovery, evidence synthesis, and manuscript preparation. The findings contribute to Library and Information Science and academic writing scholarship by offering a structured understanding of AI research tools, informing researchers, librarians, and policymakers about their practical value, limitations, and responsible integration into scholarly practices.

Objectives

- To analyze the role of AI tools in supporting academic writing, with emphasis on literature discovery and synthesis.
- To qualitatively compare SciSpace and Elicit in terms of functionality, usability, and research orientation.
- To identify the strengths, limitations, and scholarly implications of using AI-assisted tools in academic writing.
- To explore the potential impact of AI-assisted tools on traditional academic writing practices

Literature Review

Artificial Intelligence (AI) has become an integral component of contemporary academic writing, providing comprehensive support across multiple stages of the research and writing process. Prior studies indicate that AI technologies enhance scholarly productivity by assisting with idea generation, content organization, literature engagement, data handling, editing, and academic communication (Mohamed Khalifa et al., n.d.). Empirical research further shows that AI-powered writing tools improve fluency, coherence, and analytical rigor, particularly for non-native English speakers who often face linguistic and cognitive barriers in academic communication (Sharina Saad et al., 2025). At the same time, the literature highlights ethical and intellectual concerns associated with AI adoption, including issues of authorship, ownership, originality, and the potential erosion of critical thinking. Timothy J. Ros et al. (2025) emphasize that while AI significantly augments academic productivity, it should complement rather than replace human intellectual engagement, underscoring the importance of transparent and responsible integration to preserve scholarly integrity.

The impact of AI has been especially pronounced in the domain of literature reviews, including Systematic Literature Reviews (SLRs). Traditionally, literature reviews required extensive manual effort involving the identification, screening, and synthesis of relevant scholarly works, often conducted in physical libraries or through limited digital databases (Chinn, 2021). Although the core objective of situating new research within existing scholarly discourse remains unchanged, the methodological landscape has evolved substantially with the introduction of AI technologies. Recent studies demonstrate that AI techniques are increasingly employed to semi-automate critical stages of SLRs, such as literature searching, article screening, study selection, and data extraction (O'Connor et al., 2023). Advances in transformer-based models have further

enhanced tasks including PDF-to-text conversion, metadata extraction, and keyword identification, thereby improving the accuracy, consistency, and efficiency of scholarly synthesis (Hidayatullah et al., 2025). Additionally, AI-driven tools have shown the capacity to identify thematic patterns and improve the structural coherence of literature review sections, which is particularly valuable in technical and engineering disciplines where clarity and logical organization are essential (Xu, 2025).

Parallel to these methodological developments, the rapid growth of scholarly publishing has accelerated the emergence of AI-powered research assistants designed to support end-to-end academic workflows. Tools such as ChatGPT, Grammarly, QuillBot, Perplexity, Consensus, SciSpace, and Elicit illustrate a shift from traditional keyword-based retrieval systems toward intelligent platforms that leverage natural language processing, semantic search, and transformer-based architectures (Xu, 2025; Hidayatullah et al., 2025). By capturing contextual meaning and semantic relationships within texts, these tools enable more precise literature discovery, improved comprehension, and more effective synthesis of academic content. Empirical evidence suggests that semantic retrieval techniques enhance the relevance of retrieved literature and reduce redundancy during the writing process, allowing researchers to manage large volumes of information more efficiently (Jiang et al., 2023). Conceptual frameworks linking AI technologies with academic writing further emphasize the role of writing tools as mediating mechanisms that translate computational intelligence into meaningful scholarly outputs through improved language quality, structural coherence, and evidence integration (Dhillon et al., 2024; Nurmalia et al., 2023).

Within this evolving research ecosystem, specialized AI platforms designed specifically for academic writing and literature analysis have attracted growing scholarly attention. SciSpace is frequently characterized as an AI-assisted scholarly reading and writing platform that enhances comprehension through contextual explanations, interactive summaries, and integrated citation support. Studies on AI-supported reading environments suggest that such tools reduce cognitive load when engaging with complex academic texts and facilitate more efficient drafting aligned with academic conventions (Zhang et al., 2022; Sanmati Jinendran Jain et al., n.d.). In contrast, Elicit is primarily discussed as an AI-driven literature discovery and evidence synthesis tool that supports academic writing indirectly. By automating the extraction of research objectives, methodologies, and key findings from scholarly articles, Elicit enhances transparency and consistency in evidence synthesis, which are essential for producing high-quality literature reviews and systematic reviews (Marshall & Wallace, 2019; Sharon Whitfield et al., 2023). Together, these platforms reflect an increasing specialization of AI research assistants, with each addressing distinct stages of the research and writing lifecycle.

Despite the expanding body of literature on AI-assisted academic writing and research support tools, a clear research gap persists. Existing studies largely examine AI tools either individually or within broader technological trends, without offering direct comparative analyses of specialized platforms. While prior research acknowledges SciSpace effectiveness in enhancing comprehension and identifying literature gaps (Sanmati Jinendran Jain et al., n.d.) and highlights Elicit's strengths in structured evidence synthesis (Sharon Whitfield et al., 2023), systematic comparative studies evaluating their relative effectiveness in supporting academic writing tasks remain scarce. Moreover, much of the existing literature emphasizes technical capabilities and adoption patterns rather than examining how these tools differentially influence writing quality, workflow efficiency, and literature synthesis outcomes.

Overall, the reviewed literature demonstrates that AI has significantly reshaped academic writing and literature review practices by improving efficiency, accessibility, and analytical depth. AI-augmented frameworks offer substantial advantages over traditional manual approaches, including enhanced transparency, reduced bias, and improved consistency in scholarly synthesis (O'Connor et al., 2023; Applied Intelligence, 2024). However, ethical considerations related to authorship, intellectual ownership, and meaningful human

engagement remain central concerns (Timothy J. Ros et al., 2025). Addressing the identified research gap through a focused comparative analysis of SciSpace and Elicit is therefore essential for understanding how different AI-assisted approaches influence academic writing support and for guiding the responsible adoption of AI technologies in scholarly research.

Methodology

This study employed a qualitative approach to conduct a comparative analysis of two emerging AI-powered academic writing support tools: SciSpace and Elicit. The qualitative design was selected to provide an in-depth understanding of the functional capabilities, usability, and practical relevance of these platforms in supporting literature discovery and synthesis within academic research workflows. Unlike quantitative metrics, a qualitative approach allows for nuanced insights into how each tool supports researcher decision-making, comprehension, and manuscript preparation.

Data were collected through hands-on interaction with both platforms, focusing specifically on performing sample literature searches. The study simulated typical research tasks, including identifying relevant publications, evaluating the clarity and accuracy of AI-generated summaries, and observing the tools' assistance in organizing and synthesizing research information. SciSpace was assessed for its AI-assisted reading, summarization, interactive PDF explanations, and citation management, reflecting its suitability for exploratory research, manuscript preparation, and interdisciplinary reading. Elicit was evaluated for its structured, question-based literature retrieval and evidence synthesis, emphasizing its potential for systematic reviews, meta-analyses, and evidence-based research workflows.The specific dimensions guiding this qualitative evaluation are summarized in Table 1.

Evaluation Criterion	Description	Purpose in the Study
Literature Discovery	Ability to retrieve relevant scholarly publications	Assess breadth and relevance of AI-assisted search
Search Strategy	Keyword-based vs. question-driven retrieval	Examine methodological orientation of each tool
Reading and Comprehension Support	Summaries, explanations, and contextual assistance	Evaluate reduction of cognitive load during reading
Evidence Extraction	Extraction of objectives, methods, and results	Assess support for structured literature synthesis
Literature Organization	Ability to compare and structure multiple studies	Examine usefulness for reviews and synthesis
Writing and Drafting Support	Assistance in drafting, explanation, and citation	Assess contribution to manuscript preparation
Usability and Interface	Ease of use and learning curve	Determine accessibility for researchers
Transparency and Traceability	Visibility of original sources and citations	Ensure ethical and verifiable AI use
Research Workflow Fit	Suitability across research stages	Identify complementary or substitutive roles

Table 1. Evaluation Criteria Used in the Methodology

During the interaction, observations were recorded regarding ease of finding relevant literature, comprehensiveness of retrieved articles, quality of summaries, and overall user experience. The data were then analyzed qualitatively by comparing each tool's functionality, usability, and research support capabilities. Strengths and limitations were systematically documented, highlighting areas where the tools could complement one another in different research contexts. Ethical considerations were also noted, emphasizing the importance of human oversight to ensure the accuracy of outputs, maintain scholarly rigor, and prevent over-reliance on AI-generated content.

This hands-on qualitative methodology enabled a practical and realistic assessment of SciSpace and Elicit, providing insights into their potential applications, usability, and limitations within academic research. The approach aligns with the study's objectives by demonstrating how these AI tools support literature discovery, synthesis, and academic writing while identifying opportunities and constraints in real-world research scenarios.

Results and Discussion

The present study examined SciSpace and Elicit as AI-assisted academic writing support tools, focusing on functional capabilities, usability, and research workflow applicability. SciSpace emphasizes AI-assisted reading support, interactive PDF explanations, summarization quality, citation assistance, and suitability for exploratory literature engagement and manuscript drafting (Barrot, 2024). Elicit was evaluated for question-driven literature retrieval, structured evidence extraction, synthesis of research findings, and applicability to systematic and evidence-based research tasks (Bernard et al., 2025b).

Across both platforms, the evaluation considered relevance and coverage of retrieved literature, clarity and reliability of AI-generated summaries, support for literature synthesis, and overall usability. The comparative assessment highlights that SciSpace and Elicit support different stages of research and writing, functioning as complementary tools rather than direct substitutes in scholarly workflows.

Comparative Functional Characteristics

A comparison of the platforms' core features is presented in Table 2, highlighting their differing orientations and intended research applications. SciSpace primarily facilitates broad, exploratory searches and manuscript drafting, while Elicit emphasizes structured retrieval and analytical synthesis.

Feature	SciSpace	Elicit
Primary Function	AI-assisted scholarly reading and summarization	AI-assisted structured literature discovery
Target Users	Students, early-career researchers, academics	Researchers conducting systematic and evidence-based reviews
Literature Discovery	Broad, exploratory search across journals	Focused retrieval based on structured queries
Research Use	Writing support, collaboration, reference management	Systematic reviews, meta-analyses, evidence synthesis
Ease of Finding Relevant Papers	High for broad exploration	Medium; depends on well-defined queries

Core Purpose	Supports comprehension and manuscript preparation	Supports structured discovery and analytical synthesis
Search Approach	Keyword-based and document-oriented	Question-driven and structured
Ease of Use	High; intuitive interface	Moderate; requires methodological clarity
AI Techniques	NLP-based summarization, writing enhancement, citation support	NLP-based structured retrieval and decision models
Key Strength	Manuscript preparation and collaborative writing support	Structured evidence synthesis and decision support
Limitations	Generic outputs for niche or highly specialized fields	Requires expert input for nuanced interpretation

Table 2. Comparative Overview of Core Features of SciSpace and Elicit

These findings indicate that SciSpace is particularly effective in supporting academic reading and manuscript preparation, while Elicit prioritizes structured retrieval and analytical synthesis.

Analytical Evaluation of Platform Performance

To evaluate the platforms more comprehensively, specific performance dimensions were considered, including literature discovery, search logic, reading and comprehension support, evidence extraction, literature synthesis, writing assistance, usability, and suitability for systematic reviews.

Evaluation Dimension	SciSpace (Analytical Outcome)	Elicit (Analytical Outcome)	Interpretation
Literature Discovery Orientation	Broad and exploratory	Focused and structured	SciSpace supports early-stage topic exploration, whereas Elicit prioritizes precision aligned with defined research questions
Search Logic and Precision	Keyword-based; high recall, moderate precision	Question-driven; high precision	Elicit demonstrates stronger methodological control, while SciSpace favours discovery breadth
Reading and Comprehension Support	Strong (summaries, contextual explanations, PDF interaction)	Moderate (limited reading-level interaction)	SciSpace reduces cognitive load during engagement with complex texts
Evidence Extraction Capability	Narrative-level summarization	Structured extraction of objectives, methods, and findings	Elicit offers greater analytical rigor and transparency in evidence handling
Literature Synthesis Support	Moderate; requires manual structuring	High; comparative and tabular synthesis	Elicit aligns more closely with systematic and evidence-based review practices

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Writing and Drafting Assistance	Strong support for drafting and explanation	Minimal drafting support	SciSpace directly contributes to manuscript preparation efficiency
Usability and Learning Curve	High; intuitive and accessible	Moderate; requires research expertise	SciSpace is more suitable for novice and interdisciplinary researchers
Suitability for Systematic Reviews	Low–Moderate	High	Elicit is better positioned for formal review methodologies
Overall Research Workflow Contribution	Exploratory and writing-oriented	Analytical and synthesis-oriented	The tools function as complementary rather than substitutive systems

Table 3. Analytical Comparison of SciSpace and Elicit Based on Evaluation Criteria

Table 3 demonstrates that SciSpace and Elicit differ fundamentally in their analytical orientation and research support roles. SciSpace emphasizes exploratory literature discovery, comprehension, and manuscript preparation, making it particularly effective during early-stage research and writing phases. In contrast, Elicit prioritizes methodological rigor through structured, question-driven retrieval and systematic evidence extraction, aligning closely with systematic review and evidence-based research workflows. These findings confirm that while SciSpace enhances usability and writing efficiency, Elicit strengthens analytical depth and synthesis quality. Collectively, the results indicate that integrating both tools within a research workflow can enhance scholarly productivity while preserving methodological integrity.

The platform's keyword-based search enables broad literature exploration across disciplines, making it well suited for exploratory research and early stages of manuscript development. However, its generalized writing assistance may be less effective for highly specialized or methodologically rigorous research tasks.In contrast, Elicit demonstrates strong performance in structured literature discovery and evidence synthesis. Its question-driven search approach enables precise retrieval of studies aligned with specific research objectives, supporting systematic reviews and evidence-based research. This methodological focus enhances rigor but requires users to possess foundational research skills, which may limit usability for novice researchers.

Overall, the results suggest that SciSpace emphasizes usability and writing support, whereas Elicit prioritizes analytical rigor and structured evidence gathering. These complementary strengths indicate that tool selection should be guided by research objectives and methodological requirements.

Strength of SciSpace

SciSpace demonstrates notable strengths as an AI-assisted academic writing support tool, particularly in enhancing scholarly reading, exploratory literature discovery, and manuscript preparation. Its AI-assisted summarization and contextual explanation features improve comprehension of complex academic texts and reduce cognitive load, making it especially effective during the early stages of research. The platform's broad, keyword-based literature search supports flexible and interdisciplinary exploration, enabling researchers to identify foundational studies and emerging themes efficiently.

In addition, SciSpace integrates writing enhancement and citation assistance tools that support coherence, academic tone, and structural organization in manuscript drafting, benefiting early-career researchers and non-native English speakers. Its user-friendly interface and iterative research support further facilitate seamless integration into academic workflows, positioning SciSpace as a practical and accessible tool for literature

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engagement and academic writing, while functioning best as a complementary platform rather than a substitute for structured evidence-synthesis tools.

Strength of Elicit

Elicit demonstrates several key strengths as an AI-assisted research support tool, particularly in structured literature discovery and evidence-based academic writing. Its question-driven search mechanism enables precise retrieval of studies aligned with specific research objectives, making it suitable for systematic reviews, scoping reviews, and meta-analytical research.

A major strength of Elicit lies in its automated extraction of critical study components, including research aims, methodologies, and key findings, which enhances transparency and consistency in literature synthesis while reducing manual screening effort. Unlike tools prioritizing surface-level summarization, Elicit supports analytical synthesis through structured comparisons, facilitating identification of patterns, research gaps, and thematic relationships. This strengthens analytical depth and methodological rigor, encouraging critical engagement with empirical findings (Bernard et al., 2025b; Kung, 2023). Although effective use requires clearly formulated research questions, this requirement promotes methodological discipline, making Elicit particularly valuable for experienced researchers.

Limitations and Complementarity

While SciSpace and Elicit provide valuable support for academic writing and research, each tool has limitations that prevent it from serving as a standalone solution. SciSpace enhances comprehension, exploratory literature discovery, and manuscript drafting; however, AI-generated summaries may be generalized and lack disciplinary depth, while broad keyword-based searches can produce information overload. Elicit excels in structured retrieval and evidence synthesis but requires well-defined research questions and methodological knowledge, offering limited narrative writing support (Kung, 2023).

Integrating these AI tools with traditional research practices, including critical reading, manual database searching, and methodological evaluation, ensures rigor, depth, and responsible use. Their complementary strengths suggest a combined workflow: SciSpace for exploratory research and writing support, and Elicit for analytical, systematic evidence synthesis.

Conclusion

This study aimed to comparatively analyse SciSpace and Elicit to assess their functionality, usability, and relevance in academic writing and research workflows. The findings reveal distinct strengths: SciSpace enhances comprehension, exploratory literature discovery, and manuscript preparation through AI-assisted summarization, contextual explanations, and citation support, making it particularly useful for broad literature engagement and early-stage research. Elicit, on the other hand, excels in structured literature retrieval, evidence synthesis, and systematic review workflows, supporting methodological rigor and analytical depth. These differences suggest that the tools complement rather than replace each other, offering benefits for both exploratory and evidence-based research tasks. Nevertheless, SciSpace outputs may lack disciplinary specificity, while Elicit requires well-formulated research questions and user expertise.

Importantly, the findings also provide practical guidance for librarians and researchers: by integrating these AI-assisted tools into academic workflows, librarians can better support literature search and synthesis services, and researchers can enhance efficiency, analytical rigor, and quality in manuscript preparation. Future research should explore hybrid AI approaches, assess cross-disciplinary effectiveness, and examine strategies for responsible integration into scholarly practice. Overall, AI tools like SciSpace and Elicit enhance academic writing while supporting, not supplanting, human expertise.

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Innovative IOT-Based Solution for Assessing and Monitoring Underground Pipeline System Using Fiber Optic Sensor Network

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ABSTRACT

Transportation of petroleum products such as oil and natural gas over long distances is predominantly carried out through pipeline systems due to their economic efficiency and environmental advantages. However, underground pipelines are vulnerable to failures such as leakage and breakage, leading to material loss, economic damage, environmental pollution, and risks to human life. Most existing monitoring systems focus on detecting leakage only after failure has occurred. This paper proposes an IoT-based early warning system for assessing and monitoring underground pipeline safety using a fiber optic sensor network and LoRa wireless communication technology. The proposed system predicts the possibility of pipeline breakage or leakage by continuously monitoring critical safety parameters such as strain, external force, ground vibration, and soil displacement. Fiber optic sensors are employed due to their high sensitivity, long sensing range, and immunity to electromagnetic interference. The sensed parameters are processed by an Arduino-based embedded unit and compared with the yield strength of the pipeline material to evaluate structural integrity. Processed data are transmitted over long distances using LoRa-enabled IoT communication to a cloud-based monitoring platform, enabling real-time visualization, data storage, and remote alert generation. The proposed system is validated through simulation, demonstrating its effectiveness in providing early warnings and supporting predictive maintenance of underground pipeline infrastructure.

Keywords: IoT-based pipeline monitoring, fiber optic sensor network, LoRa communication, early warning system, yield strength analysis, Arduino, LPWAN.

INTRODUCTION

Transportation infrastructure is a fundamental requirement for economic development and industrial growth. Since essential resources such as petroleum products, natural gas, and raw materials are geographically concentrated, efficient transportation systems are necessary for their large-scale distribution. Among various transportation modes—air, water, and land—pipeline transportation is widely preferred for long-distance transfer of oil and gas due to its reliability, safety, and cost-effectiveness.

Despite these advantages, underground pipelines are exposed to several environmental and mechanical challenges, including corrosion, soil displacement, ground vibration, seismic activity, and external mechanical stress. These factors significantly increase the risk of pipeline degradation, leakage, and catastrophic failure. Ensuring the structural integrity of underground pipelines has therefore become a critical engineering concern.

Recent developments in sensor networks and wireless communication technologies have enabled real-time pipeline monitoring. However, most existing systems focus primarily on leakage detection after damage has already occurred. To overcome this limitation, this paper proposes an **IoT-based early warning system** capable of predicting pipeline failure conditions before leakage or breakage occurs.

REVIEW OF PIPELINE MONITORING AND LEAKAGE DETECTION SYSTEMS

Leakage remains one of the primary causes of pipeline accidents. Consequently, various pipeline monitoring technologies have been developed by both government and private organizations. Wireless sensor networks (WSNs) have gained popularity due to their flexibility, scalability, and low deployment cost.

Zhi Sun et al. [1] proposed MISE-PIPE, a magnetic induction–based wireless sensor network capable of collecting acoustic, vibration, pressure, and soil property data for underground pipeline monitoring. Jawhar et al. [2] introduced a WSN framework integrating pressure, temperature, chemical, and acoustic sensors with GPS and satellite communication.

Further research explored smart sensor networks for water pipeline monitoring [3–5], fuzzy logic–based LPG leakage detection [6], biosensor-based natural gas leak detection [7], and strain-based monitoring using fiber Bragg grating (FBG) sensors [8]. Distributed fiber optic sensing based on Brillouin and Raman scattering demonstrated effective long-range pipeline integrity monitoring [9–10].

Although these approaches provide accurate leakage detection, they lack **predictive monitoring and early warning capability**, which is essential for preventing pipeline failure. The proposed system addresses this gap by integrating fiber optic sensing with IoT and LoRa communication.

ASSESSING AND MONITORING UNDERGROUND PIPELINE SAFETY

System Overview

The proposed IoT-based early warning system consists of the following components:

- Fiber optic sensor subsystem
- Edge processing and data acquisition unit
- LoRa-based wireless communication module
- IoT cloud and monitoring platform
- Warning and alert mechanism

The system continuously evaluates pipeline safety by monitoring strain, external force, ground vibration, and soil movement.

IoT-Based System Architecture

The system follows a layered IoT architecture:

- **Sensing Layer:** Fiber Bragg Grating (FBG)–based fiber optic sensors are deployed along the pipeline to measure strain, stress, vibration, and soil displacement with high accuracy.
- **Edge Processing Layer:** Optical signals are converted into electrical signals using an optical interrogator. An **Arduino** microcontroller performs data acquisition, preprocessing, yield strength comparison, and local decision-making.
- **Communication Layer:** A LoRa (Long Range) LPWAN module enables low-power, long-distance wireless transmission of processed data to a LoRa gateway, making the system suitable for remote underground environments.
- **Application and Cloud Layer:** The LoRa gateway forwards data to an IoT cloud platform for real-time monitoring, data visualization, storage, predictive analysis, and alert generation.

Fiber Optic Sensor Subsystem

Fiber optic sensors operate by detecting changes in optical properties such as wavelength and intensity caused by physical deformation. FBG sensors are particularly suitable due to:

- High sensitivity and accuracy
- Immunity to electromagnetic interference
- Long-distance sensing capability

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- Resistance to harsh underground environments
- High reliability and low signal loss

Sensors are attached to or embedded near the pipeline to capture mechanical stress and environmental effects.

Yield Strength Analysis of Pipeline Material

Underground pipelines are constructed using materials such as steel, cast iron, cement, and plastic, each with distinct mechanical properties. Yield strength defines the stress at which permanent deformation begins.

The allowable operating pressure is calculated using **Barlow's formula**:

$$P = 2St/D \quad (1)$$

where
(P) = test pressure (psig),

(S) = allowable stress or SMYS (psi),

(t) = pipe wall thickness (inches),

(D) = outside diameter (inches).

Sensor-derived strain values are compared against these limits to assess pipeline safety.

Data Processing Using Arduino Platform

The Arduino microcontroller performs:

- Sensor data acquisition
- Optical-to-digital signal conversion
- Threshold comparison and decision-making
- Local data storage for trend analysis
- Control of LoRa and alert modules

Arduino is selected for its low cost, open-source ecosystem, and ease of integration with IoT technologies.

IoT-Based Wireless Communication Using LoRa

LoRa technology enables long-range, low-power communication suitable for underground pipeline monitoring. Key advantages include high penetration capability, low energy consumption, secure data transmission, and scalability. Sensor data are transmitted from Arduino to the LoRa gateway and then forwarded to the IoT cloud platform for monitoring and analysis.

Efficient data acquisition and reliable wireless communication are essential for real-time monitoring of underground pipeline systems. In the proposed system, sensor data obtained from the fiber optic sensor network are processed by the Arduino microcontroller and transmitted using an IoT-based wireless communication framework.

The integration of Internet of Things (IoT) technology enables seamless connectivity between distributed sensor nodes and the remote monitoring station. IoT allows real-time data collection, remote access, centralized monitoring, and intelligent decision-making. Through IoT platforms, pipeline condition data can be stored, analyzed, and visualized over the internet, enabling continuous surveillance and predictive maintenance of pipeline infrastructure.

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For long-distance and low-power communication, the proposed system employs LoRa (Long Range) wireless technology. LoRa is a low-power wide-area network (LPWAN) communication protocol specifically designed for IoT applications that require long-range transmission with minimal energy consumption. LoRa technology offers several advantages for underground pipeline monitoring, including:

- Long communication range (up to several kilometers)
- Low power consumption suitable for remote sensor nodes
- High penetration capability through soil and underground environments
- Secure and reliable data transmission
- Cost-effective deployment for large-scale monitoring

In the proposed system, the Arduino microcontroller interfaces with a LoRa module to transmit processed sensor data to the IoT gateway. The gateway forwards the data to a cloud-based monitoring platform, where it can be accessed by authorized personnel in real time. When abnormal conditions are detected, alert notifications are generated and delivered instantly to the monitoring station, enabling rapid preventive action.

The combination of fiber optic sensing, LoRa communication, and IoT architecture enhances the scalability, reliability, and efficiency of the underground pipeline monitoring and early warning system.

Warning and Alert Mechanism

When sensor values exceed predefined thresholds, alerts are generated through alarms, visual indicators, and cloud-based notifications. An LCD or web dashboard displays real-time pipeline conditions, while historical data support predictive maintenance.

SIMULATION RESULTS

The proposed system was simulated using **Proteus Design Suite**. Fiber optic sensor behavior was emulated using variable input signals representing different strain and force conditions. The Arduino controller successfully processed sensor data and triggered alerts when threshold limits were exceeded, validating the feasibility of the proposed IoT-based approach.

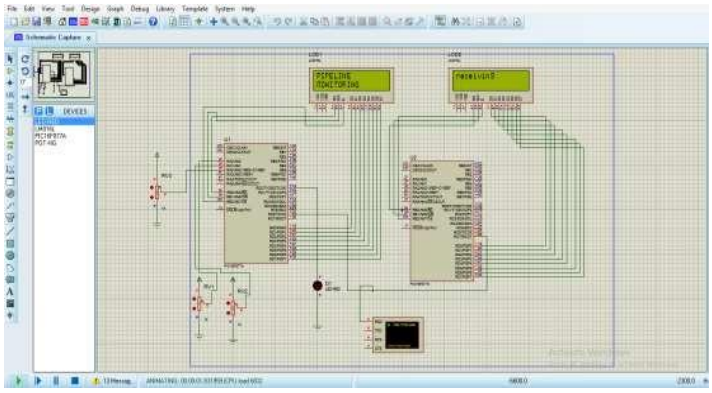


Fig.2. Schematic capture of a single pipeline monitoring unit

FINDINGS

- The system accurately predicts pipeline failure risk using fiber optic sensor data.
- LoRa communication enables reliable long-distance data transmission with low power consumption.
- IoT integration supports real-time monitoring and predictive maintenance.

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- Historical data storage improves early warning accuracy.

CONCLUSION

This paper presented an IoT-based fiber optic sensor network for early warning and monitoring of underground pipeline systems. By integrating fiber optic sensing, Arduino-based edge processing, and LoRa-enabled IoT communication, the system effectively predicts pipeline failure conditions before leakage or breakage occurs. The proposed solution is scalable, energy-efficient, and adaptable to gas, oil, water, and sewage pipelines, making it a robust solution for modern pipeline infrastructure monitoring.

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Research Trends of AI-Driven Healthcare Analytics: A Bibliometric Analysis of Indian Affiliations

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Abstract

Artificial Intelligence (AI)-enabled healthcare analytics is remodeling modern medicine worldwide by using machine learning, large-scale data, and forecasting techniques. These advancements areadvx diagnostic accuracy, supporting personalized treatment strategies, and optimizing resource allocation, particularly in response to the growing burden of chronic illnesses such as diabetes and cardiovascular diseases. In India, which serves a population of over 1.4 billion, this domain assumes critical importance, propelled by the Ayushman Bharat Digital Mission and a market expanding from USD 333 million in 2024 to over USD 4 billion by 2033 at a 30% CAGR. Institutions such as IITs, AIIMS, Saveetha Institute (leading with 448 publications), and SRM contribute robustly, yet prior bibliometric studies (e.g., Vaishya et al., 2025; Senthil et al., 2024) note over 2,000 outputs from 2004–2023 focused on convolutional neural networks and diabetic retinopathy, revealing gaps in mapping institutional productivity, collaborations, and funding amid post-2020 surges to 4,110 papers in 2025. This study conducts a comprehensive bibliometric analysis of 12,818 Scopus-indexed publications from Indian affiliations (2004–2025), examining year-wise growth, authorship patterns, prolific sources (e.g., Lecture Notes in Networks and Systems), institutions, document types, funding (led by DST), international ties (US at 8.03%), and citations (Dwivedi et al., 2021: 3,145). By identifying hotspots like rural diagnostics and outbreak prediction, it addresses equitable AI deployment gaps, informs policy, and guides stakeholders toward sustainable, India-centric innovations.

Keywords: AI-Driven Healthcare Analytics, Bibliometric Analysis, Research Trends

Introduction

Artificial Intelligence (AI)-driven healthcare analytics has revolutionized modern medicine by integrating machine learning, big data analytics, and predictive modeling to improve diagnostics, personalize treatments, and modernize resource allocation in resource-constrained settings. In India, this field gains critical importance amid a population exceeding 1.4 billion, rising chronic disease burdens like diabetes and cardiovascular ailments, and initiatives such as the Ayushman Bharat Digital Mission, which push AI adoption in telemedicine and predictive epidemiology. The Indian AI healthcare market, valued at USD 333 million in 2024, is forecasted to increase rapidly and significantly to over USD 4 billion by 2033 at a 30% CAGR, underscoring rapid institutional growth from premier bodies like IITs, AIIMS, and private innovators. Bibliometric analyses of prior studies reveal over 2,000 publications from Indian affiliations between 2004-2023 on AI in medical diagnosis, featuring keyword clusters around machine learning, convolutional neural networks, and diabetic retinopathy detection, with increasing international collaborations boosting citation impacts. This paper employs a comprehensive bibliometric approach using Scopus data from 2004-2025 to map publication patterns of development among Indian researchers. By quantifying prolific institutions, collaboration patterns, and emerging hotspots like AI for rural diagnostics and outbreak prediction, the study addresses gaps in equitable AI deployment, informs policy for sustainable innovation, and forecasts trends to guide stakeholders toward impactful, India-centric advancements in healthcare analytics.

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Literature Review

The expanding field of artificial intelligence in healthcare has witnessed an exponential increase in research, particularly from 2019 to 2023, signifying its rapid development and growing academic interest (Vaishya et al., 2025). This increase rapidly in publications reflects AI's transformative potential in improving patient care, enhancing operational efficiencies, and fostering innovation within the broader healthcare ecosystem (Faiyazuddin, M. 2025). AI-driven solutions, encompassing machine learning, natural language processing, and virtual health assistants, enable healthcare professionals to analyze extensive medical data for early disease diagnosis, risk assessment, and personalized treatment plans, thereby optimizing healthcare services and reducing costs (Khanna, N. N et al.,2022). Such advancements underscore the critical need for comprehensive bibliometric analyses to map the intellectual landscape, identify key research trends, and highlight the contributions of various geographical regions and institutions to this rapidly evolving domain (Senthil et al., 2024). Given this context, a detailed examination of AI publications within the healthcare sector over recent decades reveals the dynamic nature of this interdisciplinary field, highlighting its evolution and current trajectory (Xie et al., 2025). Explicitly, the integration of AI technologies, such as deep learning and machine learning, has profoundly impacted healthcare research, leading to a substantial increase in topic-wise and title-wise articles globally, with India emerging as a significant contributor (Vaishya, R et al., 2025).

Objectives

The primary objective of the present study is to analyze research trends in AI-driven healthcare analytics in India during the period 2004–2025, based on the publication output indexed in the Scopus database. To support this aim, the study proposes the following specific objectives:

- To analyze the year-wise growth and research publication trends of AI-driven healthcare analytics research produced by Indian affiliations.
- To examine patterns of author-wise research productivity in AI-driven healthcare analytics research in India.
- To identify the most preferred and influential sources of publication (journals and conference proceedings) in this research domain.
- To assess the institutional research productivity of leading Indian organizations contributing to AI-driven healthcare analytics.
- To examine the document type-wise distribution of publications in AI-driven healthcare analytics research.
- To analyze the contribution of funding agencies supporting AI-driven healthcare analytics research in India.
- To investigate international collaboration patterns through country-wise co-authorship analysis involving Indian researchers.
- To evaluate the open-access publication trends in AI-driven healthcare analytics research from India.

Material and Methods

Data for the present study were retrieved from the Scopus database, one of the most comprehensive and a comprehensive, multidisciplinary citation database spanning science, technology, medicine, and the social sciences. This study aims to examine the research trends in AI-driven healthcare analytics by analyzing the quantitative growth and development of scholarly publications affiliated with India. The analysis covers a 22-year period from 2004 to 2025, capturing the evolution and expansion of research output in this emerging interdisciplinary field. A total of 12,818 bibliographic records has been retrieved from Scopus for the specified period. The collected data were exported analyzed using Microsoft Excel 2010 to examine publication output

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and related bibliometric indicators. The data retrieval was performed with a structured search query in Scopus, combining key terms that related to healthcare, data analytics, and artificial intelligence, and limiting the derived results to Indian affiliations and the specified publication years. The exact structured search query used for data extraction is presented below to ensure transparency and reproducibility of the study. (ALL (health care) AND ALL (data analytics) AND ALL (Artificial intelligence)) AND (LIMIT-TO (AFFILCOUNTRY , "India")) AND (LIMIT-TO (PUBYEAR , 2004) OR LIMIT-TO (PUBYEAR , 2010) OR LIMIT-TO (PUBYEAR , 2011) OR LIMIT-TO (PUBYEAR , 2012) OR LIMIT-TO (PUBYEAR , 2013) OR LIMIT-TO (PUBYEAR , 2014) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2022) OR LIMIT-TO (PUBYEAR , 2023) OR LIMIT-TO (PUBYEAR , 2024) OR LIMIT-TO (PUBYEAR , 2025))

Results and Discussion

Growth Pattern of AI-Driven Healthcare Analytics Research

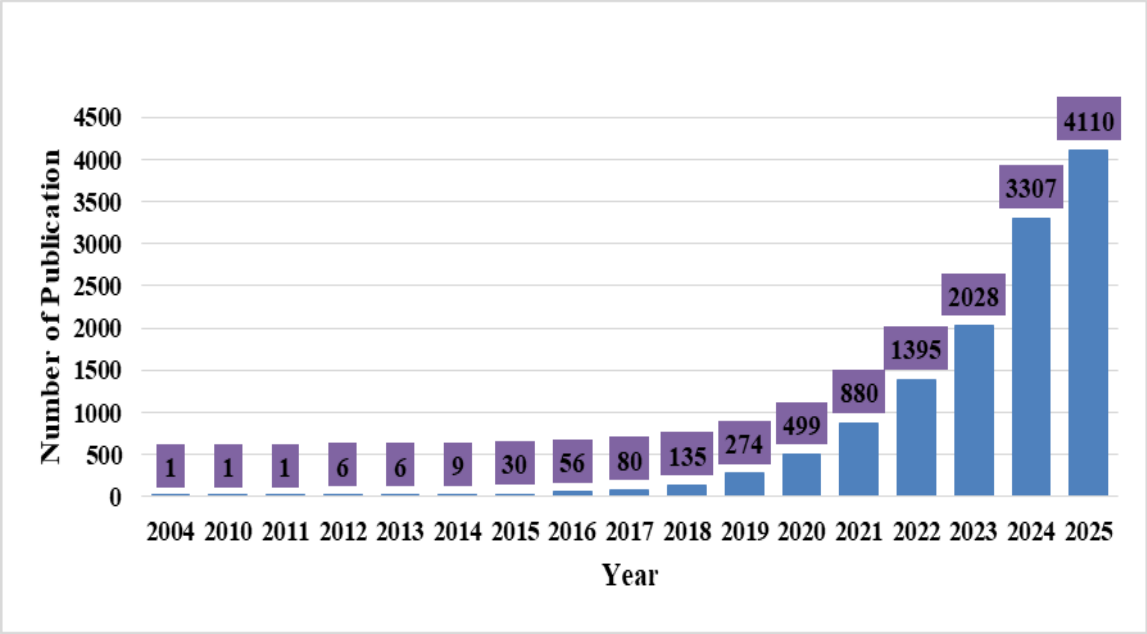


Figure 1 Growth Pattern of AI-Driven Healthcare Analytics Research

Figure 1 depicts that year-wise distribution of publications clearly indicates a rapid and sustained growth in research on AI-driven healthcare analytics associated with Indian affiliations. From a minor number of output during 2004–2014, the field entered a phase of sharp growth after 2016, followed by a continual rise from 2017 onwards. A notable Forward Momentum occurred after 2020, coinciding with the intensified digital health efforts, advances in artificial intelligence, and the effect of the COVID-19 pandemic on healthcare research. The publication productivity experienced accelerated growth between 2021 and 2025 highlights the maturation and mainstream adoption of AI and data analytics in the Indian healthcare research ecosystem. This growth mirrors the enhanced maturity of india's research ecosystem, increased institutional participation, backed by strong policy initiatives and financial support, positioning the country as an emerging contributor to global AI-driven healthcare analytics research.

Most Prolific Authors

Author Name	Number of Publication	Percentage for 12818
Singh, B.	85	0.66
Javaid, M.	47	0.37
Tyagi, A.K.	46	0.36
Boopathi, S.	44	0.34
Kaunert, C.	43	0.34
Haleem, A.	42	0.33
Kumar, N.	41	0.32
Larsimont, D.	40	0.31
Salgado, R.	40	0.31
Sotiriou, C.	40	0.31
Vincent-Salomon, A.	40	0.31
Dwivedi, Y.K.	38	0.30
Zhao, Z.	38	0.30
Chanock, S.J.	37	0.29
Ehinger, A.	37	0.29
Kahles, A.	37	0.29
Lakhani, S.R.	37	0.29
Lazar, A.J.	37	0.29
Liu, E.M.	37	0.29
Loeffler, M.	37	0.29

Table 1: Top 20 Author wise distribution on the AI-driven healthcare analytics research in India

Table 1 shows the top 20 author-wise distribution of publications in AI-driven healthcare analytics with Indian affiliations, based on the total amount of 12,818 publications. The result indicates a fragmented pattern of authorship structure, as even the most prolific author, Singh, B., gave only 85 publications (0.66%), showing that the no single researcher dominate this domain. The next tier of contributors Javaid, M. (47; 0.37%), Tyagi, A.K. (46; 0.36%), and Boopathi, S. (44; 0.34%) shows a steady decline in output, reflecting moderate but consistent engagement rather than concentrated leadership. Mainly, the top 20 authors composed account for only 650 publications, demonstrating approximately 5.07% of the total research output, which underscores the broad-based and collaborative nature of AI-driven healthcare analytics research in India. The presence of several internationally known researchers (e.g., Dwivedi, Y.K., Lakhani, S.R., Chanock, S.J.) further pushes strong global collaboration and interdisciplinary integration, rather than purely domestic author dominance. The findings indicate that Indian AI-healthcare research is distributed across a wide author base, driven more by

institutional and collaborative networks than by a small group of highly prolific authors, indicating a maturing and diversified research ecosystem rather than a centralized one.

Preferred Journals by the Scientists

Sl. No	Source	No. of Publication	Percentage for 12818
1	Lecture Notes in Networks and Systems	312	2.43
2	IEEE Access	153	1.19
3	Aip Conference Proceedings	123	0.96
4	Lecture Notes in Electrical Engineering	118	0.92
5	Multimedia Tools and Applications	94	0.73
6	Scientific Reports	84	0.66
7	Communications in Computer and Information Science	82	0.64
8	Studies in Computational Intelligence	73	0.57
9	Advances in Intelligent Systems and Computing	67	0.52
10	Smart Innovation Systems and Technologies	55	0.43
11	SN Computer Science	53	0.41
12	Lecture Notes in Computer Science Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics	51	0.40
13	International Journal of Intelligent Systems and Applications in Engineering	47	0.37
14	Lecture Notes on Data Engineering and Communications Technologies	45	0.35
15	Archives of Computational Methods in Engineering	44	0.34
16	Procedia Computer Science	43	0.34
17	Eai Springer Innovations in Communication and Computing	41	0.32
18	Sustainability Switzerland	41	0.32
19	International Conference on Artificial Intelligence for Innovations in Healthcare Industries Icaiihi 2023	39	0.30
20	Technological Forecasting and Social Change	36	0.28

Table 2 Top 20 Sources for AI-driven healthcare analytics research in India

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Table 2 highlights the top 20 publication sources contributing to AI-driven healthcare analytics research in India, drawn from the total of 12,818 publications, and high representation of conference proceedings and edited book series over traditional high-impact journals. Lecture Notes in Networks and Systems comes to light as the leading source with 312 publications (2.43%), followed by IEEE Access with 153 publications (1.19%), indicating a priority for rapid dissemination and interdisciplinary visibility. Collectively, the top five sources account for 800 publications (6.23%), while the entire top 20 sources provide only 1,561 publications (12.18%), underscoring a highly dispersed publication landscape. The prominence of Springer-based series such as Lecture Notes in Electrical Engineering, Communications in Computer and Information Science, and Advances in Intelligent Systems and Computing mirrors the AI healthcare research in India with a strong computational engineering emphasis. In contrast, the relatively lower representation of reputable, high-impact journals like Scientific Reports (0.66%) and Technological Forecasting and Social Change (0.28%) advises that much of the research highlights methodological innovation and applied system development over theory-driven or policy-oriented influences. The distribution reveals a maturing yet practice focused research ecosystem, where conference focused outlets serve as key vehicles for knowledge exchange, while opportunities remain to support publication presence in top tier healthcare and interdisciplinary journals.

Institution wise distribution on the AI-driven healthcare analytics research in India

Sl. No	Institutions	No. of Articles	Percentage for 12818
1	Saveetha Institute of Medical and Technical Sciences	448	3.50
2	SRM Institute of Science and Technology	407	3.18
3	Amity University	398	3.11
4	Vellore Institute of Technology	390	3.04
5	Chitkara University, Punjab	383	2.99
6	Chandigarh University	374	2.92
7	Lovely Professional University	368	2.87
8	Symbiosis International Deemed University	336	2.62
9	Saveetha School of Engineering	333	2.60
10	K L Deemed to be University	303	2.36
11	Graphic Era Deemed to be University	283	2.21
12	Galgotias University	229	1.79
13	Sharda University	211	1.65

14	Vel Tech Rangarajan Dr.Sagunthala R&D Institute of Science and Technology	208	1.62
15	University of Petroleum and Energy Studies	187	1.46
16	Christ University	176	1.37
17	JAIN Deemed-to-be University	175	1.37
18	Kalinga Institute of Industrial Technology, Bhubaneswar	161	1.26
19	Vellore Institute of Technology, Chennai	161	1.26
20	Manipal Academy of Higher Education	160	1.25

Table 3 Top 20 Institutions involved in AI-driven healthcare analytics research in India

The top 20 organizations advancing to AI-driven healthcare analytics research in India reveal a moderately concentrated yet competitive institutional landscape within a total output of 12,818 publications. Saveetha Institute of Medical and Technical Sciences takes the lead, creating 448 articles that make up 3.50% of all publications, followed closely by SRM Institute of Science and Technology (407; 3.18%) and Amity University (398; 3.11%), indicating strong research activity among private and deemed universities. The top five institutions collectively contribute to 2,026 publications (15.82%), while the top 20 institutions donate approximately 41.27% of the total output, reflecting significant institutional participation without excessive dominance. Institutions ranked 2 to 7 show very similar publication shares (2.87% to 3.18%), reflecting parallel growth and healthy competition. The leading role of engineering and technology universities, supported by a handful of medical institutions, emphasizes the interdisciplinary nature of AI healthcare research. However, the limited presence of major public universities and national research institutes points to an imbalanced research ecosystem, emphasizing the need for broader institutional collaboration and higher-impact research outputs.

Document type wise Distribution

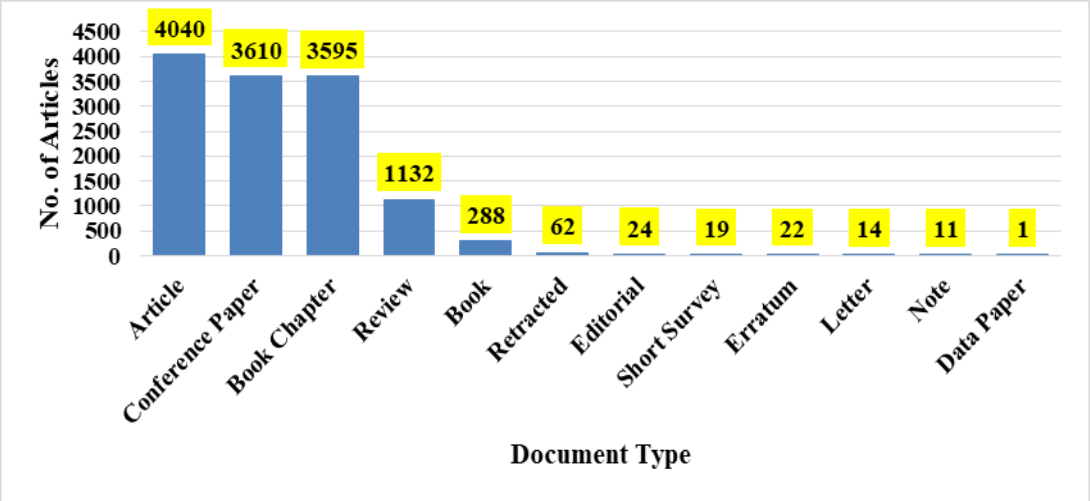


Figure 2: Document type wise Distribution on AI-driven healthcare analytics research in India

Figure 2 presents the breakdown of document types in AI-driven healthcare analytics research in India, based on 12,818 publications. The pattern clearly shows a marked preference toward original studies and formats that enable rapid dissemination of research findings. Journal articles dominate with 4,040 documents (31.52%), conference papers occupying the next position (3,610; 28.16%) and book chapters (3,595; 28.05%), which together account for 87.73% of the total output. This trend emphasizes the interdisciplinary and rapidly changing character of AI-driven healthcare research, where conferences and edited volumes play an important role in sharing early-stage insights and practice-oriented outcomes. A total of 1,132 publications (8.83%) are review articles, reflecting a growing priority placed on integrating prior research and strengthening methodological understanding. By contrast, books (288; 2.25%) and other scholarly formats including editorials, letters, and notes collectively represent under 1%, providing evidence that reflective or opinion-based works receive comparatively less attention. The presence of 62 retracted documents (0.48%) is notable and underscores concerns related to research rigor and replicability in a rapidly expanding field. The pattern points to a research environment mainly guided by output and rapid publication, while also emphasizing the Growing need for expansive knowledge integration and governance-focused studies.

Funding Agencies Involved

Sl. No	Name of the Funding Agency	No of Publication	Percentage for 12818
1	Department of Science and Technology, Ministry of Science and Technology, India	96	0.75
2	UK Research and Innovation	59	0.46
3	National Natural Science Foundation of China	50	0.39
4	National Research Foundation of Korea	50	0.39
5	Science and Engineering Research Board	48	0.37
6	National Health and Medical Research Council	46	0.36
7	King Saud University	41	0.32
8	University Grants Commission	39	0.30
9	National Institutes of Health	37	0.29
10	European Commission	34	0.27
11	Horizon 2020 Framework Programme	33	0.26
12	Princess Nourah Bint Abdulrahman University	33	0.26
13	King Khalid University	32	0.25
14	Bill and Melinda Gates Foundation	29	0.23
15	National Cancer Institute	28	0.22
16	Fundação para a Ciência e a Tecnologia	27	0.21
17	Ministry of Education	26	0.20
18	Taif University	25	0.20

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19	VIT University	25	0.20
20	Japan Society for the Promotion of Science	24	0.19

Table 5: Top 20 Funding Agencies contributed on AI-driven healthcare analytics research in India

Table 5 presents the top 20 funding agencies supporting AI-driven healthcare analytics research in India, based on 12,818 publications, and indicates a highly dispersed funding landscape with limited dominance by any single agency. The Department of Science and Technology (DST), Government of India leads with 96 publications (0.75%), after this UK Research and Innovation (59; 0.46%) and major international agencies such as the National Natural Science Foundation of China and the National Research Foundation of Korea (each 0.39%). Jointly, the top five funding agencies account for only 303 publications (2.36%), while all top 20 agencies represent a minimal proportion 662 publications (5.16%), making it evident that many research is conducted with institutional, collaborative, or unfunded support. The prominent role of global funding bodies, including NIH, European Commission, Horizon 2020, and JSPS highlights the internationalization of Indian AI-healthcare research and strong dependence on overseas funding support. However, the comparatively limited support from national agencies such as DST, SERB (0.37%), and UGC (0.30%) suggests that domestic funding potential is not being fully used, emphasizing the need for stronger, focused financial support to maintain strong research outcomes and clinically translatable AI-driven healthcare analytics research in India.

Most Relevant Countries

Sl.No	Name of the Country	No of Articles	Percentage for 12818
1	United States	1029	8.03
2	Saudi Arabia	648	5.06
3	United Kingdom	566	4.42
4	Australia	350	2.73
5	Malaysia	320	2.50
6	China	308	2.40
7	South Korea	264	2.06
8	Canada	231	1.80
9	Taiwan	225	1.76
10	Iraq	218	1.70
11	France	211	1.65
12	Italy	211	1.65
13	United Arab Emirates	203	1.58
14	Germany	186	1.45

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15	Spain	175	1.37
16	Singapore	150	1.17
17	Japan	143	1.12
18	Pakistan	143	1.12
19	Norway	134	1.05
20	Bangladesh	131	1.02

Table 6: Top 20 countries who have involved on AI-driven healthcare analytics research in India

Table 6 highlights the international collaboration landscape of AI-driven healthcare analytics research involving Indian affiliations, based on 12,818 publications, and reflects significant international involvement and connectivity. The United States stands out as India's key partner in 1,029 publications (8.03%), pointing out its leadership in AI and biomedical research. Following this Saudi Arabia (648; 5.06%) and the United Kingdom (566; 4.42%), reflecting both strategic academic partnerships and funding-driven collaborations. Collectively, the top three countries account for 2,243 publications (17.51%), with contributions from the top 10 countries totalling nearly 34.46%, indicating a network showing a balanced level of collaborative focus. The presence of Asian partners such as China (2.40%), South Korea (2.06%), Malaysia (2.50%), and Taiwan (1.76%) reflects the surging partnerships across the region in AI and healthcare. Alongside this, collaborations with developing nations, including Iraq (1.70%), Pakistan (1.12%), and Bangladesh (1.02%), highlight India's growing influence as a center for regional knowledge. The distribution reflects a diversified yet strategically aligned international collaboration network, enhancing India's visibility and impact in AI-driven healthcare analytics research.

Most Global Cited Documents

Sl. No	Name of the Authors	Title	Year	Source	Citation Count
1	Dwivedi, Y.K.; Hughes, L.; Ismagilova, E.; et al.	Artificial Intelligence (AI): Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy	2021	International Journal of Information Management	3,145
2	Ferrari, A.J.; Santomauro, D.F.; Aali, A.; et al.	Global incidence, prevalence, YLDs, DALYs, and HALE for 371 diseases and injuries, 1990–2021	2024	The Lancet	3,056
3	Dwivedi, Y.K.; Kshetri, N.; Hughes, L.; et al.	"So what if ChatGPT wrote it?" Multidisciplinary perspectives on generative conversational AI	2023	International Journal of Information Management	3,022
4	Campbell, P.J.; Getz, G.; Korbel, J.O.; et al.	Pan-cancer analysis of whole genomes	2020	Nature	2,184

5	Dwivedi, Y.K.; Hughes, L.; Baabdullah, A.M.; et al.	Metaverse beyond the hype: Multidisciplinary perspectives on emerging challenges	2022	International Journal of Information Management	2,119
6	Naghavi, M.; Ong, K.L.; Aali, A.; et al.	Global burden of 288 causes of death and life expectancy decomposition, 1990–2021	2024	The Lancet	1,775
7	Brauer, M.; Roth, G.A.; Aravkin, A.Y.; et al.	Global burden and strength of evidence for 88 risk factors, 1990–2021	2024	The Lancet	1,724
8	Haleem, A.; Javaid, M.; Qadri, M.A.; Suman, R.	Understanding the role of digital technologies in education: A review	2022	Sustainable Operations and Computers	1,563
9	Mohan, S.; Thirumalai, C.; Srivastava, G.	Effective heart disease prediction using hybrid machine learning techniques	2019	IEEE Access	1,527
10	Khurana, D.; Koli, A.; Khatter, K.; Singh, S.	Natural language processing: State of the art, current trends and challenges	2023	Multimedia Tools and Applications	1,307
11	Dutta, P.; Choi, T.-M.; Somani, S.; Butala, R.	Blockchain technology in supply chain operations: Applications and challenges	2020	Transportation Research Part E	1,284
12	Steinmetz, J.D.; Seeher, K.M.; Schiess, N.; et al.	Global burden of disorders affecting the nervous system, 1990–2021	2024	The Lancet Neurology	1,149
13	Ray, P.P.	A survey on Internet of Things architectures	2018	Journal of King Saud University – CIS	1,133
14	Hassija, V.; Chamola, V.; Mahapatra, A.; et al.	Interpreting black-box models: A review on explainable artificial intelligence	2024	Cognitive Computation	1,097
15	Dhillon, A.; Verma, G.K.	Convolutional neural network: A review of models and applications	2020	Progress in Artificial Intelligence	1,001
16	Chamola, V.; Hassija, V.; Gupta, V.; Guizani, M.	Role of IoT, AI, Blockchain, and 5G in managing COVID-19	2020	IEEE Access	978
17	Mensah, G.A.; Fuster, V.; Murray, C.J.L.; et al.	Global burden of cardiovascular diseases and risks, 1990–2022	2023	Journal of the American College of Cardiology	954

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18	Dwivedi, Y.K.; Hughes, D.L.; Coombs, C.; et al.	Impact of COVID-19 pandemic on information management research	2020	International Journal of Information Management	840
19	Wang, Z.; Bauch, C.T.; Bhattacharyya, S.; et al.	Statistical physics of vaccination	2016	Physics Reports	840
20	Clark, H.; Coll-Seck, A.M.; Banerjee, A.; et al.	A future for the world's children? A WHO–UNICEF–Lancet Commission	2020	The Lancet	801

Table 7: Top 20 highly Cited Documents on AI-driven healthcare analytics research in India

Table 7 presents the top 20 highly cited documents related to AI-driven healthcare analytics with Indian affiliations, pointing to the thematic diversity and citation density of notable research. The highly cited study authored by Dwivedi et al. (2021) received 3,145 citations, closely and then large scale global health studies published in The Lancet (Ferrari et al., 2024: 3,056 citations), reflecting the distinguished contribution of cross disciplinary and policy relevant research. Five papers stand out with more than 2,000 citations each, pointing to a concentrated group of significant publications that shape academic recognition. The strong presence of reputed journals, including the International Journal of Information Management, The Lancet, Nature, and IEEE Access, reflects the value of publishing in widely recognized, high impact outlets. Many of the top cited papers are review based, globally oriented analyses, or theoretical frameworks instead of India centered experimental studies, implying that broader relevance and carefully designed methodologies significantly influence a decisive role in attracting citations. The alignment of AI-based healthcare solutions (e.g., heart disease forecasting, NLP, and XAI) with global health data analyses signals a growing alignment between artificial intelligence methodologies and health policy frameworks. Citation patterns indicate that high impact studies are notable for their interdisciplinary orientation, scalability, and global orientation, thereby offering meaningful perspectives for advancing AI enabled healthcare research in the Indian context.

Conclusion

This bibliometric study examines 12,818 Scopus-indexed publications associated with Indian institutions between 2004 and 2025, tightfitting a dramatic expansion in AI-enabled healthcare analytics research. Output grew from relatively limited activity before 2016 to 4,110 publications in 2025 alone, driven in part by national digital health programs such as Ayushman Bharat and accelerated by the COVID-19 pandemic. Key findings reveal a collaborative, decentralized ecosystem: fragmented authorship led by Singh, B. (85 papers), dominance of conference proceedings like Lecture Notes in Networks and Systems (312 publications), leadership by private institutions such as Saveetha Institute (448 articles), and robust international ties with the US (8.03% collaboration share). Journal articles, conference papers, and book chapters contain 87.73% of outputs, with funding fragmented across DST (0.75%) and global partners, while highly cited works like Dwivedi et al. (2021; 3,145 citations) underscore multidisciplinary impact. These insights map thematic hotspots in machine learning for diagnostics and forecasting techniques, yet highlight gaps in public institution involvement, high-impact journals, and domestic funding. India's AI-healthcare analytics landscape positions the nation as a international player, with projected market growth to USD 4 billion by 2033 demanding equitable, rural-focused innovations. Policymakers should prioritize targeted funding, public private synergies, and open-access strategies to increase the practical applicability of research, fostering sustainable, inclusive advancements that address chronic disease burdens and resource constraints for 1.4 billion citizens.

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Artificial Intelligence and Ranganathan's Fourth Law: Efficiency or Illusion?

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Abstract

Dr. S. R. Ranganathan's Fourth Law of Library Science, "Save The Time of The Reader," serves as a primary consideration for evaluating the effectiveness of all information systems. In the context of today's rapidly evolving digital environment, the emergence of artificial intelligence (AI) in research workflows demands a new and critical consideration of this principle. AI tools such as ChatGPT, Perplexity AI, Semantic Scholar's assistant, etc., have hyperbolic claims of efficiency gains by speeding up the process of information collection, summarization, and classification. Yet AI's highly publicized limitations, including hallucinated citations, misleading summaries, algorithmic bias, and the persistent verification burden, challenge the straightforward assumption that AI inherently saves time (Floridi & Chiriatti, 2020; Stokel-Walker, 2023). Moreover, the human labour in and around the application of AI tools, including the work of Library and Information Science (LIS) professionals that are oftentimes unseen, complicates the narrative of automation. This paper provides a conceptual and interpretive analysis of AI mediated by Ranganathan's Fourth Law. Using classical LIS theory, current AI literature, and documented examples of AI errors, this study notes that AI simultaneously fulfills and violates the Fourth Law. It not only shortens certain stages of research but also introduces new layers of epistemic uncertainty that may increase the researcher's cognitive and temporal workload. The study also proposes a modern reformulation of the Fourth Law- "Save the time of the researcher, accurately, equitably, and responsibly", as a necessary evolution of Ranganathan's vision in an age of algorithmic mediation.

***Keywords**:* fourth law of Library Science, information literacy, artificial intelligence, research, academic libraries

Introduction

Ranganathan's Five Laws of Library Science, introduced in 1931, characterized a strong and lasting moral plus functional basis for the profession of librarianship. The Fourth Law, in particular, which states *"Save the time of the reader,"* underpins the very idea of making information super-efficient and effortless to access. Historically, this law addressed the spatial and procedural logistics of physical libraries- clear cataloguing, intuitive classification, and responsive reference services (Shera, 1972; Satija, 2008). The expansion of the law to include digital discovery, user-friendly interfaces, and metadata quality occurred as digital systems, online databases, and networked catalogues came into being (Borgman, 2000).

In the 21st century, AI systems occupy a central place in scholarly work. Tools such as ChatGPT and Perplexity AI now perform functions traditionally associated with reference services, discovery systems, and knowledge organization mechanisms. They promise quicker answers, personalized recommendations, and automated summaries that seem to lessen the effort of wading through academic research materials (Ghosh, 2023; Zhou & Kenderdine, 2022). However, such technologies frequently yield fictitious citations, incorrect justifications, and prejudiced outcomes. Since researchers are more and more dependent on AI output, the dilemma becomes pressing: Are these tools really in compliance with Ranganathan's Fourth Law, or do they simply give an illusory picture of effectiveness?

This study gives LIS a conceptual and critical deep-dive to answer the question and contend that AI boosts the processing of some academic work, and at the same time creates new, slow ways that are against the principle of speed. The study looks at AI's conduct, its reliability problems, and the unnoticed work behind the scenes to evaluate the role of AI in a new understanding of the reader's time being 'saved.'

The incorporation of AI in academic research is increasing; however, its connection with the classical LIS principles, especially Ranganathan's Fourth Law, has been given little consideration. The majority of the debates around AI are located in the dichotomy of either celebrating it as a time-saving innovation or criticizing it for its ethical risks, but seldom do they address the question of how such technologies are likely to alter the very meaning of "saving time" in scholarly work. This research aims to provide the necessary analysis to establish whether AI is a true time saver for the researcher or just a means to transfer the labour from one type of cognitive/verification task to the other.

Objectives

This study is based on the following objectives-

1. To examine how AI tools fulfill the spirit of Ranganathan's Fourth Law- "Save the time of the reader" within contemporary research workflows.
2. To analyze how AI systems introduce new inefficiencies, epistemic risks, and labour burdens that may violate or destabilize the Fourth Law.
3. To evaluate the ethical, professional, and infrastructural implications of integrating AI into academic research and library environments.
4. To propose a reconceptualized interpretation of the Fourth Law that accounts for the socio-technical conditions of AI-mediated knowledge practices.

Literature Review

Ranganathan's Fourth Law has always been interpreted as a pledge to the user-centered system. The earlier proponents of this argument, like Shera (1972) and Satija (2008), highlight that such a system is not only a matter of convenience but also a fundamental ethical duty of the library profession. As collections expanded and services changed, the law gradually adjusted to the new technologies. The digital libraries, online catalogues, and advanced indexing practices were the major factors behind the continued expansion of the mechanisms through which libraries reduced user effort. By the early part of the 21st century, Borgman had already pointed out that in the year 2000, the impact of digital retrieval systems on information access was so deep that new concepts of efficiency had to be defined in terms of navigability, interoperability, and metadata integrity.

The emergence of AI intensified these debates. Studies such as Ghosh (2023) and Zhou and Kenderdine (2022) highlight AI's potential to streamline information retrieval, automate routine tasks, and personalize recommendations in ways traditional systems cannot. Yet scholars remain cautious. Floridi and Chiriatti (2020) argue that AI's limitations, especially its tendency to hallucinate, raise serious concerns for scholarly accuracy. Stokel-Walker (2023) demonstrates how fabricated citations have already disrupted academic workflows, requiring additional layers of verification. From an LIS perspective, these hallucinations represent fundamental violations of bibliographic control and authority control- cornerstones of responsible information management.

The issue of algorithmic bias is still emerging and will continue to grow as more organisations recognise that algorithms have a bigger impact on the way they do business. Noble (2018) highlights the dangers in using tools created by algorithms that can be biased in favour of Western cultural or linguistic norms and further

marginalise non-Western knowledge systems, which is contrary to the Librarian's commitment to provide equitable access to information.

Moreover, the question of labour is equally important. Cox (2021) and Gray and Suri (2019) show that AI systems rely extensively on hidden human labour, from metadata creation to data curation and annotation. This "invisible work" is often performed by LIS professionals whose contributions remain obscured, even as AI systems are credited with providing instantaneous efficiency. This raises fundamental concerns about the redistribution of labour and time in AI-mediated environments.

All this literature reveals a striking gap, while many works examine AI's potential for efficiency or critique its errors, few explicitly reinterpret Ranganathan's Fourth Law in relation to algorithmic mediation, misinformation, and the labour ethics embedded in AI infrastructures. This study situates itself within this emerging gap, approaching the Fourth Law not as a stable doctrine but as a living principle requiring rearticulation in the era of AI.

Methodology

This research adopts a qualitative, conceptual, and interpretive approach grounded in LIS theory. The methodology includes:

- Theoretical analysis of classical LIS literature on Ranganathan's Fourth Law.
- Review of contemporary AI scholarship, focusing on hallucinations, algorithmic bias, and reliability issues.
- Analysis of documented examples of AI-generated errors, including fabricated citations and misleading summaries.
- Interpretive synthesis, comparing AI's performance with the ethical expectations embedded in the Fourth Law.

No empirical data were collected; instead, the study relies on scholarly literature, verifiable AI error reports, and conceptual reasoning to assess AI's impact on research efficiency.

Fulfillment of the Fourth Law (AI as Time-Saver)

The Fourth Law of Library Science- *"Save the time of the reader"* was envisioned by Ranganathan as a principle of user-centered efficiency in information access. In the 21st century, AI tools claim to operationalize this principle with a speed and scale unprecedented in the history of knowledge systems. AI's contribution to research workflows can be examined along several interrelated dimensions, such as speed, personalization, automation, and empirical evidence from case studies and early adoption in library contexts.

- **Speed and Instant Retrieval:**
  Perhaps the most visible fulfillment of the Fourth Law is AI's capacity to deliver instant answers that would otherwise require protracted searches through catalogues, bibliographies, or full-text databases. Large language models (LLMs) and AI-powered discovery engines significantly reduce the temporal distance between a query and its response. By collapsing search and synthesis into a single interaction, these systems align closely with the Fourth Law's emphasis on minimizing user effort. While traditional retrieval systems depend on Boolean queries and manual filtering, AI models such as ChatGPT or Semantic Scholar's research assistant provide synthesized, contextually relevant results in real time. This capacity is particularly valuable in high-stakes scholarly environments where time efficiency directly correlates with research productivity (van Dis et al., 2023).

- **Personalization and Relevance:** The adage *"Every reader his/her book"* may be reformulated in the AI era as *"Every user his/her algorithm."* AI systems utilize recommender algorithms that adapt to individual research profiles, search histories, and disciplinary contexts. The AI is customizing its outputs in ways that include recommended articles, suggested citations, and even topic clusters, making the process of information discovery less distracting and more directed. The AI's personalization, in addition to being time-saving, also allows for more accidental discovery by bringing to light materials that would otherwise be hidden in the classic keyword-based retrieval methods (Ghosh, 2023). The precision of algorithmic tailoring thus translates the Fourth Law into an individualized digital praxis.
- **Automation of Routine Tasks:** AI has made an immense impact in the automation of tedious scholarly tasks, aside from its retrieval function. Areas such as metadata generation, entity recognition, summarization of texts, and even support for systematic reviews are some of the major instances that show a reduction in monotonous human work through AI. For instance, the automated tagging and classification systems are speeding up the cataloguing workflow, while the AI summarization tool is helping the researchers to determine the relevance of a paper without having to read it completely. Systematic review platforms that utilize machine learning can carry out the pre-screening of thousands of abstracts, and thus the manual labour usually needed in evidence synthesis gets drastically reduced (Zhou & Kenderdine, 2022). This kind of automation is consistent with the extension of logic outlined in the Fourth Law by shifting the time-saving from mere access to the entire research lifecycle.
- **Case Illustration:** A specific example of AI compliance with the Fourth Law is found in the use of Semantic Scholar's AI-powered assistant. The system's use of natural language processing and citation network analysis allows researchers to find essential studies, related works, and methodological trends in just a few seconds. Initial testing shows that there is a significant drop in the time taken for literature discovery, which implies that such systems are not only increasing access but also enhancing the precision of the knowledge that is retrieved (Van Dis et al., 2023). This case demonstrates that AI at Ranganathan's principle operates through very large scales and thus makes it very hard for scholars to navigate in a short amount of time.
- **Empirical Evidence:** By the time the first academic libraries received AI technology for their use and began to experiment with it, the theory about its potential impact as a time-saving device was already established. Ghosh (2023) gives a few examples of reference services that were AI-powered, and the time consumed for the complex queries got significantly less. Similarly, Zhou and Kenderdine (2022) state the same thing about library environments where AI is involved, that is, faster cataloguing and better user satisfaction. These research observations lead to the conclusion that if AI is cleverly placed in the right institutional framework, the Fourth Law is, to an extent, fulfilled as libraries and researchers can then allocate their cognitive and temporal resources more strategically.

The speed, personalization, and automation features are typical of AI and, when coupled with the exhibited empirical benefits, imply that Ranganathan's dream of efficiency is largely adopted by AI. Through compliance with the Fourth Law, AI has changed the focus from just making access to the total optimization of academic workflows, thereby becoming a transformative ally in the current knowledge space.

Violation of the Fourth Law (AI as Time-Waster)

Generative AI technologies create fake citations, nonexistent journals, misnamed authors, and distorted overviews. Although these outputs seem trustworthy, users are still forced to spend a lot of time checking the information, which they thought was already reliable at first.

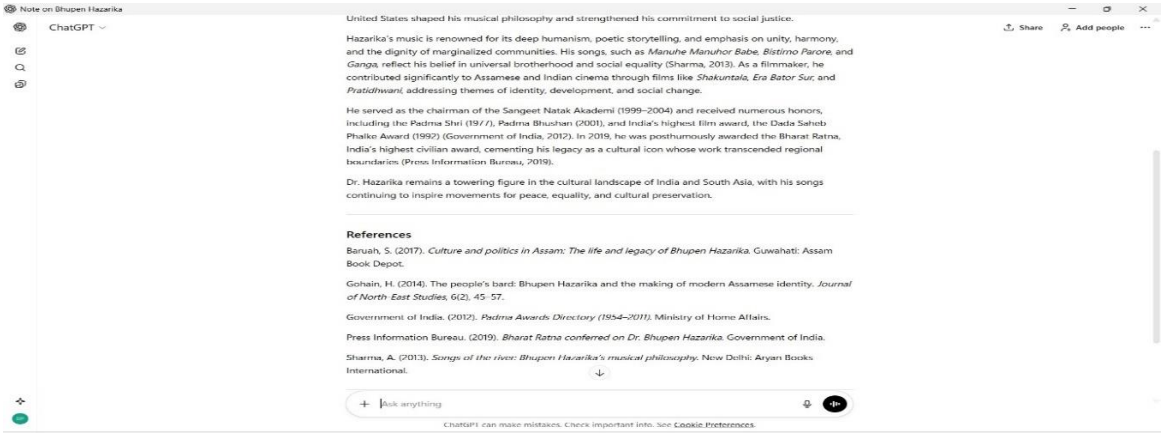


Figure 1: Hallucinated citation generated by ChatGPT

As shown in Figure 1, a note about the famous cultural personality Dr. Bhupen Hazarika was created by ChatGPT; nonetheless, the examination of the references showed that a number of the cited works were not authentic. Among the five sources provided, three were fabricated: the cited Journal of North-East Studies does not exist, the book titled "Culture and Politics in Assam: The Life and Legacy of Bhupen Hazarika" purportedly published by Assam Book Depot could not be traced, and no publication titled "Songs of the River: Bhupen Hazarika's Musical Philosophy" from Aryan Books International is catalogued in any verified bibliographic database. These cases demonstrate one of the major drawbacks of the usage of large language models, which may produce references that sound plausible but are actually incorrect even in the presence of disclaimers such as "ChatGPT can make mistakes." These fictitious references highlight the necessity of critical validation and human supervision while dealing with academic content generated by AI.

From an LIS perspective, hallucination is not just an error; it is a disturbance to the cataloguing standards, authority files, and the trustworthiness of metadata. It impairs the authenticity of academic discourse by inserting non-existent items into the list of approved vocabulary or indexes (Floridi & Chiriatti, 2020).

Moreover, AI produces untrustworthy or oversimplified abstracts. These can misrepresent the methods or results of the research and confuse the scholars who depend on the brief to determine if it is relevant to their work. Such inaccuracies significantly increase the verification burden, and the researchers must devote their time to check whether an AI-generated detail is correct. This verification process negates any time saved during initial retrieval. Instead of saving time, AI often shifts the burden onto researchers, librarians, and instructors who must correct errors in bibliographies, assignments, and research drafts.

Another significant violation is represented by algorithmic bias. If AI tools give preferential treatment to certain languages, journals, or epistemic traditions, they will inadvertently limit the researcher's access to a variety of sources. Such an action goes against the values of LIS, which focus on the inclusion and fairness of access. Moreover, AI makes it difficult to see the massive work done by the LIS professionals who build and support the metadata, taxonomies, authority records, and digital infrastructures that AI relies on. The illusion of efficiency obscures the human expertise that supports it, redistributing time and labour in ways that are seldom noted.

Findings and Discussion

The examination of AI against the backdrop of Ranganathan's Fourth Law presents a significant dilemma: AI at the same time represents and nullifies the rule of time-saving for researchers. Its functions of quick retrieval, tailor-made recommendation, and task automation, for instance, are the law's very spirit. Its

drawbacks, like hallucination, verification burdens, algorithmic bias, cognitive overload, and the hidden work of information professionals, are, however, a clear violation of the law in practice. This paradox brings to the forefront the question of how exactly time-saving for the reader- or rather, the researcher- is to be interpreted in the digital world.

Acceleration vs. Trust: The paradox of acceleration without reliability is the main point of contention. The researchers were made to spend time on verification again due to AI tools delivering instant answers and synthesized results, but at the same time, their lack of epistemic transparency forced them to do so. AI systems, unlike earlier information systems whose limitations were clear and navigable, generate outputs that impose a kind of authority that very often conceals inaccuracies. This scenario makes the Fourth Law's realization contingent not only on speed but also on the reliability of the sped-up processes. Time saved at the access point may be lost in the repeated action of validation.

Contextual Differences across Disciplines: The extent to which AI adheres to or contravenes the Fourth Law differs markedly among different fields of study. In the case of STEM fields, where the data is usually structured, quantitative, and cumulative, AI's ability to expedite data analysis and literature discovery might surpass the risks associated with errors. On the other hand, in the case of the humanities and social sciences, where AI's biases and limitations in the representation of complex humanistic knowledge are seen as the main reasons for wasting time, the case is different where nuance, contextual interpretation, and epistemic diversity hold sway. Thus, the evaluation of the Fourth Law's fulfillment or violation cannot be made in a general way but rather needs to take disciplinary epistemologies into account.

User Competence and Information Literacy: User competence is another axis of variation. It is possible that highly skilled researchers, who are trained in information literacy and critical evaluation, will be able to use the benefits of AI while at the same time reducing the risks. On the other hand, beginners will probably uncritically take AI results as true and thus create more misinformation and inefficiency. In this way, the Fourth Law has to be amended so that it includes not only the technology's ability to save time but also the user's mental readiness to interact with AI critically. Therefore, libraries and information science professionals have an important role in the mediation process between AI effectiveness and human judgment.

Ethical Dimensions of Efficiency: Beyond practical considerations, the Fourth Law's reinterpretation in the AI era raises ethical questions. To whom is time being saved, and at whose expense? AI's functioning as a whole is dependent on the obscured labour of librarians and archivists, which, though not acknowledged, is still an integral part of AI functionality. Moreover, such biases in algorithms could lead to the marginalization of scholars' time who would have to put in extra labour to get the views of the non-dominant datasets. Issues of fairness, equity, and professional recognition are all tied to the time-saving aspect that cannot be separated from one another.

Reconceptualizing the Fourth Law: These complexities imply that Ranganathan's principle needs to be supplemented. In the AI era, *"saving the time of the researcher"* must be accompanied by the condition that such efficiency will not be at the cost of accuracy, fairness, or transparency. A potential restatement could be: *"Save the time of the researcher, without losing it to disinformation, inequality, or invisible labour."* This wider statement not only clarifies the issue of efficiency but also brings out its holistic nature as a value, which, apart from speed and convenience, includes being conscious of and safeguarding against epistemological and moral compromises.

In a nutshell, AI not only complies with or breaks the Fourth Law; it shifts its significance, thereby compelling a re-evaluation of the interplay between time, trust, and technology in academic practice. To uphold the integrity of Ranganathan's vision, the LIS community must be the voice for responsible AI integration, enhanced information literacy, and acknowledgment of professional work. A comprehensive approach is the

only way for the Fourth Law to remain an informative principle for knowledge systems in an era of algorithmic mediation.

Suggestions and Implications

The findings of this study indicate that the integration of AI into research workflows requires careful calibration if it is to truly fulfill Ranganathan's Fourth Law.

1. Libraries should implement AI systems that are interpretable and that put the recommendation algorithms under the spotlight as far as transparency is concerned.
2. The researchers ought to regard the outputs of AI as provisional and thus carry out verification for all citations, claims, and interpretations.
3. The library and information science education should not only have AI literacy as a part of the curriculum but should also emphasize the areas of ethics, bias, and critical evaluation.
4. The institutions should come up with explicit policies regarding the use of AI that would include such issues as who is responsible for errors, fairness, and recognition of the work done by professionals.
5. The partnership between the library and information science professionals and the technologists is a must if the AI systems are to maintain bibliographic integrity and provide equitable access.

Conclusion

Ranganathan's Fourth Law- "Save the time of the reader" remains a long-lasting and fundamental ethical rule. Nonetheless, its interpretation needs to be reevaluated in the context of artificial intelligence. There is no doubt that AI tools quicken the pace of certain research phases, but at the same time, they introduce new types of inefficiency, such as fake citations, confusing summaries, biased algorithms, and hidden efforts to keep them going. AI is not a time-saver or a time-waster; rather, it redistributes the aspects of time, accountability, and risk throughout the research ecosystem.

The Fourth Law is still applicable, but it will have to go through changes reflecting the new situations of algorithm mediation. Perhaps the most appropriate expression of the present time could be: **"Save the time of the researcher- accurately, equitably, and responsibly."** This modification maintains the essence of Ranganathan's perception while recognizing the difficulties of the current scholarly communication. Future information systems will not only rely on automation but also on the factors of transparency, critical literacy, and the continuous acknowledgment of human skill.

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An Overview of Artificial Intelligence Tools for Digital Archive Extraction in Libraries

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Abstract

As libraries and cultural heritage institutions rapidly digitize vast collections of physical materials, the primary challenge has shifted from preservation to effective accessibility. The growing volume of digital archives has made traditional manual indexing methods inefficient, often creating significant delays in information retrieval. Artificial intelligence (AI) technologies offer a transformative solution by enabling the automated extraction of structured metadata from unstructured digital content such as scanned texts, images, and audiovisual records. Recent advances in machine learning, natural language processing, and computer vision have led to the development of specialized AI tools designed to enhance archive organization, searchability, and discovery. This overview examines contemporary AI-driven solutions used in libraries for digital archive extraction, highlighting their functionalities, benefits, and potential to reshape archival management and information access in the digital era.

Keywords: Artificial intelligence, Digital Archives, Automated Metadata Extraction, Tools, Data retrieval

Introduction

The expansion of digital collections in libraries has created new challenges in organizing and accessing archival materials. As institutions digitize books, manuscripts, and historical records, managing large volumes of unstructured data has become increasingly complex. Manual cataloging and indexing methods are often insufficient to meet the demands of modern users. Artificial intelligence (AI) technologies provide effective solutions by automating the extraction and organization of information from digital archives. Using techniques such as machine learning, natural language processing, and image analysis, AI tools improve the efficiency, accuracy, and accessibility of library archives.

AI has several advantages for a wide range of sectors and uses. Among the advantages that are most frequently mentioned are:

- Availability around-the-clock.
- Decreased danger to the body.
- Faster and more understanding from data.
- Less mistakes made by people.

Artificial Intelligence (AI) is bringing about a significant transformation in libraries. This indicates that they are improving things by utilizing smart technologies. Currently investigating how this impacts libraries, examining the advantages, difficulties, and possibilities.

Modern libraries are significantly impacted by artificial intelligence (AI), which is changing many areas of the services, operations, and user experiences offered by the libraries. Some of the main facts of which are here as:

- Information retrieval
- Digital archives and preservation
- Chatbots and virtual assistants
- Text analysis and data mining
- Language translation services

Review of literature

Veerakannan (2025)[1] The use of AI in libraries are examined in this research, with particular attention to how it affects digital resource preservation, collection administration, tailored services, and information retrieval, It dives deeper into the potential constraints and ethical issues surrounding the application of AI in these crucial establishments.

Andrew Cox (2025)[2] The analysis's conclusions mostly support the model, but they also point to numerous gaps in the library and archive AI capabilities, particularly in areas like infrastructure and technical resources, data problems brought on by inconsistent metadata, and financial resources. Empirical studies demonstrate that AI-based systems can improve efficiency, accuracy, and user access to large-scale digital collections. However, scholars consistently note that these benefits are unevenly realized due to persistent structural and organizational limitations within libraries and archives.

Sara Mannheimer (2024)[3] This paper serves as a foundational argument for "participatory ethics" and transparency in the integration of Artificial Intelligence (AI) within the archival sciences. Libraries and archives are progressively implementing AI, and practitioners are utilizing it for a wider range of objectives. It has been discovered that large, academic libraries were where AI deployment was most prevalent.

Sarafudheen M. Tharayil (2024)[4] This study demonstrates that using rule heuristics to target particular document parts speeds up the extraction process. Furthermore, our test show the IVF indexing method's higher search speed and the efficiency of our novel parallelism strategy in query processing optimization. Additionally, the BeIR dataset showed comparable performance according indexing techniques, with the exception of a discernible decline in accuracy for the PQ index.

Abid Hussain(2023)[5] The purpose of this essay is to demonstrate how AI is used in library operations. Numerous studies have been conducted on this topic, although they only cover small number of applications. The benefits and drawbacks of AI in library services are discussed in this study. Although there is a significant relationship between AI and libraries, there are still unanswered questions regarding the application and awareness of AI in library service which are discussed in this paper.

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Overview: Ai Tools for Digital Archive Extraction in Library

The data extraction tool is a software solution designed to retrieve specific data from diverse sources, including documents, databases, and websites. This type of software uses advanced AI algorithms to automate the extraction process. Ultimately, the goal is to ensure high accuracy and operational efficiency.

Tools and Methods

The specialized tools like Transkribus for manuscripts, AudioPen for audio, and Cataloging.ai for metadata, AI tools for digital archive extraction in libraries use OCR, NLP, and image recognition to automate text/content extraction, generate metadata, transcribe audio/video, and create searchable, accessible records from vast physical/digital collections, simplifying tasks for librarians and enhancing discovery.

Tool: Transkribus

- An industry – leadind platform that libraries and archives use to train AI models to recognize, transcribe, and search printed and handwritten historical documents.
- Optical Character Recognition (OCR): After being trained, AI systems use OCR methods to automatically extract text from scanned documents. Characters in scanned photographs are recognized by OCR technology, which then transforms them into text that can be read by machines.

Tool: Archipanion

- This tool is specializes in creating structured, machine – readable datasets from scanned, unsearchable archival pictures (letters, registers, manuscripts).

Tool: ChatPDF

- An AI powered application that functions as a search Engine or document expert by allowing you to upload PDF Documents (and occasionally other files like word, PPTX) and ‘chat’ with them. User may ask questions receive summaries, extract important insights, or even create content based on the PDF’s text.

Tool: QuillBot/Grammarly

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- An AI – powered writing platform that helps users improve text for efficiency, professionalism, and clarity in academic, professional, and creative writing activities by providing tools for summarizing, paraphrasing, grammar checking, plagarism detection, and content generation.
- **Natural Language Processing (NLP):** Understands text to extract entities (names, places), summarize content, translate languages, and tag items. It extracts key entities such as names, dates, locations, organizations, and quantities.

Tool: WARC – GPT



- An open – source AI tool from the Harvard library innovation lab that uses Retrieval – Augmented Generation (RAG), allow users to converse with web archives (WARC files) in natural language. This allows users to explore large digital collections in a conversational manner and provides cited answers from historical web pages rather than just keyword search results.
- It allows users to ask complex questions instead of relying on keyword searches. It helps retrieve relevant historical web pages before generating responses.

Key capability and functions

Automated Metadata Extraction:

- AI reduces manual, time – consuming data rnty by automatically classifying and extracting data from digital assets.

Text and picture Recognition:

- These tools use computer vision for picture tagging and face recognition, and they translate scanned, handwritten, and printed materials into machine readable text.

Contextual Search (semantic Analysis):

- AI powered solutions enable users to search based on the meaning of their query across many languages rather than just using straightforward keywords.

Preservation planning:

- To ensure long-term usage, AI evaluates the physical state of materials, forecasts data loss risks, and helps automate file format conversions.

Suggestions

- AI technology should be utilized to cut down on the amount of time spent in libraries.
- To use the technology more effectively, library employees need to be taught to operate artificial intelligence.

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- The artificial intelligence tools must be used to preserve the library's digital archives for better preservation and increased security.
- To raise awareness of AI technologies among more library patrons.

Conclusion

The development of data extraction techniques driven by AI has drastically changed how libraries operate. These solutions increase efficiency and create new opportunities for data-driven decision-making by automating and improving data collection procedures. AI is drastically changing library services, presenting fascinating chances to boost productivity, improve user experiences, and increase information access. The advantages of AI in libraries are substantial, notwithstanding ongoing difficulties. Libraries may continue to be essential centers of learning, connection, and empowerment in the digital age by adopting AI and resolving the related issues.

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Adoption and Utilization of Artificial Intelligence Tools for Research: A Study of Faculty Members of select Arts and Science Colleges in Dindigul District, Tamil Nadu, India

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Abstract

This study examines the adoption, utilization patterns, and perceptions of artificial intelligence (AI) tools among faculty members in 3 arts and science colleges in Dindigul District, Tamil Nadu, India. Colleges were selected based on purposive sampling method. Faculty members were drawn using stratified random sampling method. Data was collected from 78 faculty members using a structured questionnaire. The findings reveal that : 71 (91.0%) indicated they had heard of artificial intelligence tools for research, demonstrating high general awareness; 52 (66.7%) reported currently using at least one AI tool for research purposes; over 60% of users (63.4%) use AI tools at least several times per week; ChatGPT is the most used AI Tool for research; Literature search and review (84.6%), writing and editing (75.0%), and citation management (67.3%) are the most common applications; lack of training and guidance is the major challenge. The findings indicate moderate adoption rates with significant variations across disciplines, age groups, and levels of technological literacy. This study provides recommendations both for institutions and faculty members to facilitate effective AI integration in academic research.

***Keywords**:* Artificial Intelligence, Research Tools, Faculty Development, Higher Education, Tamil Nadu, Arts and Science Colleges, Technology Adoption

Introduction

Background

The integration of artificial intelligence into academic research represents one of the most transformative developments in contemporary higher education. AI technologies are reshaping how researchers approach literature reviews, data analysis, hypothesis generation, and scholarly communication. From automated citation management to sophisticated data visualization, from predictive modeling to intelligent writing assistance, AI tools offer capabilities that can significantly enhance research efficiency and effectiveness.

Arts and science colleges, which form the backbone of undergraduate and postgraduate education in India, educate millions of students annually and conduct substantial research across diverse disciplines. Faculty members in these institutions face increasing pressures to publish research, secure funding, mentor students, and maintain teaching excellence—all while navigating resource constraints typical of many Indian higher education institutions.

Tamil Nadu, with its rich educational heritage, has been proactive in promoting technology integration in education, yet the actual adoption and effective utilization of AI tools for research purposes among faculty members remain inadequately documented. Understanding current usage patterns, identifying barriers to adoption, and recognizing opportunities for enhancement are essential for developing targeted interventions that can support faculty research productivity.

Review of Literature

Chen et al. (2022) examined how AI tools are reshaping research workflows in universities globally. Their study identified several key applications: automated literature review and synthesis, intelligent data collection and analysis, predictive modeling, research collaboration platforms, and AI-assisted writing and editing. They found that researchers using AI tools reported time savings of 30-40% in literature review processes and significant improvements in data analysis capabilities.

Zawacki-Richter et al. (2019) conducted a systematic review of AI applications in higher education, identifying 146 articles across four major application areas: profiling and prediction, intelligent tutoring systems, assessment and evaluation, and adaptive systems. Notably, their review found that research-focused applications constituted only 12% of the literature, indicating a gap in understanding how AI tools support scholarly research specifically.

Van Noorden and Perkel (2023) surveyed scientists about their use of AI tools, finding that 30% of respondents had used ChatGPT or similar large language models in their research, primarily for literature review, writing assistance, and code generation. However, concerns about accuracy, attribution, and ethical implications were prevalent.

Khosravi et al. (2022) reviewed AI applications in research data management, highlighting tools for automated data cleaning, pattern recognition, anomaly detection, and predictive analytics. They emphasized that AI tools are particularly valuable for handling large datasets that would be impractical to analyze manually, a capability increasingly important across disciplines.

Gibney (2022) documented widespread AI adoption in natural sciences, particularly for genomics, drug discovery, materials science, and climate modeling. Machine learning algorithms have become standard tools in many scientific disciplines.

Bail (2024) explored AI applications in social science research, including text analysis, network analysis, and predictive modeling. However, adoption has been slower than in natural sciences, partly due to epistemological concerns and methodological traditions.

Ng et al. (2021) found that lack of training and insufficient understanding of AI capabilities represented major barriers to adoption among educators. Many faculty members expressed interest in AI tools but felt unprepared to use them effectively.

Laato et al. (2022) investigated trust in AI among university staff, finding that concerns about accuracy, bias, privacy, and academic integrity significantly influenced willingness to adopt AI tools. These concerns were particularly pronounced among faculty in fields emphasizing critical thinking and originality.

Research Gaps

While existing literature provides valuable insights into AI in higher education and technology adoption patterns, it is clearly understood that there are gaps in the literature. These include: limited empirical data from Indian contexts; insufficient attention to disciplinary differences; Lack of comprehensive assessment; Limited understanding of barriers in resource-constrained settings and inadequate focus on faculty perspectives. This study addresses these gaps by providing empirical data on AI tool adoption among arts and science college faculty in Tamil Nadu, examining disciplinary variations, identifying specific barriers, and exploring faculty perspectives on opportunities and challenges.

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Objectives of the Study

This research was guided by the following objectives:

- To assess the current level of awareness and adoption of AI tools among faculty members for research purposes in arts and science colleges in Tamil Nadu.
- To identify the specific AI tools and applications most commonly used by faculty members in their research work.
- To examine the purposes for which faculty members utilize AI tools in their research processes.
- To explore variations in AI tool adoption across different demographic variables including age, gender, discipline, teaching experience, and institutional type.
- To identify the challenges and barriers faculty members face in adopting and effectively utilizing AI tools for research.
- To assess faculty members' perceptions of the benefits and limitations of AI tools in academic research.
- To determine the training and support needs of faculty members for effective AI tool utilization.

Methodology

Research Design

This study employed a descriptive survey research design using quantitative methods to collect and analyze data on AI tool adoption among faculty members.

Population and Sample

Population: The population for this study consisted of all faculty members employed in 3 arts and science colleges of Dindigul District, Tamil Nadu, India. The population comes around 270 faculty members.

Sampling Technique: A purposive sampling technique was employed to select colleges representing different types (government, aided, self-financing) and locations (urban, semi-urban, rural). From the selected colleges, faculty members were chosen using stratified random sampling to ensure representation across disciplines (sciences, social sciences, humanities) and experience levels.

Sample Size: The final sample consisted of 78 faculty members from three arts and science colleges in Dindigul district of Tamil Nadu. While this represents a small fraction of the total population, the sample size is considered adequate for an exploratory study providing preliminary insights into AI adoption patterns.

Data Collection Instrument

A structured questionnaire was developed specifically for this study, consisting of five sections:

- Section A: Demographic Information
- Section B: Awareness and Adoption
- Section C: Usage Patterns
- Section D: Perceptions and Attitudes
- Section E: Support and Training Needs

The questionnaire included both closed-ended questions (multiple choice, Likert scale) and open-ended questions allowing respondents to provide detailed feedback.

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Validity and Reliability: A pilot study was conducted with 10 faculty members (not included in the final sample) to test clarity, comprehensiveness, and reliability. Based on feedback, minor modifications were made to improve question clarity and response options. Cronbach's alpha was calculated for the Likert scale sections, yielding values of 0.82 for perceived benefits and 0.78 for perceived challenges, indicating good internal consistency.

Data Collection Procedure

Data collection was conducted over a three-month period (August-October 2025) through the following process:

1. **Institutional Permission**: Formal permission was obtained from college principals/administrators of participating institutions.
2. **Participant Recruitment**: Faculty members were approached through department heads and email invitations explaining the study's purpose and requesting voluntary participation.
3. **Informed Consent**: All participants provided informed consent, with assurances of confidentiality and anonymity.
4. **Survey Administration**: Questionnaires were administered both in person and online (Google Forms) based on participant preference.
5. **Response Rate**: Of 90 questionnaires distributed, 78 complete responses were received, yielding a response rate of 86.66%, considered very good for academic surveys.

Data Analysis

Data were analyzed using Statistical Package for Social Sciences (SPSS) version 26.0. The following analytical techniques were employed: Descriptive Statistics, Cross-tabulation, Comparative Analysis and Correlation Analysis. Statistical significance was set at $p < 0.05$ for all tests.

Scope and Limitations

This study focuses specifically on faculty members' use of AI tools for research purposes, including literature review, data analysis, writing assistance, reference management, and other research-related activities. It does not extensively examine AI use in teaching, though some overlap is acknowledged. The study is limited to 78 faculty members from selected colleges in Tamil Nadu and therefore may not be fully representative of all arts and science colleges in the state or India more broadly. Findings should be interpreted within this context.

Findings and Discussion

Table 1: Demographic Characteristics of Respondents (N=78)

Characteristic	Category	Frequency	Percentage
Gender	Male	42	53.8%
	Female	36	46.2%
Age Group	25-35 years	28	35.9%
	36-45 years	31	39.7%
	46-55 years	15	19.2%

	Above 55 years	4	5.1%
Discipline	Physical Sciences	22	28.2%
	Biological Sciences	14	17.9%
	Social Sciences	18	23.1%
	Humanities	15	19.2%
	Commerce/Management	9	11.5%
Teaching Experience	Less than 5 years	24	30.8%
	5-10 years	26	33.3%
	11-20 years	21	26.9%
	More than 20 years	7	9.0%
Institutional Type	Government	28	35.9%
	Aided	18	23.1%
	Self-financing	32	41.0%

The sample showed reasonable gender balance (53.8% male, 46.2% female) and representation across age groups, with the largest proportion (39.7%) in the 36-45 age range. The distribution across disciplines ensured diverse perspectives, while the range of teaching experience (from less than 5 years to over 20 years) allowed examination of experience-related differences in AI adoption.

Table 2: Awareness of Specific AI Tools

Of the 78 respondents, 71 (91.0%) indicated they had heard of artificial intelligence tools for research, demonstrating high general awareness. However, when asked to identify specific AI tools by name and function, only 38 respondents (48.7%) could name three or more specific tools, indicating that awareness often remained superficial.

AI Tool/Application	Aware (%)	Used (%)
ChatGPT / Large Language Models	88.5%	42.3%
Google Scholar AI features	76.9%	61.5%
Grammarly / AI writing assistants	74.4%	53.8%
Reference managers (Zotero, Mendeley)	71.8%	56.4%
Data analysis tools (SPSS, R with AI features)	55.1%	28.2%
Plagiarism checkers (Turnitin, iThenticate)	67.9%	44.9%
Research Rabbit / Connected Papers	23.1%	6.4%

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AI Tool/Application	Aware (%)	Used (%)
Semantic Scholar	29.5%	12.8%
AI-powered survey tools	35.9%	15.4%
Machine learning platforms	21.8%	7.7%

The data reveal a significant gap between awareness and actual usage across most tools. ChatGPT showed the highest awareness (88.5%) but only 42.3% usage, suggesting barriers beyond awareness prevent adoption. Tools integrated into familiar platforms (Google Scholar, Grammarly) showed higher usage rates, indicating that accessibility and integration matter significantly.

Table 3: Level of AI Tool Adoption by Demographic Variables

Of the 78 respondents, 52 (66.7%) reported currently using at least one AI tool for research purposes, while 26 (33.3%) reported no current usage. This indicates moderate adoption overall, with two-thirds of faculty members engaging with AI tools to some degree.

Variable	Category	Users (%)	Non-users (%)	χ^2	p-value
Age Group	25-35 years	82.1%	17.9%	15.32	0.002**
	36-45 years	71.0%	29.0%		
	46-55 years	40.0%	60.0%		
	Above 55 years	25.0%	75.0%		
Discipline	Sciences	77.8%	22.2%	9.87	0.043*
	Social Sciences	72.2%	27.8%		
	Humanities	46.7%	53.3%		
	Commerce	55.6%	44.4%		
Institutional Type	Government	60.7%	39.3%	1.24	0.538
	Aided	66.7%	33.3%		
	Self-financing	71.9%	28.1%		
Ph.D. Status	Ph.D. holders	80.0%	20.0%	6.42	0.011*
	Non-Ph.D.	60.4%	39.6%		

*Significant at $p < 0.05$; **Significant at $p < 0.01$

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Key observations:

1. **Age is a significant factor** ($\chi^2 = 15.32$, $p = 0.002$): Younger faculty (25-35 years) show significantly higher adoption (82.1%) compared to faculty above 55 years (25.0%). This suggests a generational digital divide that institutions must address.
2. **Disciplinary differences are significant** ($\chi^2 = 9.87$, $p = 0.043$): Science faculty show the highest adoption (77.8%), while humanities faculty show the lowest (46.7%). This likely reflects both the computational nature of scientific research and disciplinary cultures around technology use.
3. **Ph.D. holders adopt more** ($\chi^2 = 6.42$, $p = 0.011$): Faculty with doctoral degrees show higher adoption (80.0%) than those without (60.4%), possibly reflecting greater research engagement and exposure to advanced research tools during doctoral training.
4. **Institutional type shows no significant difference** ($\chi^2 = 1.24$, $p = 0.538$): Contrary to expectations, government, aided, and self-financing colleges show similar adoption rates, suggesting that institutional resources may not be the primary determinant of individual adoption.

Table 4: Frequency of AI Tool Usage (N=52)

Frequency	Number	Percentage
Daily	14	26.9%
Several times per week	19	36.5%
Weekly	11	21.2%
Monthly	6	11.5%
Occasionally	2	3.8%

Among the 52 faculty members who use AI tools, over 60% of users (63.4%) use AI tools at least several times per week, indicating that once adopted, these tools become integrated into regular research workflows. However, the duration of usage reveals that adoption is relatively recent:

Table 5: Duration of AI Tool Usage (N=52)

Duration	Number	Percentage
Less than 6 months	18	34.6%
6 months - 1 year	21	40.4%
1-2 years	10	19.2%
More than 2 years	3	5.8%

Three-quarters of users (75%) have been using AI tools for less than one year, suggesting that widespread adoption in this population is a very recent phenomenon, likely accelerated by the release of ChatGPT and similar highly accessible tools in late 2022-2023.

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Table 6: Most Frequently Used AI Tools (N=52 users, multiple responses allowed)

Tool/Category	Number of Users	Percentage
ChatGPT/GPT-based tools	38	73.1%
Google Scholar (with AI features)	34	65.4%
Grammarly/AI writing assistants	28	53.8%
Reference managers (Zotero, Mendeley)	27	51.9%
Plagiarism detection tools	23	44.2%
Google Translate/language tools	19	36.5%
Statistical software with AI (SPSS, R)	15	28.8%
Survey platforms with AI analysis	8	15.4%
Specialized research databases with AI	7	13.5%
Machine learning platforms	4	7.7%
AI-powered literature mapping tools	3	5.8%

ChatGPT's dominance (73.1%) reflects its accessibility, ease of use, and widespread publicity. Tools requiring specialized training or discipline-specific knowledge show much lower adoption, suggesting that ease of access and low barriers to entry are crucial for widespread adoption.

Table 7: Research Activities Using AI Tools (N=52, multiple responses allowed)

Research Activity	Number	Percentage
Literature search and review	44	84.6%
Writing and editing	39	75.0%
Citation and reference management	35	67.3%
Language translation and correction	28	53.8%
Summarizing research papers	27	51.9%
Generating research ideas	24	46.2%
Data organization and management	21	40.4%
Creating visualizations and figures	18	34.6%
Statistical analysis	15	28.8%

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Research Activity	Number	Percentage
Coding and programming	9	17.3%
Qualitative data analysis	7	13.5%
Predictive modeling	4	7.7%

Literature search and review (84.6%), writing and editing (75.0%), and citation management (67.3%) emerge as the most common applications. These are largely supportive or administrative tasks rather than core analytical activities. Only 28.8% use AI for statistical analysis, and fewer still for advanced applications like predictive modeling (7.7%), suggesting that faculty members are more comfortable using AI for routine tasks than for substantive analytical work.

Table 8: Perceived Benefits of AI Tools (All respondents, N=78)

Respondents rated various potential benefits on a 5-point Likert scale (1=Strongly Disagree, 5=Strongly Agree):

Benefit	Mean Score	SD	% Agree/Strongly Agree
Saves time in research tasks	4.21	0.89	82.1%
Improves efficiency of literature review	4.15	0.92	79.5%
Enhances writing quality	3.87	1.02	69.2%
Facilitates access to research materials	3.95	0.96	73.1%
Helps organize research data	3.76	1.08	65.4%
Enables handling larger datasets	3.68	1.15	61.5%
Generates new research ideas	3.42	1.21	52.6%
Improves research quality overall	3.54	1.13	56.4%
Increases research productivity	3.89	1.01	70.5%
Provides 24/7 research assistance	4.08	0.94	76.9%

Time-saving (M=4.21) and improved literature review efficiency (M=4.15) received the highest ratings, with over 80% and 79.5% agreement respectively. The ability to access assistance 24/7 (M=4.08, 76.9% agreement) is particularly valued in contexts where human research support may be limited.

Interestingly, generating new research ideas (M=3.42) and improving overall research quality (M=3.54) received more moderate ratings, suggesting that faculty members view AI tools as efficiency enhancers rather than as fundamentally transformative for research creativity or quality.

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Table 9: Perceived Challenges of AI Tools (All respondents, N=78)

Challenge	Mean Score	SD	%Agree/Strongly Agree
Lack of training and guidance	4.15	0.88	80.80%
Concerns about accuracy and reliability	4.08	0.91	78.20%
Insufficient institutional support	3.95	1.01	71.80%
Limited internet connectivity	3.87	1.15	69.20%
High cost of premium AI tools	3.76	1.08	65.40%
Lack of awareness about available tools	3.82	0.99	67.90%
Difficulty in learning new technologies	3.45	1.12	55.10%
Concerns about data privacy	3.91	1.04	70.50%
Fear of over-dependence on AI	3.68	1.16	61.50%
Ethical concerns (plagiarism, authorship)	4.12	0.93	79.50%
Lack of discipline-specific AI tools	3.54	1.09	57.70%
Resistance from colleagues/institution	2.98	1.21	38.50%

The highest-rated challenges are:

1. **Lack of training and guidance** (M=4.15, 80.8% agreement)
2. **Ethical concerns** (M=4.12, 79.5% agreement)
3. **Concerns about accuracy and reliability** (M=4.08, 78.2% agreement)

These findings highlight that barriers to effective AI adoption extend beyond simple access issues. Even among current users, concerns about accuracy (important for 78.2% of all respondents) and ethics (79.5%) remain prominent. The overwhelming agreement on lack of training (80.8%) indicates a critical institutional gap that must be addressed.

Interestingly, resistance from colleagues or institutions (M=2.98, 38.5% agreement) is rated relatively low, suggesting that the primary barriers are practical and knowledge-based rather than cultural or institutional resistance.

Table 10: Training Received on AI Tools (N=78)

Training Type	Number	Percentage
Formal institutional training	8	10.3%
Self-learning (online tutorials, etc.)	43	55.1%
Peer learning/colleagues	22	28.2%

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Training Type	Number	Percentage
Conference/workshop attendance	5	6.4%
No training received	24	30.8%

Only 10.3% received formal institutional training on AI tools, with the majority (55.1%) relying on self-learning. Nearly one-third (30.8%) received no training at all. This lack of systematic training likely contributes to suboptimal tool utilization and persistent concerns about accuracy and ethics.

Table 11: Desired Training Topics (N=78, multiple responses allowed)

Training Topic	Number	Percentage
Hands-on workshops on specific AI tools	68	87.2%
Ethical use of AI in research	61	78.2%
Data analysis using AI tools	55	70.5%
AI for literature review and synthesis	52	66.7%
Writing and editing with AI assistance	48	61.5%
Discipline-specific AI applications	59	75.6%
Critical evaluation of AI outputs	57	73.1%
AI tool selection and evaluation	49	62.8%
Integration of AI into research workflows	46	59.0%
Legal and copyright issues with AI	43	55.1%

Hands-on workshops (87.2%) and ethical use training (78.2%) are most desired, followed by discipline-specific applications (75.6%) and critical evaluation skills (73.1%). The strong demand for ethics training aligns with the ethical concerns identified earlier, suggesting faculty members want guidance navigating this complex terrain.

Table 12: Barriers to Adoption (N=26 non-users, multiple responses allowed)

Barrier	Number	Percentage
Lack of knowledge/training	21	80.8%
Uncertainty about reliability	19	73.1%
No institutional support	18	69.2%
Insufficient internet/infrastructure	16	61.5%

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Barrier	Number	Percentage
Cost concerns	14	53.8%
Prefer traditional research methods	13	50.0%
Ethical concerns	13	50.0%
Too busy to learn new tools	12	46.2%
Don't see relevance to my research	11	42.3%
Fear of making mistakes	10	38.5%
Concerned about job security	2	7.7%

Lack of knowledge and training (80.8%) is the primary barrier, followed by reliability concerns (73.1%) and lack of institutional support (69.2%). These findings suggest that many non-users might adopt AI tools if provided with adequate training, support, and assurance about reliability.

Half of non-users (50.0%) indicate preference for traditional methods, suggesting that some resistance may be philosophical or methodological rather than merely practical. However, the relatively low concern about job security (7.7%) suggests that faculty members do not generally view AI as threatening their professional roles.

Table 13: Dominant AI Applications by Discipline

Discipline	Most Common AI Application (% of users in discipline)
Physical Sciences	Statistical analysis (78%), Data visualization (67%), Literature review (89%)
Biological Sciences	Literature search (93%), Data analysis (64%), Image analysis (43%)
Social Sciences	Survey analysis (56%), Qualitative coding (33%), Literature review (83%)
Humanities	Writing assistance (82%), Translation (73%), Literature review (91%)
Commerce/Management	Data analysis (60%), Writing (80%), Citation management (100%)

These patterns reflect different research methodologies and needs across disciplines. Humanities faculty show highest use for writing assistance and translation, likely due to the text-intensive nature of their work and potential language barriers in accessing international scholarship. Science faculty emphasize analytical applications, while social science faculty show more diverse applications reflecting mixed-methods approaches.

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Table 14: Perceived Impact on Research Productivity (N=52 users)

Impact Category	Number	Percentage
Significantly increased productivity	18	34.6%
Moderately increased productivity	26	50.0%
No noticeable change	7	13.5%
Decreased productivity (learning curve)	1	1.9%

An overwhelming 84.6% of users report at least moderate productivity increases, with over one-third (34.6%) reporting significant increases. Only one user reported decreased productivity, attributed to time invested in learning the tools. These self-reported productivity gains should be interpreted cautiously, as objective productivity measures (publications, grants) were not tracked longitudinally, and perception may not align perfectly with measurable outcomes.

Table 15: Future Intentions Regarding AI Tools (N=78)

Intention	Number	Percentage
Plan to continue current usage (current users)	49	94.2% of users
Plan to expand usage to new applications	41	78.8% of users
Plan to start using AI tools (non-users)	17	65.4% of non-users
Interested in learning more (all respondents)	72	92.3%
No intention to use AI tools	6	7.7%

These findings are encouraging: 94.2% of current users plan to continue, 78.8% plan to expand their usage, and 65.4% of non-users plan to start using AI tools. The near-universal interest in learning more (92.3%) suggests that appropriate training and support interventions would find a receptive audience. Only 6 respondents (7.7%) express no intention to use AI tools, indicating that resistance is limited to a small minority.

Recommendations and Suggestions

For College Administrators and Management: Invest in Comprehensive Training Programs; Develop Clear Institutional Policies and Guidelines; Provide Infrastructure and Access; Create Supportive Structures; Address the Generational Divide

For Faculty Members: Take Initiative in Learning; Develop Critical AI Literacy; Engage Ethically; Balance AI Use with Professional Judgement.

Conclusion

This study provides a baseline understanding of AI adoption in arts and science colleges in Tamil Nadu, identifying both achievements and challenges. As AI technologies continue to evolve rapidly, ongoing research will be essential to track adoption patterns, assess impacts, identify emerging issues, and inform evidence-based

policy. The colleges and faculty members who thoughtfully integrate AI tools while maintaining research integrity and disciplinary rigor will be best positioned to contribute meaningfully to knowledge creation in an increasingly AI-enabled academic world. The integration of AI into academic research is not a question of if, but how. This study suggests that with appropriate support, training, infrastructure, and ethical frameworks, arts and science college faculty in Tamil Nadu—and by extension, across India—can harness AI tools to enhance research productivity while upholding the scholarly values of rigor, integrity, and intellectual contribution that remain the foundation of academic inquiry.

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Leveraging Google Gems in Modern Libraries: An Exploration of Applications and Opportunities

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Abstract

Google Gems, introduced as part of Google's Gemini AI platform, represents a new frontier in customizable artificial intelligence tools that allow users to create specialized AI assistants for specific tasks. This paper explores the potential applications of Google Gems in library settings, examining how these personalized AI tools can enhance reference services, information literacy instruction, collection development, and user engagement. Through practical examples and theoretical frameworks, this paper demonstrates how libraries can leverage Gems to create tailored AI assistants that align with institutional missions while maintaining professional standards. The paper also addresses benefits and best practices for integrating Google Gems into library workflows.

Keywords: Google Gemini, GEMS, Libraries, Research Assistance, Literary Instruction, Best Practices

Introduction

The landscape of library technology continues to evolve rapidly, with artificial intelligence emerging as a transformative force in information services. Google Gems, launched in 2024 as a feature of the Gemini AI platform, allows users to create customized AI assistants with specific expertise, personalities, and instructions. Unlike general-purpose chatbots, Gems can be trained with particular knowledge bases, communication styles, and operational parameters, making them uniquely suited for specialized library applications.

Libraries have long been early adopters of technology that enhances information access and user services. From online catalogs to digital repositories and chatbot reference services, libraries continuously seek tools that improve efficiency while maintaining quality service. Google Gems presents a novel opportunity: the ability to create multiple specialized AI assistants, each designed for specific library functions, user populations, or subject areas.

This paper investigates how libraries can strategically deploy Google Gems across various service areas. It provides concrete examples of Gem configurations for different library contexts and examines the benefits, challenges, and ethical considerations associated with their implementation. As libraries navigate an increasingly AI-integrated information environment, understanding how to effectively leverage customizable AI tools like Google Gems becomes essential for remaining relevant and responsive to user needs.

Understanding Google Gems

What Are Google Gems?

Google Gems are customizable AI assistants built on Google's Gemini large language model. Users can create Gems by providing specific instructions, defining the Gem's expertise area, setting its communication style, and establishing parameters for how it should respond to queries. Once created, a Gem maintains consistent behavior across interactions, effectively serving as a specialized AI assistant.

Key features of Google Gems include:

- **Customization**: Users can define the Gem's role, expertise, tone, and response style

- **Persistence**: Gems retain their configuration across sessions
- **Shareability**: Gems can be shared with others within an organization
- **Versatility**: Multiple Gems can be created for different purposes
- **Integration**: Gems work within the Google Workspace ecosystem

How Gems Differ from Standard Chatbots

Unlike traditional rule-based chatbots or even general-purpose AI assistants, Gems offer several distinctive advantages:

- **Specialization**: Each Gem can be designed with deep focus on a particular domain, task, or user group, whereas general chatbots attempt to handle all queries with the same approach.
- **Personality customization**: Libraries can create Gems with communication styles appropriate to different contexts—formal for academic research assistance, friendly for children's services, or technical for specialized collections.
- **Consistency**: Once configured, a Gem provides predictable responses aligned with library policies and professional standards, reducing the variability common in general AI tools.
- **Multiple assistants**: Libraries can deploy different Gems for different purposes simultaneously, allowing users to select the most appropriate tool for their needs.

Applications of Google Gems in Libraries

Reference and Research Assistance

Libraries can create specialized Gems to support different aspects of reference work:

Example 1: Academic Research Assistant Gem A university library might create a "Research Methods Guide" Gem designed to help students understand different research methodologies. This Gem could be instructed to:

- Explain qualitative versus quantitative research approaches
- Suggest appropriate databases for specific disciplines
- Provide guidance on formulating research questions
- Offer tips on evaluating scholarly sources
- Use encouraging, educational language appropriate for undergraduate students

Configuration instructions might include: "You are a seasoned research librarian helping undergraduate students learn research skills. Explain concepts clearly without jargon. When students ask about finding sources, first help them clarify their research question, then suggest 2-3 specific databases with brief explanations of why each is appropriate. Always encourage critical thinking about source evaluation."

Example 2: Quick Reference Gem A public library could create a "Library Info Assistant" Gem to handle frequently asked questions:

- Library hours and locations
- How to get a library card
- Information about programs and events

- Borrowing policies and renewal procedures
- Technology assistance basics

This Gem could be configured with: "You are a helpful library staff member providing quick, accurate information about library services. Be friendly and concise. For complex questions beyond basic library information, acknowledge the question and direct users to contact reference staff at [contact information]. Always provide specific details about our three library locations and their individual hours."

Example 3: Subject Specialist Gem An academic law library might develop a "Legal Research Navigator" Gem with instructions like: "You are a law librarian assistant specializing in legal research. Help users identify relevant primary and secondary legal sources. Explain legal research concepts in accessible terms. When suggesting research strategies, differentiate between federal and state resources. Remind users that you provide research guidance but not legal advice. For complex legal research questions, recommend consultation with our law librarians."

Information Literacy Instruction

Google Gems can serve as on-demand tutors for information literacy concepts:

Example 4: Citation Helper Gem Libraries commonly receive questions about citation formats. A "Citation Coach" Gem could be designed to:

- Explain differences between APA, MLA, Chicago, and other citation styles
- Provide examples of citations for different source types
- Help students understand why citation matters
- Guide users through creating citations step-by-step
- Identify when to use citation management tools

Configuration: "You are a patient citation expert helping students learn to cite sources properly. When asked about citations, first clarify which citation style is required. Provide clear examples and explain the logic behind citation elements. Encourage use of citation managers like Zotero for complex projects. Use a supportive tone that reduces citation anxiety."

Example 5: Database Search Tutor Gem A "Search Strategy Mentor" Gem could help users develop effective database search skills:

- Breaking research topics into searchable concepts
- Building search strings with Boolean operators
- Using subject headings and controlled vocabularies
- Refining searches that return too many or too few results
- Understanding database filters and limiters

Instructions might include: "You are an instructional librarian teaching database search techniques. Use the PICO framework for health sciences questions or similar structured approaches for other disciplines. Provide step-by-step search building guidance. Give examples using the student's actual topic. Celebrate progress and normalize the iterative nature of research."

Example 6: Evaluation Skills Gem A "Source Evaluator" Gem could teach critical evaluation skills:

- Applying the CRAAP test (Currency, Relevance, Authority, Accuracy, Purpose)
- Identifying predatory publishers
- Recognizing bias and perspective in sources
- Distinguishing scholarly, trade, and popular publications
- Understanding peer review processes

Collection Development and Reader's Advisory

Example 7: Reader's Advisory Gem Public libraries could create a "Book Recommendation Specialist" Gem configured to:

- Ask users about their reading preferences and recent favorites
- Suggest books based on mood, themes, or specific interests
- Explain why particular recommendations match user preferences
- Introduce readers to new genres or authors similar to their favorites
- Provide information about format availability (print, ebook, audiobook)

Configuration: "You are an enthusiastic reader's advisor with deep knowledge of fiction and nonfiction across all genres. When making recommendations, ask about recent books the user enjoyed and what specifically appealed to them. Suggest 3-5 titles with brief descriptions explaining why each matches their interests. Mention if titles are available in our catalog, and encourage users to ask our librarians for holds or additional suggestions."

Example 8: Collection Gap Identifier Gem An acquisitions librarian might create an internal Gem to assist with collection analysis:

- Analyzing curriculum needs against current holdings
- Identifying underrepresented subject areas
- Suggesting titles to fill collection gaps
- Monitoring trends in specific disciplines
- Comparing collections with peer institutions

This internal-use Gem could help streamline collection development decisions while maintaining human oversight for final selections.

Specialized Subject Support

Example 9: Local History Gem A library with significant local history collections could create a "Community Heritage Guide" Gem:

- Providing context about local historical events and figures
- Guiding users to relevant archival materials
- Explaining how to use specific finding aids or indexes
- Offering background on local history research methods

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- Connecting local events to broader historical contexts

Configuration: "You are a local history librarian assistant specializing in [City/Region] history. Help researchers navigate our local history collection by explaining our unique organizational systems and suggesting relevant finding aids. Provide historical context for local events and recommend primary sources in our archives. For genealogy questions, explain our available resources but recommend consultation with our genealogy specialist for complex family history research."

Example 10: Data Services Gem An academic library's data services could deploy a "Research Data Assistant" Gem:

- Explaining data management plan requirements
- Suggesting appropriate data repositories
- Providing guidance on data documentation and metadata
- Introducing data visualization tools
- Explaining FAIR principles (Findable, Accessible, Interoperable, Reusable)

Instructions: "You are a research data management specialist helping researchers plan for data throughout the research lifecycle. When researchers describe their projects, ask about data types, volume, and funder requirements. Suggest appropriate repositories and data management tools. Explain concepts in discipline-appropriate terms. For complex data curation needs, recommend consultation with our data services librarian."

Multilingual and Accessibility Services

Example 11: Multilingual Support Gem Libraries serving diverse communities could create Gems configured to communicate in multiple languages:

- Providing library information in users' preferred languages
- Assisting with resource discovery in multilingual collections
- Explaining library services to newcomers and immigrants
- Offering ESL learning resource recommendations

A "Multilingual Library Guide" Gem could be instructed: "You are a multilingual library assistant fluent in English, Tamil, Hindi, Malayalam, Kannada and Telugu. When users ask questions in any of these languages, respond in their preferred language. Provide information about ESL resources, citizenship exam preparation materials, and multicultural programming. Be sensitive to varying levels of familiarity with library systems."

Example 12: Accessibility-Focused Gem An "Accessible Services Navigator" Gem could help users find and use accessibility resources:

- Information about assistive technologies available in the library
- Guidance on accessing materials in alternative formats
- Instructions for using screen readers with library databases
- Recommendations for accessible learning materials
- Explanations of ADA services and accommodations

Programming and Community Engagement

Example 13: Program Registration Assistant Gem Libraries offering numerous programs could create an "Events and Programs Guide" Gem:

- Providing information about upcoming library programs
- Explaining registration processes
- Recommending programs based on user interests and age groups
- Answering questions about program requirements or materials
- Sharing information about room bookings and community spaces

Configuration: "You are a friendly library programming coordinator helping community members find programs that interest them. When asked about programs, inquire about age group and interests. Describe programs enthusiastically while providing practical details like dates, times, registration requirements, and any materials needed. For detailed registration assistance, direct users to our events calendar or front desk."

Example 14: Makerspace Guide Gem Libraries with makerspaces could deploy a "Makerspace Mentor" Gem:

- Explaining available equipment and technologies
- Providing safety guidelines for different tools
- Offering project ideas for various skill levels
- Directing users to tutorials and learning resources
- Scheduling equipment reservations

Internal Library Operations

Example 15: Staff Training Gem Libraries could create internal Gems for staff development:

- Answering policy and procedure questions
- Providing just-in-time training on library systems
- Helping new staff learn organizational knowledge
- Standardizing responses to common situations
- Serving as a reference for complex workflows

An "Internal Knowledge Base" Gem for staff might include: "You are an internal assistant for library staff, providing information about policies, procedures, and systems. When staff ask about procedures, provide step-by-step instructions and reference relevant policy documents. For patron interaction scenarios, suggest approaches consistent with our customer service values. This Gem is for staff use only and contains internal operational information."

Example 16: Collection Processing Gem Technical services could use a "Cataloging Assistant" Gem to:

- Answer questions about cataloging standards
- Provide guidance on RDA (Resource Description and Access) rules

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- Suggest appropriate subject headings
- Explain MARC field usage
- Offer troubleshooting for cataloging workflows

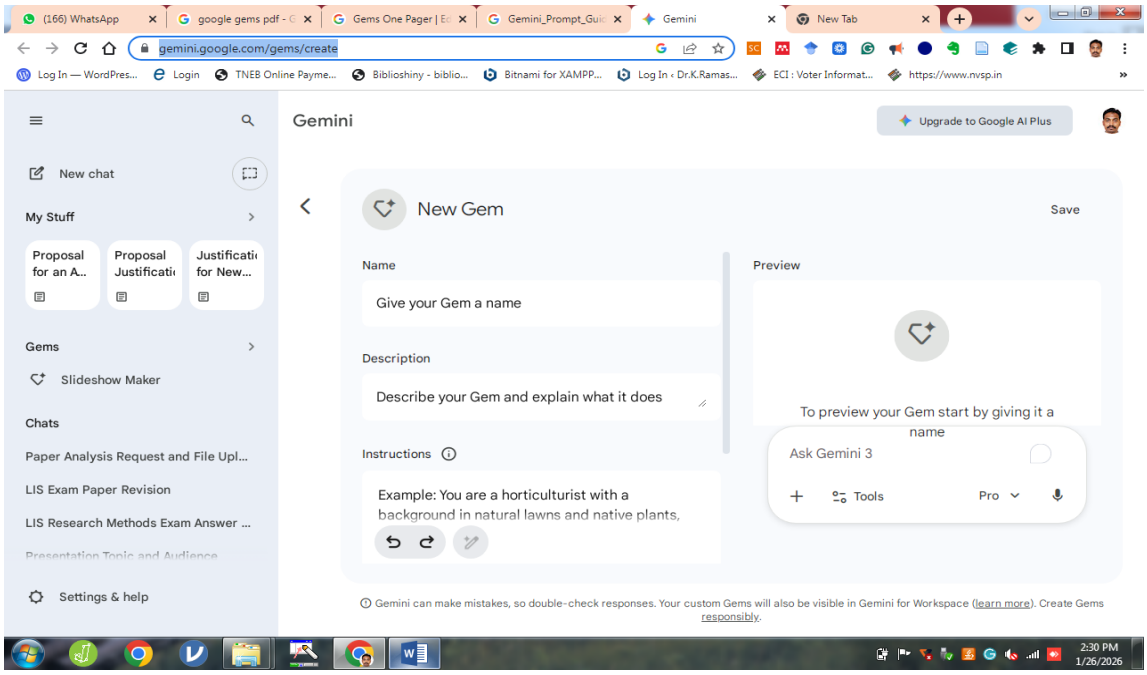


Figure 1: Creating New GEM-1

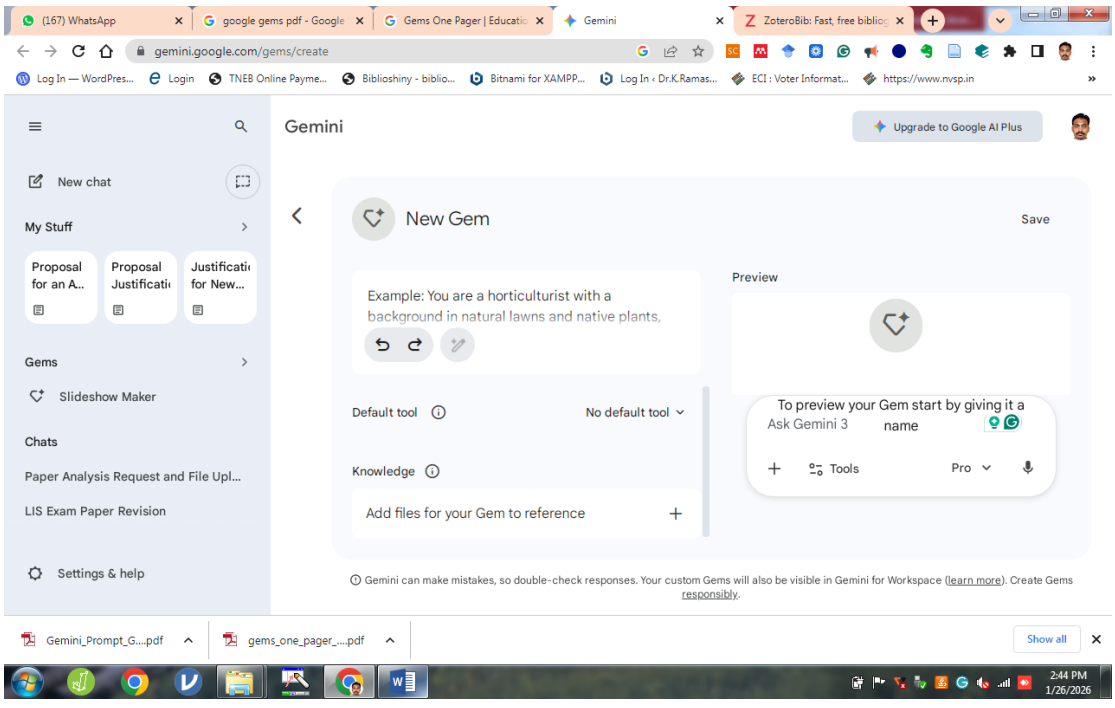


Figure 2: Creating New Gem-2

Benefits of Google Gems in Library Contexts

Customization for Specific Needs

Unlike one-size-fits-all chatbots, Gems allow libraries to create AI assistants precisely tailored to their unique collections, user populations, and service philosophies. A children's library can create Gems with age-appropriate language, while a research library develops Gems with sophisticated subject expertise.

Consistency with Library Values

Libraries can configure Gems to embody professional values such as intellectual freedom, privacy protection, equitable access, and service excellence. Instructions can include reminders about patron confidentiality, unbiased information provision, and inclusive language.

Scalable Expertise

Gems enable libraries to scale specialized knowledge across multiple service points and time zones. A single subject specialist's expertise can inform a Gem that assists users 24/7, extending the impact of professional knowledge beyond individual consultations.

Reduced Cognitive Load

By creating task-specific Gems, libraries reduce the cognitive burden on both users and staff. Users select the Gem that matches their need rather than navigating a complex general system, while staff can use specialized Gems for different aspects of their work.

Enhanced Learning Opportunities

Educational Gems provide scaffolded learning experiences, allowing users to develop information literacy skills at their own pace with patient, consistent guidance. The AI doesn't tire of repetitive questions and can provide unlimited practice opportunities.

Multilingual Accessibility

Google's Gemini platform supports multiple languages, allowing libraries to create Gems that serve diverse linguistic communities without requiring multilingual staff for every service point.

Data-Informed Service Improvement

Interactions with Gems generate insights into user needs, common questions, and service gaps. Libraries can analyze these patterns to improve collections, services, and user education.

Best Practices for Library Implementation of Google Gems

Based on the applications and considerations discussed, the following best practices emerge:

- **Start small and focused**: Begin with one or two high-impact use cases rather than attempting comprehensive Gem deployment.
- **Involve stakeholders**: Engage librarians, staff, and users in Gem design and testing to ensure tools meet actual needs.
- **Document thoroughly**: Maintain clear documentation of each Gem's purpose, instructions, limitations, and maintenance requirements.
- **Establish quality control**: Implement regular review processes to assess Gem accuracy, appropriateness, and effectiveness.
- **Create escalation pathways**: Always provide clear, easy routes for users to connect with human librarians when Gems cannot adequately help.

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- **Monitor and iterate**: Continuously gather data on Gem performance and user satisfaction, using insights to refine configurations.
- **Train staff comprehensively**: Ensure all staff understand how Gems work, when to recommend them, and how to assist users experiencing difficulties.
- **Communicate clearly with users**: Provide transparent information about what Gems are, their capabilities and limitations, and when human assistance is preferable.
- **Protect privacy**: Review terms of service, implement necessary safeguards, and inform users about data handling practices.
- **Maintain professional oversight**: Ensure human librarians remain responsible for service quality and intervene when Gems provide inadequate assistance.
- **Assess accessibility**: Test Gems with screen readers and other assistive technologies to ensure equitable access.
- **Plan for sustainability**: Consider long-term costs, maintenance requirements, and platform dependencies before large-scale implementation.

Conclusion

Google Gems represents a significant opportunity for libraries to leverage customizable artificial intelligence in service of their missions. Unlike generic chatbots or one-size-fits-all AI assistants, Gems allow libraries to create specialized tools precisely aligned with their unique collections, user populations, service philosophies, and professional values.

The applications explored in this paper—from reference assistance and information literacy instruction to collection development and multilingual support—demonstrate the versatility of Gems across diverse library contexts. When thoughtfully designed and strategically implemented, Gems can extend library expertise, provide 24/7 assistance, support learning at scale, and free professional staff to focus on complex, high-value interactions that require human judgment, empathy, and expertise.

However, successful implementation requires careful attention to design principles, rigorous testing, ethical considerations, and ongoing maintenance. Libraries must balance the efficiency gains of AI assistance with commitments to accuracy, privacy, equity, and professional values. Gems should be positioned as tools that enhance rather than replace human librarians, complementing professional expertise while respecting the irreplaceable value of human connection in library service.

As artificial intelligence continues to advance, libraries that thoughtfully experiment with tools like Google Gems will be better positioned to understand both the possibilities and pitfalls of AI integration. By maintaining critical perspectives, prioritizing user needs, upholding professional ethics, and ensuring human oversight, libraries can harness AI technologies to provide more responsive, accessible, and effective services while preserving the human-centered values that remain fundamental to library work.

The future of library services will likely involve sophisticated human-AI collaboration, with tools like Google Gems serving as specialized assistants in a service ecosystem that values both technological innovation and the irreplaceable contributions of skilled library professionals. Libraries that approach this future with intentionality, creativity, and commitment to core values will continue to serve as vital institutions in the evolving information landscape.

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Technological Innovations and Emerging Trends in Modern Libraries

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ABSTRACT

Rapid advancements in information and communication technologies have profoundly transformed the structure, services, and functions of modern libraries. Contemporary libraries are evolving from traditional, print-oriented repositories into dynamic, technology-driven knowledge centers that offer digital, hybrid, and user-centric services. This paper examines key technological innovations and emerging trends influencing modern library services, including cloud computing, mobile technologies, radio-frequency identification (RFID), the Internet of Things (IoT), big data analytics, artificial intelligence (AI), machine learning (ML), blockchain, robotics, and immersive technologies such as augmented and virtual reality. Using a qualitative and conceptual research approach based on an extensive review of scholarly literature, this study analyses the impact of these technologies on library operations, information access, user engagement, and service delivery. The findings highlight that technological integration enhances efficiency, personalization, accessibility, and sustainability of library services while simultaneously redefining the professional roles of librarians. The paper emphasizes the importance of strategic planning, skill development, and ethical considerations to ensure the effective adoption of emerging technologies in modern libraries.

Keywords: Emerging technologies; Modern libraries; Digital transformation; Artificial intelligence; User-centered services

INTRODUCTION

The digital revolution has significantly reshaped the way information is created, stored, accessed, and disseminated. Libraries, as core institutions of knowledge preservation and dissemination, are undergoing a fundamental transformation driven by rapid technological innovation. Traditional library models centered on print collections and physical spaces are increasingly complemented—or replaced—by digital and hybrid service environments.

Emerging technologies such as cloud computing, mobile applications, RFID, IoT, artificial intelligence, and immersive technologies are redefining library operations and user interactions. These advancements enable libraries to deliver personalized, efficient, and remote services while responding to evolving user expectations. At the same time, librarians are required to adapt their professional roles, develop new competencies, and engage in continuous learning to remain relevant in a rapidly changing information landscape. This paper explores major technological innovations and emerging trends shaping modern libraries and examines their implications for library services and professional practice.

OBJECTIVES OF THE STUDY

The objectives of the study are:

1. To describe major technological innovations and emerging trends in modern libraries.
2. To explain the impact of digital technologies on library services and user engagement.
3. To highlight challenges and future directions of technology adoption in libraries.

METHODOLOGY

The present study adopts a qualitative and conceptual research approach. It is based on an extensive review of secondary sources, including scholarly journals, books, conference proceedings, reports, and

authoritative web resources related to library technology and digital transformation. The collected literature was critically analyzed to identify key trends, technological applications, and their implications for modern library services.

REVIEW OF RELATED LITERATURE

Recent studies indicate that modern libraries are transitioning from static repositories into dynamic, technology-enabled knowledge hubs. Researchers have emphasized the growing role of data analytics, artificial intelligence, mobile technologies, and immersive tools in enhancing service delivery and user engagement. While technological adoption has progressed rapidly in developed countries, several studies highlight a disparity in implementation across developing regions, particularly in academic libraries in India. Existing literature underscores the need for infrastructure development, professional training, and institutional support to bridge this gap and fully realize the potential of emerging technologies.

EMERGING TECHNOLOGICAL TRENDS IN MODERN LIBRARIES

Digital Transformation of Libraries

Digital transformation has enabled libraries to expand beyond physical boundaries and provide seamless access to electronic resources. Digital libraries and institutional repositories allow users to access information anytime and anywhere, supporting learning, teaching, and research activities. In India, digital library initiatives have contributed significantly to the preservation of cultural heritage and scholarly communication.

Electronic Resource Management

The increasing reliance on electronic resources has reshaped library collection development and access strategies. Libraries now manage large volumes of e-books, e-journals, and databases using advanced authentication systems such as single sign-on (SSO). Usage analytics supports evidence-based decision-making and helps librarians optimize resource allocation and service quality.

RFID Implementation in Libraries

RFID technology enhances efficiency in circulation, inventory management, and security. Automated check-in and check-out systems reduce transaction time and staff workload while improving accuracy and user satisfaction. RFID also supports self-service models, contributing to streamlined library operations.

Cloud Computing and Cloud-Based Library Solutions

Cloud computing enables libraries to host systems and digital resources on remote servers, reducing infrastructure costs and improving scalability. Cloud-based library management systems support remote access, mobile compatibility, and data integration, making library services more flexible and sustainable.

Internet of Things (IoT)

IoT technologies facilitate automated monitoring and management of library resources, spaces, and services. Applications include smart shelves, environmental sensors, user tracking, and personalized notifications through beacon technology. IoT enhances operational efficiency and supports data-driven service improvement.

Big Data and Data Visualization

Big data analytics allows libraries to analyze large volumes of user and usage data to understand information behavior, improve resource discovery, and enhance decision-making. Data visualization tools such as dashboards and graphs help librarians interpret complex data and identify trends effectively.

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Artificial Intelligence and Machine Learning

AI and ML technologies are transforming libraries by enabling intelligent search systems, automated cataloguing, personalized recommendations, and predictive analytics. These technologies enhance information retrieval accuracy, improve user engagement, and support proactive service delivery.

Mobile-Based Library Services

Mobile technologies extend library services beyond physical spaces by providing access through smartphones and tablets. Mobile applications, messaging platforms, and learning management systems enable real-time communication, remote access, and continuous user engagement.

Immersive Technologies: AR and VR

Augmented and virtual reality technologies offer immersive learning experiences, virtual library tours, and access to rare or fragile collections. These tools enhance inclusivity, engagement, and experiential learning opportunities.

Robotics and Automation

Robotics supports automation of repetitive tasks such as shelving and inventory control. While robotics improves efficiency, libraries must address challenges related to cost, maintenance, and staff reskilling to ensure sustainable implementation.

Blockchain Technology

Blockchain enhances data security, transparency, and digital rights management in libraries. Applications include secure transactions, authentication, copyright management, and preservation of digital records, ensuring trust and integrity in digital services.

CHALLENGES IN ADOPTING EMERGING TECHNOLOGIES

Despite the benefits, libraries face challenges such as high implementation costs, technological complexity, infrastructure limitations, data privacy concerns, and skill gaps among library professionals. Addressing these challenges requires strategic planning, institutional investment, and continuous professional development.

CONCLUSION

Technological innovations and emerging trends have transformed modern libraries into dynamic, user-centered, and technology-driven institutions. By adopting digital tools, automation, artificial intelligence, and immersive technologies, libraries enhance accessibility, efficiency, and user engagement while sustaining their core mission of knowledge dissemination. The successful integration of emerging technologies depends on strategic vision, ethical practices, and continuous skill development among librarians. As libraries continue to evolve, embracing innovation while upholding professional values will be essential for ensuring their relevance and impact in the digital knowledge society.

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Brain inspired AI – Integrating Neuromorphic Computing with Intelligent Systems

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Abstract

The rapid growth of artificial intelligence (AI) has enabled significant advancements in automation, data analysis, and decision-making systems. However, conventional AI architectures face major challenges related to energy consumption, scalability, and real-time processing. Inspired by the efficiency and adaptability of the human brain, Brain-Inspired Artificial Intelligence (BIAI) has emerged as a promising paradigm that integrates neuromorphic computing with intelligent systems. Neuromorphic computing mimics biological neural structures using spiking neural networks and event-driven hardware, while intelligent systems provide learning, reasoning, and autonomous decision-making capabilities. This paper presents a comprehensive study of Brain-Inspired AI, its architecture, applications, advantages, challenges, and future research directions. The integration of these technologies offers energy-efficient, adaptive, and real-time AI solutions suitable for edge computing, defense, healthcare, robotics, and IoT systems.

Keywords: Brain-Inspired AI, Neuromorphic Computing, Intelligent Systems, Spiking Neural Networks, Edge AI

Introduction

Artificial Intelligence has transformed numerous domains, including healthcare, defense, transportation, and smart cities. Traditional AI systems rely heavily on von Neumann architectures and deep neural networks, which require substantial computational power and energy. As AI applications increasingly demand real-time processing and deployment on edge devices, limitations such as high power consumption, latency, and scalability become more pronounced.

The human brain, in contrast, performs complex cognitive tasks using remarkably low energy while demonstrating adaptability, learning, and parallel processing. Brain-Inspired AI seeks to replicate these characteristics by combining neuromorphic computing architectures with intelligent systems. This integration enables machines to process information in a brain-like manner, achieving higher efficiency and autonomy.

This paper explores the foundations of Brain-Inspired AI, emphasizing the synergy between neuromorphic hardware and intelligent software systems to overcome the limitations of traditional AI.

Motivation for Brain-Inspired AI

The motivation behind Brain-Inspired AI arises from several technological and practical challenges:

1. **Energy Efficiency:** Conventional AI models consume large amounts of power, making them unsuitable for battery-powered and edge devices.
2. **Real-Time Processing:** Applications such as autonomous vehicles and defense systems require instant responses.
3. **Scalability Issues:** Increasing model size leads to higher computational and memory requirements.
4. **Edge Intelligence Demand:** Modern systems require local decision-making without constant cloud dependency.

Biological neural systems demonstrate efficient learning and decision-making, motivating researchers to design AI systems inspired by the brain's structure and functioning.

Brain-Inspired Artificial Intelligence

Brain-Inspired AI refers to AI systems designed by emulating the structure, functioning, and learning mechanisms of the human brain. Unlike traditional AI, which relies on continuous numerical computation, brain-inspired systems operate using event-based processing and parallel architectures.

Key Characteristics

- Massive parallelism
- Event-driven computation
- Adaptive learning
- Low power consumption
- Fault tolerance

These characteristics make Brain-Inspired AI suitable for complex and dynamic environments.

Neuromorphic Computing

Neuromorphic computing is a core component of Brain-Inspired AI. It focuses on designing hardware architectures that mimic biological neurons and synapses.

Architecture

Neuromorphic systems use:

- Artificial neurons
- Artificial synapses
- Spiking Neural Networks (SNNs)

Unlike traditional neural networks, SNNs transmit information through discrete electrical spikes, closely resembling biological neural communication.

Aspect	**Focus in Survey**	**Key Observations**	**Insights / Implications**
Artificial Neurons	Models of spiking neurons (e.g., integrate-and-fire, leaky integrate-and-fire)	Neurons process information using time-based spikes rather than continuous activations	Enables biologically realistic computation and supports ultra-low-power processing
Artificial Synapses	Synaptic plasticity and weight storage mechanisms	Synapses adapt dynamically through learning rules such as STDP	Facilitates on-chip learning and adaptability in real-time environments
Spiking Neural Networks (SNNs)	Event-driven neural network models	Information is encoded in spike timing and frequency	Improves energy efficiency and temporal data processing compared to traditional ANNs
Information Encoding	Temporal and spike-based encoding schemes	Spike timing carries critical information	Suitable for real-time sensory data such as vision, audio, and radar signals
Hardware	Neuromorphic chips and	Co-location of memory and	Overcomes von Neumann

Aspect	**Focus in Survey**	**Key Observations**	**Insights / Implications**
Architecture	parallel processing	computation reduces data movement	bottleneck and enhances scalability
Learning Mechanisms	Unsupervised and local learning rules	Learning occurs with minimal global control	Ideal for autonomous and adaptive systems
Energy Efficiency	Power-aware computation	Sparse spike activity leads to lower power consumption	Critical for edge devices, IoT, and defense systems
Biological Inspiration	Brain-inspired design principles	Strong resemblance to biological neural communication	Bridges neuroscience and artificial intelligence research

Features

- Event-driven processing
- Asynchronous operation
- Ultra-low power consumption
- High parallel processing capability

Neuromorphic chips enable efficient processing of sensory data such as vision, sound, and motion.

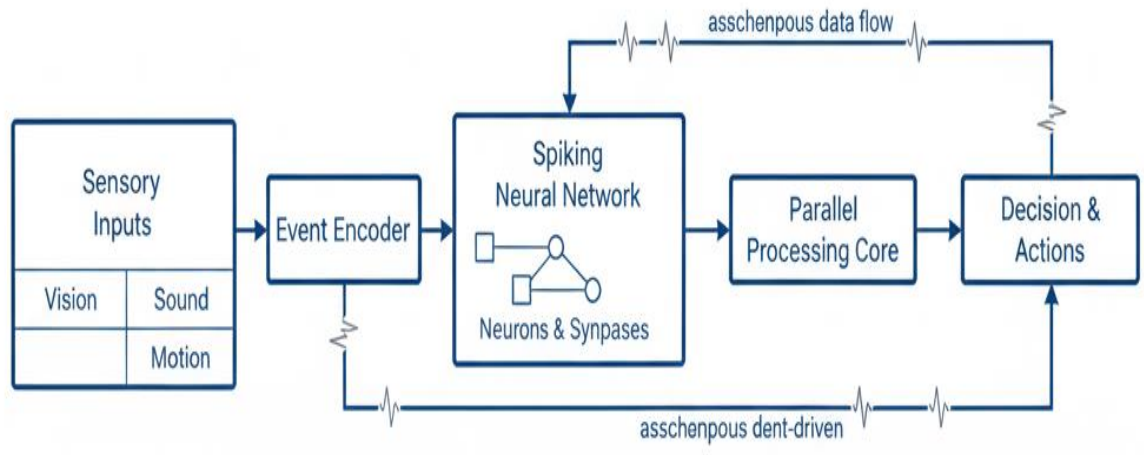


Figure:1 (Features of Brain-Inspired AI)

Intelligent Systems

Intelligent systems are software-based systems capable of learning, reasoning, and decision-making.

Components

- Machine learning algorithms
- Neural networks
- Adaptive control systems
- Autonomous agents

These systems interact with the environment, analyze data, and generate appropriate responses. When integrated with neuromorphic hardware, intelligent systems achieve real-time learning and adaptability.

Need for Integration

Individually, neuromorphic computing and intelligent systems have limitations. Neuromorphic hardware alone lacks high-level reasoning, while intelligent systems on conventional hardware suffer from inefficiency.

Benefits of Integration

- Energy-efficient intelligence
- Faster response times
- Continuous learning at the edge
- Reduced latency and bandwidth usage

The integration results in AI systems capable of autonomous operation in real-world environments.

Integrated Architecture of Brain-Inspired AI

A typical Brain-Inspired AI architecture consists of:

1. **Sensors:** Capture real-time data (vision, sound, motion).
2. **Neuromorphic Processor:** Performs event-based computation.
3. **Intelligent System Layer:** Executes learning and decision-making algorithms.
4. **Actuators / Output Systems:** Trigger actions or responses.

This architecture enables closed-loop intelligence, where systems continuously learn and adapt to their environment.

Applications of Brain-Inspired AI

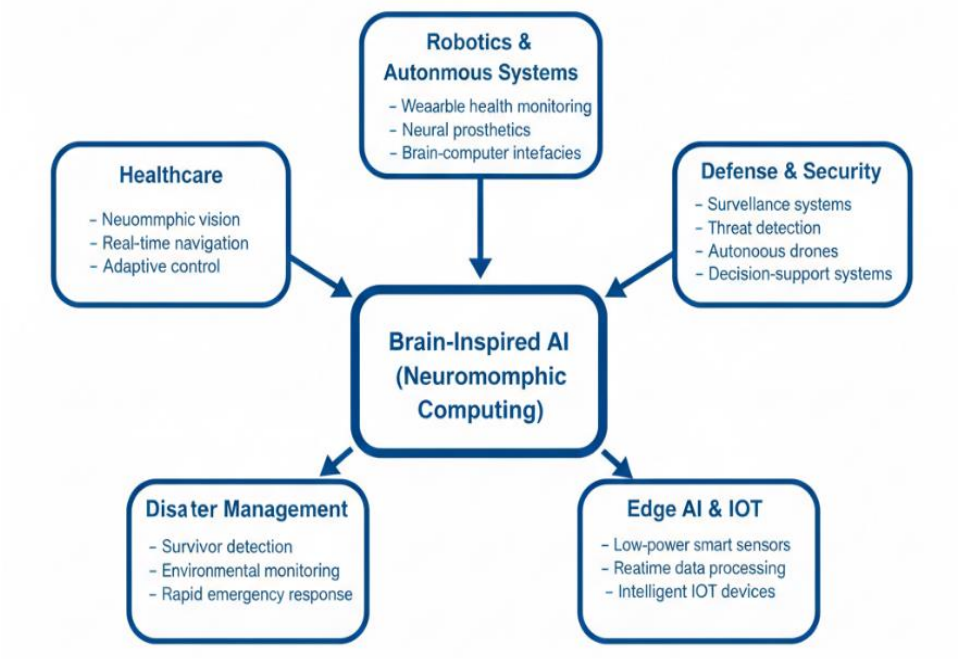


Figure:2 (Applications of Brain-inspired AI)

Brain-Inspired AI is applied across multiple domains:

- **Robotics and Autonomous Systems -** Robots use neuromorphic vision and control systems for real-time navigation and interaction.
- **Healthcare -** Applications include wearable health monitoring, neural prosthetics, and brain-computer interfaces.
- **Defense and Security -** Used in surveillance, threat detection, autonomous drones, and decision-support systems.
- **Disaster Management -** Helps in survivor detection, environmental monitoring, and rapid response systems.
- **Edge AI and IoT -** Enables low-power intelligence in smart sensors and IoT devices.

Advantages of Brain-Inspired AI

- Extremely low power consumption
- High scalability
- Real-time intelligent response
- Improved robustness and fault tolerance
- Suitable for embedded and edge systems

These advantages make Brain-Inspired AI a key technology for next-generation AI systems.

Challenges and Limitations

Despite its potential, Brain-Inspired AI faces several challenges:

1. Complexity in programming spiking neural networks
2. Limited availability of neuromorphic hardware
3. Difficulty in integrating with existing AI frameworks
4. Lack of standardized development tools
5. High initial development cost

Addressing these challenges is crucial for widespread adoption.

Emerging Trends and Future Scope

Future research in Brain-Inspired AI focuses on:

- Hybrid AI models combining ANN and SNN
- Brain-machine interfaces
- Large-scale neuromorphic systems
- Integration with cyber-physical systems
- Sustainable AI development

Advancements in these areas will push AI closer to human-like intelligence.

Impact on the Evolution of AI

Brain-Inspired AI represents a paradigm shift from computation-centric AI to cognition-centric AI. It moves beyond traditional computing limits and aligns AI development with biological efficiency and sustainability.

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Conclusion

Brain-Inspired AI, through the integration of neuromorphic computing and intelligent systems, offers a promising solution to the limitations of traditional AI. By mimicking the efficiency, adaptability, and learning capabilities of the human brain, these systems enable low-power, real-time, and autonomous intelligence. As research and development progress, Brain-Inspired AI is expected to play a vital role in shaping the future of artificial intelligence across multiple industries.

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Redesigning Library Services through Artificial Intelligence Technologies

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Abstract

Artificial Intelligence (AI) is revolutionizing library operations by transforming them into intelligent knowledge environments and reshaping the delivery of information services. This study examines the integration of AI technologies in library functions, including information retrieval, resource organization, and service management. AI-enabled systems improve operational efficiency, facilitate data-driven decision-making, and provide personalized user experiences. By leveraging automation and advanced analytics, librarians can optimize workflows and deliver tailored services to diverse user groups. While challenges such as ethical concerns, infrastructure limitations, and staff skill requirements exist, strategic AI implementation provides significant opportunities for innovation. AI has the potential to create inclusive, adaptive, and future-ready library services in the digital era.

Keywords: Artificial Intelligence, Libraries, Information Services, Digital Transformation

Introduction

Artificial Intelligence (AI) has emerged as a critical driver of innovation in Library and Information Science, transforming how libraries manage, organizes, and delivers information. The growing digitalization of resources, expanding user expectations, and increasing information volumes have created challenges for traditional library services. AI provides solutions that enable libraries to modernize operations, enhance service delivery, and respond efficiently to user needs.

Integration of AI in libraries enhances functions such as cataloguing, information retrieval, content recommendation, and virtual reference services. Machine learning and predictive analytics allow libraries to understand user behavior, enabling personalized services. AI-based catboats and virtual assistants provide instant support, improve accessibility, and enhance user engagement (Harborage & Mukarambi, 2023).

Beyond operational benefits, AI supports research by using tools like natural language processing, semantic analysis, and text mining for deeper exploration of scholarly content. Predictive analytics further assist in resource management and demand forecasting. Consequently, libraries are evolving into intelligent, adaptive hubs that play a central role in the digital information ecosystem (Bisht et al., 2023).

Background of the Study

Artificial Intelligence is becoming increasingly relevant across academic and commercial sectors. In libraries, AI supports advanced search systems, automates repetitive tasks, and enables data-driven decision-making, allowing professionals to focus on specialized services and research facilitation (Pence, 2022).

Adesina and Zubairu (2024) observed rapid AI adoption in libraries through tools such as expert reference systems, robotic automation for material handling, and immersive learning environments with virtual and augmented reality. While workforce displacement concerns exist, AI primarily complements professional expertise, enhancing efficiency and innovation. Continued AI development is expected to reshape library workflows and service models.

Hussain (2023) emphasizes AI as a key technological driver, improving decision-making and supporting innovative service design in libraries. Ethical considerations, infrastructure readiness, and skill development are essential for sustainable AI adoption. Previous studies provide insight into AI applications, challenges, trends,

and evaluation of AI-enabled library services (Ajakaye, 2022; Jha, 2023; Oyelude, 2021; Balasubramanian & Tamilselvan, 2023).

Methodology

This research adopts a **systematic literature review** approach. Academic publications were collected from databases including Web of Science, Scopus, and Google Scholar. Inclusion and exclusion criteria ensured selection of high-quality studies relevant to AI applications in libraries. The selected literature was analyzed to identify AI functionalities, benefits, challenges, and future opportunities.

Objectives of the Study

- Examine the incorporation of AI technologies into library systems and services.
- Assess the impact of AI on the efficiency, accuracy, and quality of library information services.
- Explore AI's potential to transform libraries into dynamic hubs for knowledge creation and dissemination.
- Propose recommendations for effective AI integration to enhance future library services.

AI Integration in Libraries

Concept: AI in libraries refers to using intelligent technologies to improve operations, enhance user services, and support decision-making.

Scope: Applications include automated cataloguing, AI-assisted reference, intelligent information retrieval, user behavior analytics, chatbots, virtual assistants, and recommendation systems. These tools improve accessibility, service quality, and operational efficiency.

Implementation: Effective AI adoption requires:

- Adequate infrastructure
- Staff training and skill development
- Efficient data management
- Financial planning and sustainability (Huang, 2022)

Impact: AI supports access to information, research facilitation, and improves ethical, social, and cultural aspects of library services.

Future Prospects: Emerging AI tools and predictive analytics are expected to transform workflows and support long-term strategic planning in libraries (Tait & Pierson, 2022).

Challenges: Adoption barriers include data privacy, limited resources, staff resistance, interoperability issues, and equitable access.

Ethical Considerations: Ensuring user privacy, algorithmic fairness, transparency, and inclusivity is central to responsible AI use.

Best Practices & Collaboration: Libraries can learn from successful case studies and partnerships with academic institutions, technology providers, and stakeholders to strengthen AI initiatives (Okunlaya, Syed Abdullah & Alias, 2022).

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Impact of AI on Library Services

AI enhances library services by analyzing user behavior and delivering personalized access. Key improvements include:

- **Advanced Information Retrieval:** Improves search speed and precision.
- **Automated Cataloguing:** Reduces staff workload and improves accuracy.
- **Enhanced User Assistance:** Chatbots and virtual assistants provide continuous support.
- **Analytical Insights:** Data-driven collection development and service planning.
- **Inclusive Access:** Supports accessibility tools for diverse users.
- **Optimized Resource Utilization:** Efficient allocation of resources and cost reduction.
- **Continuous Service Improvement:** Adaptive and responsive service delivery.
- **Scalable Services:** Flexible systems for evolving user needs.
- **Ethical AI Use:** Ensures privacy, transparency, and fairness.

Transforming Libraries into Dynamic Knowledge Hubs

AI is reshaping libraries into user-centric, adaptive hubs (Murphy, 2019). Core areas include:

- **Enhanced Knowledge Access** – Personalized recommendations, improved indexing, transparent algorithms.
- **Research Support** – AI tools for literature review, citation analysis, and data management.
- **Interactive Learning** – AI-enabled VR and AR platforms; adaptive learning systems complement traditional teaching.
- **Collaboration Facilitation** – AI matchmaking for partnerships, equitable access to collaborative opportunities.
- **Continuous Service Improvement** – AI-driven feedback and monitoring for service enhancement.
- **Accessibility Enhancements** – Text-to-speech, natural language interfaces, and assistive technology integration.
- **Optimized Resource Allocation** – Predictive analytics for efficient planning and cost savings.
- **Enhanced User Engagement** – Personalized recommendations and feedback-based service optimization.

Leveraging AI for Future Library Optimization

- **Strategic Integration:** Use AI to enhance efficiency, anticipate needs, and shift toward proactive service models (Wooldridge, 2018).
- **Data-Driven Decisions:** Convert large datasets into actionable insights for resource and service planning.
- **Technological Innovation:** Implement intelligent search, virtual assistance, and immersive learning tools.

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- **Staff Empowerment:** Automate routine tasks to allow focus on research support and innovative programs.
- **Accessibility & Inclusivity:** Ensure equitable access for diverse users.
- **Continuous Improvement:** Refine AI systems based on performance metrics and user feedback.
- **Ethical Considerations:** Maintain transparency, accountability, fairness, and privacy.
- **Outcome:** Libraries become adaptive, innovative, and future-ready centers of knowledge.

Conclusion

The integration of AI into library systems is transforming the delivery of information services. AI enhances user engagement, operational efficiency, and provides adaptive, personalized services. Despite challenges such as ethical concerns, infrastructure constraints, and staff training, AI serves as a critical driver of innovation.

With continued adoption, libraries are evolving into dynamic knowledge hubs for creation, dissemination, and access. Intelligent systems will shape the future of library services by promoting accessibility, personalization, and sustainable growth. Strategic and responsible AI implementation ensures libraries remain relevant, trusted, and impactful in the digital information environment.

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Emerging Trends and Technologies in Ransomware Prevention and Response

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ABSTRACT

Ransomware is a type of extortion-based malware designed to lock or encrypt a victim's data, demanding a ransom, typically in the form of money, in exchange for restoring access. This malicious software has gained significant notoriety over the past four to five years, particularly following several high-profile attacks. One of the most notable incidents was the WannaCry ransomware attack, which severely impacted the British healthcare system and brought widespread attention to the threat posed by ransomware. As ransomware attacks have grown in frequency and severity, numerous detection and analysis solutions have been proposed and implemented. These solutions vary in approach depending on the type and scale of the attack, utilizing techniques such as signature-based detection, behavioral analysis, and machine learning algorithms. Despite the development of these methods, they are not without their limitations and challenges. Current detection techniques can struggle with the adaptability of ransomware, which often evolves to bypass security measures. This survey paper aims to provide a comprehensive overview of the existing solutions for ransomware detection and analysis. By examining the various methodologies employed in these solutions, we identify their strengths and weaknesses, highlighting areas where they fall short. The paper also addresses the ongoing challenges in effectively detecting and mitigating ransomware attacks, emphasizing the need for continuous improvement in this area. Through this analysis, the paper seeks to offer insights into the current state of ransomware detection and underscore the importance of developing more robust and adaptable solutions to combat this evolving threat.

KEYWORDS: Ransom, Security Measures, Attack, Detection

INTRODUCTION

Ransomware attacks have dramatically increased in recent years, becoming one of the most widespread and destructive types of cybercrime. Several factors contribute to this rise, including greater reliance on digital infrastructure, the shift to remote work, and the growth of cryptocurrencies, which enable anonymous ransom payments.

1. **Rising Frequency**: The frequency of ransomware attacks has escalated, with 2021 marking a particularly sharp increase. Cybercriminals have become more aggressive, targeting diverse sectors such as healthcare, education, and critical infrastructure.
2. **Advanced Techniques**: Ransomware has evolved from simple encryption malware to more sophisticated threats using methods like double extortion, where attackers not only encrypt data but also threaten to leak sensitive information if the ransom isn't paid. Additionally, they employ obfuscation, packing, and other techniques to avoid detection.
3. **High-Value Targets:** Increasingly, attackers are focusing on larger organizations, governments, and critical infrastructure, understanding that the significant impact of service disruptions increases the likelihood of ransom payments.
4. **Zero-Day Exploits:** The use of zero-day vulnerabilities, which exploit unknown software flaws, has become more prevalent, allowing ransomware to be deployed before security patches are available.
5. **Escalating Ransom Demands:** Ransom amounts have soared, with some reaching into the millions. Cryptocurrencies, particularly Bitcoin, facilitate anonymous ransom payments, making it easier for attackers to receive funds.

6. **Ransomware-as-a-Service (RaaS):** The advent of RaaS platforms has democratized ransomware attacks, allowing even those with minimal technical expertise to launch attacks, thereby increasing the overall volume of incidents.
7. **Global Reach:** Ransomware has become a global issue, affecting organizations and countries worldwide. High-profile attacks like the Colonial Pipeline and WannaCry incidents have highlighted the severe and widespread consequences of these attacks.

A. Ransomware Overview

The upward trend in ransomware attacks highlights the critical need for enhanced cybersecurity, continuous vigilance, and collaboration between the public and private sectors to effectively address this growing threat.

Ransomware is a type of malicious software designed to block or restrict users from accessing their systems or critical data until a ransom is paid. It typically achieves this by either locking the user's screen, effectively freezing the system, or by encrypting specific files, rendering them inaccessible. The more advanced and modern variants of ransomware, often referred to as crypto ransomware, go a step further by encrypting a wide range of file types on the infected system. This encryption is done using complex algorithms that are virtually impossible to break without the decryption key, which is held by the attackers.

Once the ransomware has taken hold, victims are typically presented with a ransom demand, which often includes instructions on how to make the payment. The ransom is usually requested in digital currencies like Bitcoin, which offer a level of anonymity for the attackers. The payment is positioned as the only way for victims to obtain the decryption key needed to restore access to their locked files. If the ransom is not paid within a specified timeframe, the attackers may threaten to delete the decryption key permanently, leaving the files irretrievable.

In recent years, crypto ransomware has become the predominant form of ransomware due to its effectiveness in coercing payments. The impact of such attacks can be devastating, particularly for businesses and organizations that rely heavily on access to their data. This has made ransomware a particularly lucrative and persistent threat in the cyber landscape.

B. Types of Ransomware

Ransomware comes in various forms, each with distinct characteristics and attack methods:

1. **Crypto Ransomware:** The most prevalent type of ransomware, crypto ransomware encrypts the victim's files and demands a ransom in exchange for the decryption key. It is commonly spread through email attachments or downloads from compromised websites. The encryption algorithms used by crypto ransomware are often highly secure, making it extremely difficult to recover the data without the decryption key.
2. **Locker Ransomware:** Also known as screen lockers, this type of ransomware blocks access to the victim's system or specific files without encrypting them. Instead, it locks the user out of their system and displays a message demanding payment to restore access. Locker ransomware is typically distributed through infected websites or phishing emails.
3. **Double Extortion Ransomware:** This form of ransomware combines data encryption with the threat of data theft. Attackers first encrypt the victim's data and then threaten to publish or leak the information online if the ransom is not paid. Double extortion ransomware often targets businesses, where the potential exposure of sensitive data can lead to significant financial losses and reputational damage.

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4. **Ransomware as a Service (RaaS):** RaaS is a model in which the creators of ransomware rent or sell their malicious software to other criminals. This service allows individuals with limited technical expertise to carry out ransomware attacks. RaaS operators provide the necessary software and infrastructure to conduct the attack, typically taking a percentage of the ransom as payment. The accessibility and affordability of RaaS have contributed to an increase in ransomware attacks.

C. Impact of Ransomware

Ransomware attacks can inflict severe financial and reputational harm on enterprises and government agencies. Beyond disrupting business operations and critical services, these attacks can also pave the way for other malicious activities. Quantifying the total cost of an attack is challenging, particularly when considering reputational damage. Often, the expenses incurred from recovering after an attack exceed what early and ongoing investments in prevention would have cost. The financial impacts include: Ransomware attacks can have devastating consequences for businesses, leading to severe financial losses, data breaches, reputational harm, and, in extreme cases, even forcing businesses to close. The aftermath of such an attack can be chaotic and crippling. Financial losses are often immediate and significant. Ransom demands can be exorbitant, draining resources and impacting the company's financial health. Additionally, businesses may face costs related to system restoration, forensic investigations, and the implementation of enhanced security measures.

Data loss is another critical concern. Ransomware encrypts essential data, making it inaccessible without a decryption key. Without reliable backups or if the ransom isn't paid, businesses risk losing crucial information, which can lead to operational disruptions, compliance issues, and legal repercussions. Reputational damage is a long-term consequence of ransomware attacks. The news of an attack can erode customer trust and confidence, negatively impacting future business opportunities. Negative publicity and potential lawsuits can further damage a company's reputation, making recovery even more challenging. In severe cases, businesses may be forced to shut down due to the overwhelming financial and operational strain, coupled with the loss of customer trust. To mitigate these risks, businesses must prioritize preparedness. Implementing strong cybersecurity measures—such as regular backups, advanced security software, and employee training to recognize phishing emails and suspicious links—can significantly reduce the likelihood of falling victim to ransomware. At Pentest People, we offer a wide range of services, including Ransomware Defence Assessments, Email Phishing Assessments, and Mobile Application Testing, to help your organization combat cyber threats, particularly ransomware attacks. Contact us today to learn more.

D. Ransomware Attack Lifecycle

Ransomware has plagued IT security practitioners for nearly three decades, and there is little indication that it will subside anytime soon. This extortion-based form of data theft continues to wreak havoc across organizations of all types and sizes. While ransomware techniques and tactics have become more sophisticated over the years, the structure of a typical attack generally follows a consistent sequence, starting with the distribution of malware and ending with extortion. Gaining a comprehensive understanding of the ransomware lifecycle can provide security teams with crucial insights for defending against these attacks.

The ransomware lifecycle typically encompasses the following stages:

1. **Malware Distribution and Infection:** To initiate the ransomware lifecycle, attackers first need to distribute malware that enables them to access an organization's data and eventually hold it hostage. The most prevalent method of ransomware distribution is through email, particularly by sending phishing emails with malicious attachments or links. Cybercriminals employ social engineering tactics to make these emails appear legitimate. When a user unsuspectingly downloads and opens an attached file or clicks on a harmful link, it

triggers the infection process on their device. Other methods of ransomware distribution include exploiting unpatched software vulnerabilities, using Remote Desktop Protocol (RDP) vulnerabilities, stealing credentials, infecting removable devices like USB drives, and targeting pirated software.

2. **Command and Control:** After the malware has successfully infected a target device, it typically starts communicating with a command-and-control (C&C) server, which is hosted externally on the internet and controlled by the attackers. This server is responsible for sending encryption keys to the infected device and may also deploy additional malware or network-probing tools to assist in further exploration and lateral movement within the network. The timing between the initial infection and the establishment of communication with the C&C server can vary. In some cases, attackers deliberately delay this communication to avoid detection by malware prevention tools and to reduce the risk of early interception.

3. **Discovery and Lateral Movement:** In a sophisticated ransomware attack, the compromised device begins to quietly probe other targets to spread the infection. This phase includes discovery, where attackers gather information about the IT environment to determine the best approach for further attacks, and lateral movement, where they infiltrate additional devices and seek to escalate their access privileges to reach the network's most valuable assets. The wider the malware spreads, the more effective the attackers' extortion efforts are likely to be. To facilitate lateral movement and privilege escalation, attackers often exploit stolen credentials, software vulnerabilities, and network misconfigurations. This phase can extend over several months as the attackers work to establish a persistent presence and gain access to critical resources while avoiding detection.

4. **Malicious Data Theft and File Encryption:** Once the ransomware has established communication with the C&C server, attackers begin scanning infected devices to identify and upload valuable data to the server. Similar to the discovery and lateral movement phase, this data exfiltration process may occur gradually over weeks or months to avoid triggering alerts from unusual network activity. After the data exfiltration is complete, the ransomware proceeds to encrypt the local files on the targeted devices, using the encryption keys supplied by the C&C server.

5. **Extortion:** After the ransomware has encrypted the files on the target devices, the extortion phase commences. Users are typically presented with a message that includes:

- Notification of Infection: Information that the system has been compromised.
- Ransom Demand: The amount of money the attackers require in exchange for the decryption key. Payment Instructions: Detailed steps on how to make the payment.
- Countdown Timer: A clock that shows the remaining time to pay before the data may be permanently lost or the ransom amount may increase.

E. Execution

How ransomware executes once inside a system.

Step 1: Infection and Distribution Vectors

Ransomware, like other types of malware, can infiltrate an organization’s systems through various methods, but certain infection vectors are particularly favoured by ransomware operators.

Phishing emails are one of the most common vectors. A malicious email might include a link to a website hosting a harmful download or an attachment with built-in downloader functionality. If the recipient is deceived by the phishing attempt, the ransomware is downloaded and executed on their computer. Another prevalent infection method exploits services like the Remote Desktop Protocol (RDP). If an attacker obtains or

guesses an employee's login credentials, they can use RDP to remotely access a computer within the enterprise network. Once inside, the attacker can directly download and execute the ransomware on the compromised machine. Some ransomware variants attempt to infect systems directly, similar to how WannaCry exploited the Eternal Blue vulnerability. Many ransomware types utilize multiple infection vectors to maximize their reach.

Step 2: Data Encryption

After gaining access to a system, ransomware begins encrypting files. Leveraging the operating system's built-in encryption functionality, the malware accesses files, encrypts them with a key controlled by the attacker, and replaces the original files with the encrypted versions. Ransomware often carefully selects which files to encrypt to maintain system stability. Additionally, some variants may delete backup and shadow copies of files to complicate recovery without the decryption key.

Step 3: Ransom Demand

Once file encryption is complete, the ransomware initiates the ransom demand. This can be implemented in various ways depending on the ransomware variant. Commonly, the victim's display background is changed to show a ransom note, or text files containing the ransom demand are placed in each encrypted directory. These notes typically require payment in cryptocurrency in exchange for access to the victim's files. If the ransom is paid, the attacker provides either a copy of the private key used for encryption or the symmetric encryption key itself, along with a decrypt or program to restore access to the encrypted files.

F. Ransomware Detection Methods

Signature-Based Detection: Traditional methods relying on known malware signatures. Malware possesses a distinct signature made up of details like domain names, IP addresses, and other identifying indicators. Signature-based detection relies on a database of these signatures to compare against active files on a system. While this is the most fundamental method for detecting malware, it has its limitations. Ransomware attackers can generate new versions of malware with unique signatures for each attack, making signature-based detection ineffective against unfamiliar threats. This leaves systems exposed to new and evolving malware variants that aren't yet recognized.

G. Heuristic/Behavioural-Based Detection

Detecting suspicious behaviours, such as file encryption or communication with C2 servers. Ransomware exhibits abnormal behaviour by opening numerous files and replacing them with encrypted versions. Behavior-based detection monitors for this unusual activity, alerting users when it occurs. Unlike signature-based methods, this approach can identify ransomware based on its actions rather than known signatures, making it effective against new or evolving threats. Additionally, behavior-based detection enhances protection against a variety of cyberattacks by identifying suspicious activities that deviate from normal system behaviour.

Machine Learning-Based Detection

Use of algorithms to identify patterns associated with ransomware. Machine learning-based detection leverages advanced algorithms to identify patterns and anomalies associated with ransomware. By analyzing vast amounts of data, these algorithms learn to recognize behaviors and characteristics typical of ransomware, such as unusual file access, rapid encryption processes, or abnormal network activity. Unlike traditional methods, machine learning can adapt to new and evolving threats, making it more effective at detecting previously unknown ransomware variants. As the algorithm continuously learns from new data, it improves its accuracy in identifying and mitigating ransomware attacks before significant damage occurs.

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Hybrid Detection Methods

Hybrid detection methods combine multiple approaches, such as signature-based, behavior-based, and machine learning-based techniques, to enhance ransomware detection and prevention. By integrating these methods, hybrid detection leverages the strengths of each approach while compensating for their individual limitations. For example, signature-based detection quickly identifies known threats, while behavior-based methods catch suspicious activity, and machine learning detects new, evolving threats. This multi-layered strategy provides a more comprehensive defence against ransomware, improving accuracy, reducing false positives, and ensuring robust protection against both known and emerging ransomware variants.

H. Comparative Analysis

When comparing ransomware detection methods, several key parameters are used:

1. **Accuracy:** Measures how effectively a method identifies ransomware, including new variants.
2. **False Positives:** Indicates the frequency of benign activities being incorrectly flagged as malicious, affecting reliability.
3. **Speed:** Refers to the time taken to detect and respond to ransomware, crucial for minimizing damage.
4. **Resource Consumption:** Assesses the computational and memory resources required by the detection method, impacting system performance.
5. **Scalability:** Evaluates how well the method handles increased workloads or larger environments.
6. **Adaptability:** Gauges the method's ability to evolve with new threats and update itself automatically.

CONCLUSION

Ransomware has emerged as a critical issue in the digital world, exposing the fragility of corporate security and backup practices. Despite the widespread belief that companies have robust backups and security measures, the reality often proves otherwise. This challenge is even greater for individual users, who face significant difficulties in defending against such attacks. As both corporations and individuals increasingly move their data and lives online, the risk grows. Unlike traditional criminals, ransomware attackers are often elusive figures from countries with weak or non-existent law enforcement, making it difficult for authorities to effectively combat the ransomware epidemic.

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Applications of Virtual Reality in Education, Training and Healthcare Sectors

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ABSTRACT

Virtual Reality (VR) has emerged as an important innovation with tremendous potential across numerous sectors, allowing for immersive, interactive, and simulation-based experiences. Virtual reality (VR) allows users to interact with realistic settings that improve knowledge, skill development, and decision-making. This article investigates the use of Virtual Reality in education, training, and healthcare, with an emphasis on how it improves learning effectiveness, professional competence, and the quality of healthcare delivery. VR enables immersive, learner-centred approaches in education by allowing complex topics to be visualized and by creating virtual learning environments that extend beyond standard classroom settings. In training, VR provides safe, cost-effective, and regulated simulations for skill learning in areas such as aviation, manufacturing, and defence. VR in healthcare is used for medical education, surgical training, treatment, rehabilitation, and remote healthcare services. The research also looks at the benefits, problems, and prospects for VR adoption. Overall, the study identifies VR as a potent tool capable of disrupting traditional methods and promoting innovation, efficiency, and better outcomes in education, training, and healthcare.

Keywords: Virtual Reality, Immersive Learning, Simulation, Healthcare Technology, Training Systems

INTRODUCTION

The swift growth of digital technology has fundamentally altered the way information is generated, communicated, and utilized in a variety of fields. Among these technologies, Virtual Reality (VR) has received a lot of attention for its capacity to create immersive, interactive, and experiencing worlds. Unlike traditional learning and training tools, VR allows users to actively participate in simulated real-world settings, which improves engagement, understanding, and skill acquisition.

Education systems have been using virtual reality (VR) more and more in recent years to get over issues including passive learning techniques, abstract material delivery, and a lack of infrastructure. Professional training programs also employ virtual reality (VR) to cut down on overall time, expense, and risk of in-person training. VR has become a useful tool for medical education, surgical simulation, treatment, and rehabilitation in the healthcare industry. The purpose of this study is to present a thorough examination of VR applications in the fields of healthcare, education, and training, emphasizing their advantages, difficulties, and potential.

Objectives of the Study

The primary objectives of this study are as follows:

- To examine the concept and fundamental components of Virtual Reality technology.
- To analyze the applications of Virtual Reality in education, training, and healthcare sectors.
- To assess the benefits of VR in enhancing learning outcomes, skill development, and healthcare delivery.
- To identify the challenges and limitations associated with the adoption of VR technologies.
- To explore prospects and emerging trends of Virtual Reality across different sectors.

Scope of the Study

A conceptual and analytical evaluation of virtual reality applications in the fields of education, training, and healthcare is the extent of this work. Understanding how VR is used for professional skill development, medical education, treatment, rehabilitation, and teaching-learning processes is the main goal of the study. It also considers the operational, ethical, and technological concerns of implementing VR.

The study is based on published research articles, existing literature, and documented case studies rather than experimental testing or direct data collecting. The study's conclusions are intended to offer valuable information to researchers, instructors, trainers, and medical experts who are considering using VR-based solutions.

Concept of Virtual Reality

A computer-generated, three-dimensional environment that mimics actual or imagined environments and enables real-time human interaction is known as virtual reality. In order to provide immersive experiences, VR systems usually combine specialized software with hardware, including controllers, motion trackers, sensors, haptic devices, and head-mounted displays (HMDs).

VR may be divided into three categories based on the degree of immersion: completely immersive VR (HMD-based systems), semi-immersive VR (big displays or projection-based systems), and non-immersive VR (desktop-based systems). Immersion, presence, interaction, and realism are important aspects of virtual reality. Because of these characteristics, VR is very useful for training simulations, treatments, and experiential learning.

Applications of Virtual Reality in Education

Virtual Classrooms and Learning Environments

Irrespective of where they live, students and teachers may communicate in shared digital environments thanks to VR-based virtual classrooms. These settings facilitate group discussions, virtual labs, and cooperative learning, increasing access to high-quality education.

Visualization of Complex Concepts

Many academic disciplines have abstract or complicated ideas that are hard to grasp from textbooks alone. VR improves conceptual knowledge and long-term memory by enabling students to see three-dimensional reconstructions of historical locations, chemical structures, and anatomical systems.

Skill-Based and Experiential Learning

VR simulations provide hands-on learning experiences where students can practice experiments, procedures, and problem-solving tasks without real-world consequences. This approach is particularly beneficial in science, engineering, and medical education.

Inclusive and Special Education

By providing students with impairments with specialized learning settings, virtual reality promotes inclusive education. It makes regulated, distraction-free environments possible as well as learning materials that are customized to meet each student's needs.

Applications of Virtual Reality in Training

VR has become an essential tool in professional and industrial training programs due to its realism and safety.

Industrial and Corporate Training

VR simulations are used by industries including manufacturing, aviation, oil and gas, and construction to teach workers in emergency response, safety protocols, and equipment handling. VR improves operating efficiency and lowers workplace hazards.

Military and Defense Training

Combat scenarios, battlefield settings, and mission planning exercises are simulated via VR-based training systems. In a risk-free setting, these simulations aid employees in honing their tactical and decision-making skills.

Soft Skills and Behavioral Training

Through the simulation of authentic social interactions and work environments, virtual reality (VR) is also utilized to enhance teamwork, communication, leadership, and customer service abilities.

Applications of Virtual Reality in Healthcare

The healthcare sector has widely adopted VR for education, diagnosis, treatment, and patient care.

Medical Education and Surgical Simulation

Surgeons and medical students may repeatedly perform difficult procedures without endangering patients thanks to virtual reality. Surgical simulators enhance procedural competence, accuracy, and confidence.

Therapy and Rehabilitation

Through regulated and interactive activities, virtual reality (VR) aids therapies for anxiety disorders, phobias, post-traumatic stress disorder, and stroke rehabilitation. It is also utilized in pain management, mental health therapy, and physical rehabilitation.

Telemedicine and Remote Healthcare

VR makes patient monitoring, training, and remote consultations easier, particularly in underserved and rural settings. It improves patient involvement in healthcare services and accessibility.

Benefits of Virtual Reality Applications

The implementation of VR offers several advantages across sectors:

- Increased learner engagement and motivation
- Improved knowledge retention and skill acquisition
- Safe, controlled, and risk-free environments
- Cost-effectiveness in long-term training
- Realistic and repeatable simulations

Challenges and Limitations

Despite its advantages, VR adoption faces several challenges:

- High initial cost of VR hardware and content development
- Technical issues such as motion sickness and system latency
- Requirement of technical expertise for design and maintenance

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- Ethical, privacy, and data security concerns, particularly in healthcare

Conclusion

Virtual reality has become a potent and adaptable technology that is revolutionizing the fields of training, education, and healthcare. Because of its immersive and interactive features, learning experiences are improved, training efficacy is increased, and new healthcare practices are supported. Even while issues like cost and technological constraints still exist, it is anticipated that further developments in VR technology will remove these obstacles. A trained workforce, better educational results, and higher-quality healthcare services can all result from the successful incorporation of virtual reality. Virtual reality has become a potent instrument that is revolutionizing training, education, and

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Recent Developments in Emerging Technologies

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ABSTRACT

Emerging technologies refer to innovations whose development and practical applications are still at an early or evolving stage. These technologies are characterized by radical novelty, rapid growth, significant potential impact, and a high degree of uncertainty regarding their future influence across industries. Often viewed as transformative forces, they possess the capacity to disrupt existing systems and redefine the status quo. Key examples include artificial intelligence, nanotechnology, biotechnology, robotics, the Internet of Things, blockchain, and 3D printing. As drivers of a new technological era, emerging technologies enable the creation of innovative tools and contribute to profound changes in industries, societies, and everyday life. This paper presents an overview of widely recognized general-purpose emerging technologies and examines their growing significance.

KEYWORDS: Technology; Emerging Technologies; Artificial Intelligence; Blockchain; Nanotechnology

EMERGING TECHNOLOGIES

Emerging technologies are innovations that are currently developing or expected to have a significant impact on society, industry, and the global economy in the near future. Key examples include artificial intelligence (AI), blockchain, the Internet of Things (IoT), big data, quantum computing, 3D printing, and biotechnology. Each of these technologies represents a foundational element shaping future technological advancement. Some of the most widely recognized general-purpose emerging technologies are discussed below [6–9].

1. 3D Printing

3D printing, also known as additive manufacturing, is a production technique in which objects are created layer by layer using digital models. This technology is transforming traditional manufacturing by enabling rapid prototyping, customization, and the creation of complex structures that are difficult to produce using conventional methods. When combined with internet technologies, 3D printing allows digital design files to be transmitted instantly, enabling products to be manufactured on demand at remote locations and significantly reducing production and delivery time.

2. 5G Technology

5G represents the fifth generation of mobile network technology, offering substantially higher data transfer speeds, wider coverage, and lower latency compared to previous generations. These improvements support advanced applications such as autonomous vehicles, augmented and virtual reality, and large-scale IoT deployments. The availability of high-speed, low-latency connectivity enables real-time communication and rapid processing of massive data volumes. Furthermore, the adoption of private and hybrid 5G networks is increasing as enterprises seek greater control, security, and reliability in their communication infrastructures, contributing to broader economic and technological growth.

3. Artificial Intelligence

Artificial Intelligence (AI) refers to the ability of machines and software systems to simulate human intelligence, enabling them to learn, reason, and perform complex tasks. AI systems support advanced functions such as decision-making, predictive analytics, automation, and content generation. Core areas of AI research include reasoning, learning, knowledge representation, planning, natural language processing, perception, and

robotics. In recent years, generative AI has emerged as a dominant subfield, transforming industries by producing highly realistic text, images, audio, and simulations, thereby reshaping how content is created and consumed.

4. Big Data

Big data refers to extremely large and complex datasets that are generated at high speed and in diverse formats. In the modern digital era, nearly all activities—from online transactions and social media interactions to sensor readings and healthcare records—produce vast amounts of data. Big data can be structured, semi-structured, or unstructured and originates from sources such as smartphones, IoT devices, e-commerce platforms, emails, social networks, and multimedia systems. When effectively analyzed, big data provides organizations with valuable insights into patterns, trends, risks, and customer behavior, enabling improved decision-making, innovation, and competitive advantage.

5. Biotechnology

Biotechnology involves the use of living organisms, biological systems, or their derivatives to develop new products and solutions for health, agriculture, and industry. Recent advancements in areas such as gene therapy, stem-cell research, and synthetic biology are enabling innovative treatments and therapies for complex biological challenges. In agriculture, biotechnology is driving the development of crops with enhanced characteristics, including improved resistance to pests and diseases, higher nutritional value, and increased productivity, thereby contributing to food security and sustainable development.

BENEFITS

Emerging technologies are expected to bring transformative changes across societies and industries by creating new opportunities while simultaneously disrupting traditional systems. Many scholars argue that these technologies have the potential to reduce poverty, alleviate human suffering, and address some of humanity's most pressing global challenges. Continuous innovation from research laboratories worldwide is producing breakthrough solutions at an unprecedented pace. For instance, generative artificial intelligence (AI) systems can create new content such as text, software code, images, videos, and even protein sequences by learning patterns from massive datasets.

Collaboration

Technologies such as 5G networks, cloud computing, and video conferencing platforms have significantly enhanced communication and collaboration. They enable seamless real-time interaction across geographical boundaries, supporting global connectivity, remote work, and virtual teamwork.

Productivity

Automation, artificial intelligence, and the Internet of Things (IoT) streamline workflows, minimize human error, and allow workers to focus on higher-value and more complex tasks. These technologies contribute to substantial improvements in operational efficiency and productivity across industries. AI, in particular, is reshaping business problem-solving, customer engagement, and creative processes by making advanced tools more accessible and adaptable.

Robotic Services

The convergence of labour shortages and increasing demand for automation has accelerated the adoption of service robots. Pilot projects are rapidly evolving into full-scale deployments, improving operational throughput and generating new revenue streams for early adopters. Advanced robots, including polyfunctional,

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humanoid, and collaborative robots, can perform multiple tasks dynamically and operate safely alongside humans, replacing traditional single-purpose machines.

CHALLENGES

Despite their potential to create a more efficient and prosperous future, emerging technologies also introduce significant challenges and ethical concerns. Critics of rapid technological change caution that some advanced technologies may pose serious risks, including unintended social, economic, and even existential consequences. Artificial intelligence (AI) and machine learning systems, for example, may unintentionally reinforce biases embedded in training data, resulting in unfair or discriminatory outcomes. As technologies increasingly make autonomous decisions, ensuring transparency, accountability, and responsible governance becomes a critical concern.

Data Privacy

The extensive collection and processing of data by emerging technologies raise substantial concerns regarding privacy and security. Personal and sensitive data may be vulnerable to misuse, including unauthorized surveillance, social manipulation, or exploitation. As data is increasingly regarded as a valuable economic asset, questions surrounding data ownership, access, and usage have become paramount. Ensuring robust data protection mechanisms, informed consent, and ethical data governance is essential to balance technological innovation with individual rights and societal values.

Ethical Concerns

Ethical debates surrounding emerging technologies often focus on issues of fairness and distributive justice. Unequal access to advanced technologies may exacerbate existing social and economic inequalities, disproportionately benefiting certain groups while marginalizing others. Some critics argue that continued technological development, without appropriate safeguards, could deepen poverty and widen the digital divide, underscoring the need for inclusive and equitable technology policies.

CONCLUSION

Technological advancements are fundamentally reshaping how societies produce, build, and operate across industries. These emerging technologies are central to humanity's future and will play a defining role in the coming decades. Understanding their implications is therefore essential not only for scientists and engineers but for policymakers, educators, businesses, and the general public. From artificial intelligence optimizing production systems to Internet of Things (IoT) devices enabling real-time monitoring and quality control, the influence of emerging technologies is extensive and far-reaching.

In today's rapidly evolving technological landscape, emerging technologies function both as powerful disruptors and as critical enablers of innovation and growth. Organizations and individuals who proactively adapt to these changes are better positioned to remain competitive, while those who fail to do so risk falling behind. Staying informed and developing relevant skills is increasingly important for future-proofing careers and ensuring organizational resilience.

As emerging technologies continue to advance, the responsibility lies with society to harness their potential in an ethical, inclusive, and sustainable manner. By adopting responsible innovation practices and informed governance, these technologies can be leveraged to create a more equitable and prosperous future. Additional insights into emerging technologies can be found in the literature cited in references and in specialized publications such as the *Journal on Emerging Technologies*.

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The Role of the Internet of Things (IOT) in Academic Libraries as a User-Friendly Facilitator for Patrons

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ABSTRACT

We are entering a new phase of computer technology commonly referred to as the Internet of Things (IoT), which is expected to significantly transform the way people live and interact with information systems. IoT represents the next stage in the evolution of the Internet, shifting from an Internet of Communication to an Internet of Things, where physical objects are interconnected and capable of exchanging data with minimal or no human intervention. In the context of academic libraries, IoT serves as a foundation for developing smart libraries that offer user-friendly services to patrons. This paper explores the role of IoT as a facilitator that enhances user experience, service efficiency, and security in academic libraries. It specifically focuses on the application of IoT technologies in academic libraries in India. The paper begins with an overview of IoT, followed by a discussion on its potential applications in academic library environments and the challenges involved in implementing IoT-based systems.

KEYWORDS: Internet of Things (IoT), Cloud Computing; Mobile Applications, Academic Libraries, Patrons

INTRODUCTION

Information Technology devices and the Internet play a vital role in modern human life. These technologies have become an integral part of day-to-day activities and possess immense potential in transforming how information is accessed and utilized. Initially, the Internet was mainly used in a traditional manner for browsing and searching information. However, it has now entered a new phase known as "Internet Plus."

The term *Internet Plus* was first introduced by the Chinese Prime Minister Li Keqiang in the Government Work Report in March 2015, attracting significant attention across various sectors. Internet Plus is a comprehensive concept that integrates technologies such as Mobile Internet, Cloud Computing, Big Data, and the Internet of Things (IoT). The Internet Plus strategy emphasizes the integration of Internet technologies with traditional industries through advanced information and communication technologies. Its primary objective is to create a new ecosystem that fosters innovation, efficiency, and development across different domains.

INTERNET OF THINGS (IoT)

The term Internet of Things (IoT) is derived from two components: *Internet* and *Things*. The Internet, commonly referred to as the *Net*, is a global system of interconnected computer networks that enables users to access and share information worldwide. *Things* refer to physical objects or real-world devices. The Internet of Things is a cloud-based technological framework in which physical objects are connected to the Internet—either locally or globally—through sensors and embedded systems, enabling them to collect, exchange, and process data.

The concept of IoT was first introduced in 1999 by British technology pioneer Kevin Ashton, who defined it as "a system where the Internet is connected to the real world via ubiquitous sensors." He emphasized the use of Radio Frequency Identification (RFID) technology to connect physical objects to the Internet, allowing automatic identification and tracking without human intervention.

Several scholars and technologists have provided their perspectives on IoT. Sir Tim Berners-Lee highlighted the relationship between IoT and the Semantic Web, stating that linking real-world objects to the

web using Uniform Resource Identifiers (URIs) represents the final step in connecting physical things to digital networks. According to Wikipedia, the Internet of Things refers to a wireless and self-configuring network of objects, such as household appliances, that communicate with each other. Wim Elfrink, Executive Vice President of Cisco, stated that IoT is already a reality and continues to create unprecedented opportunities, emphasizing the importance of preparing future generations to contribute to IoT-driven innovation.

In recent years, IoT has gained widespread recognition as a key technology that extends Internet connectivity and computing capabilities to a wide range of devices, sensors, and everyday objects, enabling smarter and more efficient systems.

LITERATURE REVIEW

The Internet of Things (IoT) is an emerging area within Information and Communication Technology (ICT). However, literature related to the application of IoT in the field of Library and Information Science (LIS) is still limited. Existing studies mainly focus on conceptual understanding, technological frameworks, and potential applications in library environments.

Xueqing Liu and Wenwen Sheng [6] described IoT as the *Internet of Objects*, referring to the networked interconnection of physical items enabled through various information-sensing devices such as Radio Frequency Identification (RFID), infrared sensors, Global Positioning Systems (GPS), laser scanners, and other similar technologies. According to the authors, when objects are embedded with chips and sensors, they gain the ability to "think," "sense," and "communicate" with one another, thereby enabling intelligent interaction among devices.

Matthew B. Hoy [7] emphasized that the fundamental concept of IoT lies in the idea that the Internet is no longer a place that users merely visit. Instead, through the connectivity of devices and objects, operations can be managed beyond physical boundaries. He highlighted that libraries are uniquely positioned to benefit from IoT technologies, as these devices can be seamlessly integrated into library spaces. Additionally, librarians can act as knowledge facilitators, helping patrons understand and effectively use IoT-enabled technologies in their daily lives.

Shamprasad M. Pujar and K. V. Satyanarayana [8] discussed the concept of IoT by reviewing definitions proposed by various scholars and further provided their own definition. They defined IoT as a system that enables natural or man-made objects to communicate with each other and exchange data using assigned IP addresses, with or without human intervention. The authors also explained the growth and development of IoT and the technologies that enable its functioning, including RFID, wireless communication devices such as beacons, sensors, energy-harvesting technologies, cloud computing, and IPv6.

Furthermore, the authors discussed the potential applications of IoT in libraries, stating that although IoT is still in its early stages, it holds immense potential for enhancing library services. They emphasized that IoT can help libraries add value to their services and provide enriched user experiences. Since libraries already use RFID technology for tracking and managing resources, IoT can further extend this functionality by enabling direct Internet-based interaction with physical objects such as books, journals, CDs/DVDs, and theses. IoT applications can also help address long-standing library issues such as resource misplacement and monitoring usage patterns [9].

Ashwini Nag and Khaiser Nikam [9] examined the concept of IoT in academic libraries with a focus on improving patron services. Their study highlighted the role of emerging technologies such as cloud computing, Magic Mirror, and pressure sensor pads integrated with wireless sensor networks. The authors argued that these technologies can enhance resource utilization, improve management services, and increase operational

efficiency in academic libraries. The proposed systems are expected to enhance user convenience and are likely to be effectively adopted in the near future**.**

IoT APPLICABLE AREAS IN ACADEMIC LIBRARIES

When library administrators or ICT professionals discuss the implementation of the Internet of Things (IoT) in academic libraries, the primary objective is to achieve a high level of automation in library operations and services. Although digital libraries enable access to electronic resources through a single click, IoT-based libraries differ in nature. While digital libraries focus mainly on digital content, IoT applications extend to both physical resources and digital assets, enabling seamless interaction between users and library objects. The following are key areas where IoT can be effectively applied in academic libraries.

A. Virtual Tour and Patron Orientation

The implementation of IoT in academic libraries can begin with a virtual tour and orientation service designed for registered patrons. By downloading a dedicated mobile application on iOS or Android devices, users can access an interactive virtual tour and orientation video. This feature provides an overview of the library layout, services, rules, and facilities, helping new users become familiar with the library environment.

B. Smart Shelf Guidance Based on Patron Preferences

One of the major challenges faced by new patrons is locating required resources within the library. Most academic libraries already use library management systems with online public access catalogues (OPAC). Through IoT integration, patrons can create personalized profiles and maintain a list of preferred resources such as books, CDs/DVDs, and theses. When they enter the library, IoT-enabled audio or video shelf guides can assist them in locating these materials quickly and accurately.

C. Online Fine and Fee Payment

IoT applications can provide real-time information regarding overdue items and fines incurred by patrons. This system enables users to pay fines online without standing in queues at the circulation desk. Additionally, IoT-based platforms can facilitate online payment for other library services, such as plagiarism checking and document delivery.

D. Availability of Library Equipment and Seating

IoT can assist patrons in identifying the availability of library equipment and facilities upon entering the library premises. Through their mobile devices, users can view which computers are currently in use and which are available. Information regarding printers, scanners, photocopiers, seating in reading halls, discussion rooms, meeting rooms, research scholars' cabins, and faculty rooms can also be accessed in real time, enhancing convenience and efficient space utilization.

E. Alert and Notification Services

IoT-enabled alert services notify patrons about overdue materials, reserved items that have become available, and important library announcements. According to Shamprasad M. Pujar and K. V. Satyanarayana [8], IoT systems can analyze user data and borrowing history to provide personalized recommendations using real-time information. For instance, when a researcher searches for resources on a particular topic, IoT can suggest additional relevant materials. Moreover, when a user visits or comes near the library, the system can inform them about new arrivals in their area of interest or the availability of previously borrowed or reserved items.

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DATA INTERPRETATION AND ANALYSIS

A structured questionnaire was circulated via Gmail to seventy academic libraries across the Indian subcontinent to collect data related to the awareness, implementation, benefits, and challenges of the Internet of Things (IoT) in academic libraries. Out of these, twenty-six libraries responded, and twenty-three complete responses were considered valid for detailed analysis. The collected data were analyzed using pie charts and bar charts for clear interpretation.

Awareness of IoT among Library Professionals

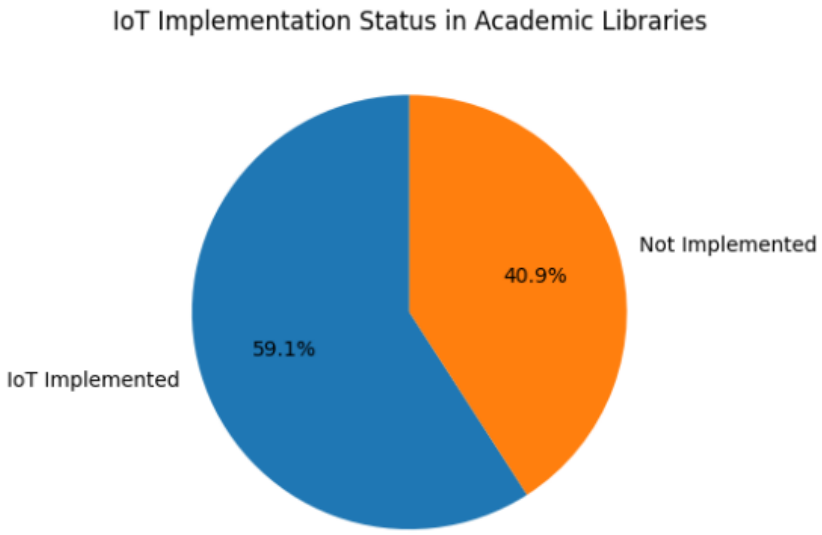
The first question examined awareness of the term *Internet of Things (IoT)* among library professionals. The findings reveal that 95.7% of respondents were aware of IoT, while only 4.3% had not heard of the term, indicating a high level of awareness among LIS professionals.

Sources of Awareness

Respondents reported that they became aware of IoT through multiple sources. These include conferences and seminars (52.2%), professional discussions and meetings (52.2%), and journals and magazines (26.1%). This highlights the importance of professional forums and scholarly communication in spreading awareness about emerging technologies.

IoT Implementation in Academic Libraries

The analysis shows that 59.1% of academic libraries have implemented IoT applications, whereas 40.9% have not yet adopted IoT technologies.



Areas of IoT Application

Among libraries that have adopted IoT, the highest level of implementation was observed in textbook collections (81.3%), followed by new arrivals alert services (62.5%), theses and dissertations (56.3%), and study chairs, computers, printers, and scanners (43.8%). IoT usage in audio/video collections (37.5%), discussion rooms, faculty cabins, research scholar cabins, and online fine payment systems (31.3%) was comparatively lower. Only 18.8% of libraries reported full IoT implementation across all services.

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Benefits of IoT in Academic Libraries

All respondents (100%) agreed that IoT applications help save patrons' time. A significant number of library professionals stated that IoT improves communication with library resources (85.7%), keeps users updated (81%), and encourages active patron participation and monitoring (71.4%). Additionally, 66.7% felt that IoT provides a digital view of physical resources, making it easier to locate and manage library materials.

Challenges in IoT Implementation

Despite its benefits, libraries face several challenges in implementing IoT. The major challenges identified were technical issues (76.2%), manpower constraints (61.9%), infrastructural limitations (57.1%), and financial constraints (52.4%). Other concerns included real-time response issues (47.6%), big data management (33.3%), and scalability, privacy, security, and interoperability (28.6%).

CONCLUSION

The application of the Internet of Things (IoT) in academic libraries represents the evolution of libraries into smart knowledge centers, similar to the development of smart cities and smart homes. IoT offers significant opportunities to achieve comprehensive automation within Library and Information Centres (LICs), enhancing service efficiency, resource management, and user experience. However, the Indian context presents several challenges, including technical, infrastructural, financial, and manpower-related constraints, which limit large-scale implementation. To address these issues, strong support and encouragement from the Government of India are essential, particularly in formulating policies and providing financial and technological assistance to library administrators and decision-makers. Despite the existing challenges, there is considerable potential for growth, and the authors remain optimistic about future advancements in the adoption of IoT in academic libraries.

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Global Research Trends in AI Literacy: A Scientometric Perspective from SCI, SSCI and ESCI

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Abstract

This research paper presents a scientometric assessment of AI literacy research since 2016 through 2025 based on the Web of Science Core Collection data. 2,287 publications with 21,193 citation counts were included for analysis with Biblioshiny (R-Bibliometrix) for determining author productivity (Lotka's Law), annual growth, leading sources, country level output and keyword co-occurrence. The overall growth rate of the literature is modest, with accelerated growth after 2021 and an even more pronounced increase after 2023. The citations issued have continued to rise faster than the number of articles published, demonstrating an increasing body of literature regarding AI literacy. Lotka's Law applies in that there is a very small number of prolific authors publishing the majority of the papers. Several new journals are becoming among the top journals publishing AI literacy research. Although there is a greater number of articles published from the United States and China, authors in Jordan, Ireland, and the United Arab Emirates have a higher average citation impact. There has also been a shift in keyword usage from general AI terms to applied and educational pattern recognition with the introduction of the term "Chat GPT". These findings indicate that AI literacy will be a rapidly evolving globally critical area of study.

Keywords: Artificial Intelligence Literacy, Scientometric Analysis, Research Trends, Lotka's Law, Annual Growth Rate, Research Trends

Introduction

The tremendous growth of AI in decision-making, communication, and educational settings has made understanding and being able to critically analyse AI - known as AI literacy - one of the most important skills for the 21st century population. Having an understanding of how to use AI technology but also being aware of ethical issues, being able to evaluate what AI produces and having an understanding of the impact of AI on society in terms of bias, privacy and accountability are some of the significant elements that will facilitate success in the area of AI literacy.

Over the last decade, there has been a considerable increase in the volume of research conducted on AI literacy and as a consequence there have emerged a number of different frameworks and pedagogical approaches towards developing AI literacy within a number of different subject areas; education, computer science, information science and social science. Although there have been some literature reviews published that report on this literature, there have not been any literature reviews that have incorporated a complete and quantitative analysis of the entirety of the literature relating to AI literacy.

Using scientometrics to provide a systematic procedure for mapping the growth of research in a certain subject area. Therefore, this study uses a scientometric approach to provide a comprehensive overview of all scholarly work linked with AI literacy published between 2015 and 2025 and as listed in the Web of Science Core Collection (i.e. SCI, SSCI and ESCI). In addition, the analysis is provides information about trends in publications, leading authors, key journals, and thematic areas; providing clarity about the global landscape of research associated with AI literacy and future areas that warrant further research into AI literacy.

Review of Literature

By integrating scientometric methodologies with an analysis of artificial intelligence (AI) literacy, researchers are able to conduct systematic mapping of this highly dynamic research area. Using bibliometric tools, such as bibliometrix, researchers are able to conduct large-scale analyses of publication output, collaboration patterns, and thematic evolution across disciplines **(Aria & Cuccurullo, 2017)**. To help guide researchers in exactly how to conduct bibliometric analyses, **Donthu et al. (2021)** proposed methodology frameworks that provide a standardised set of best practices for conducting bibliometric analyses in terms of rigor, transparency, and reproducibility of results.Research indicates persistent gaps between theoretical development and implementation of AI in education, as reported by **Chen et al. (2020)** who highlighted the need for coherent AI literacy frameworks. Through a review of AI-in-education research published between 2010–2020, **Zhai et al. (2021)** noted rapid growth and conceptual fragmentation. **Long and Magerko (2020)** responded by defining the foundational competencies of AI literacy which include: understanding, interaction with, and the critical evaluation of AI; systems.**Huang et al. (2017)** have shown that Emerging Sources Citation Index (ESCI) is a valuable source of data for investigating interdisciplinary and immature research fields; AI Literacy is an example of such a topic that encompasses several fields, including Technology, Education and Social Sciences. Building on this idea, **Tenor even et al.(2023)** performed the first bibliometric analysis related to AI Literacy. The researchers identified major themes, such as Ethics, Pedagogy and Computational Thinking, but noted an overall lack of geographical diversity within the studies. Together these studies validate the validity for combining usage of SCI, SSCI and ESCI to create a complete scientometric map of AI Literacy. Currently, according to the most recent information available (2023), not enough research has been done on recent advancements related to AI Literacy. Therefore, research expansion should occur to encompass global participation by countries as they continue to study new topics within AI Literacy.

Objectives

The major objectives of this study are:

1. To assess the yearly patterns for both the amount of AI literacy publications and citations for 2016 through 2025 Using the Annual Growth Rate (AGR);
2. To identify Authors Productivity in the field of AI Literacy using Lotka's Law;
3. To determine top authors and sources identified using their h-index, g-index, m-index, total number of citations and publications;
4. To identify the most cited countries and also country-wise scientific production through SCP and MCP;
5. To analysis keyword co-occurrence in AI Literacy Research.

Methodology

The study obtained data from the Web of Science Core Collection (consisting of the Science Citation Index Expanded, the Social Sciences Citation Index and Emerging Sources Citation Index) to provide a wide range of content related to current AI literacy research as well as new developments in AI literacy. A keyword search was conducted using the following terms: TS=("AI literacy"). The time frame restricted data between 2016 and 2025 and restricted to English journal articles and conference proceedings. After completing a PRISMA search to identify duplicate and non-reference records using title, abstract, and publication type, the dataset was created in plain text and then analyzed using the Bibliometrix R package via the Biblioshiny interface. This analysis examined annual publication trends, author and source productivity (Bradford's Law and Lotka's Law), citation impact, collaborative networks and co-occurrence of keywords.

Data Analysis and Interpretation

1. Annual Growth Rate (AGR) of AI Literacy Publications and Citations (2016-2025)

AI Literacy Publication & Citation Annual Growth Rate 2016-2025.The annual growth rate (AGR) for AI literacy from 2016 to 2025 can be seen in both publications and citations as shown in the figure above showing the overall increase of research output and academic influence from AI literacy research pre- and post-2023 will increase relatively at rapid pace. There has been a continuous steady increase in the amount of AI literacy research from 2016 through 2020, however, there is marked rapid growth from 2021 onward, particularly after 2023. Publications are growing with an AGR between 31% and 263% over the later years as well as citations at an AGR between 122% and 303%, thus citations are growing at a more robust pace than publications indicating that there are not only more AI literacy research publications being created, but there is also a high level of citation prevalence for these studies demonstrating relevancy and high value to the worldwide scholarly community. The rapid growth of AI literacy research beginning at approximately 2023 indicates that the world is focusing on AI education and literacy and that this research is becoming well-established globally and of greater importance related to studies of technology, education, and policy.

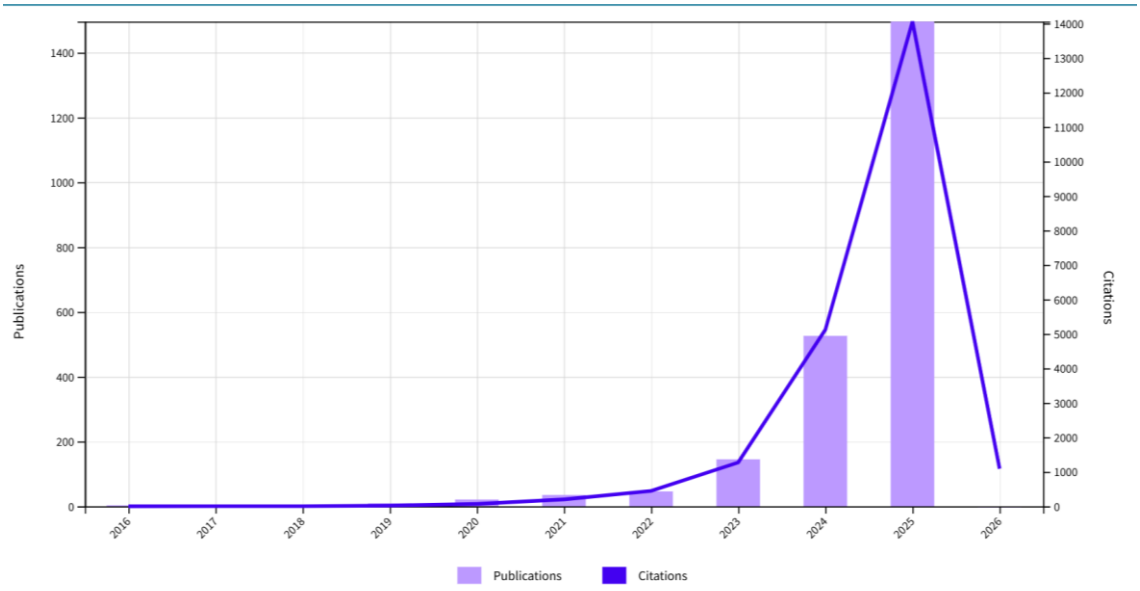


Figure 1: Publications Over Time

Table 1: Annual Growth Rate (AGR) of AI Literacy Publications and Citations (2016-2025)

Sl. No	Year	Recs	AGR (Publication %)	Citations	AGR (Citation %)
1	2016	3	-	1	-
2	2017	4	33.30%	3	200%
3	2018	2	-50%	3	0%
4	2019	9	350%	19	533%
5	2020	21	133%	70	268%
6	2021	35	66.70%	201	187%
7	2022	46	31.40%	447	122%

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8	2023	145	215%	1270	184%
9	2024	526	263%	5122	303%
10	2025	1496	184%	14057	174%
	Total	**2287**	**12.264**	**21193**	**19.71**

2. Author Productivity through Lotka's Law

Lotka's Law states that there is an unequal spread of quantity in scholarly works among different authors in any field of study, and analysis of Lotka's Law of Distribution (Figure 2) supports this claim. The figure above shows that most authors only published one document (the steep decline in the observed curve) and have a small number of people who publish multiple documents (the long, flat tail). When comparing to the expected result/expected value of publication (dashed line), we find that the number of moderately productive authors is slightly below what Lotka said they would be (i.e., the majority of authors publish sometimes, not always). The pattern also demonstrates that there is a core group of highly productive authors driving research output and that the majority of authors produce very little but are contributing in a sporadic manner. This is a trend that has been shown throughout the scientific community. The study provides evidence for the inequity in research output and supports Lotka's theory about author publishing distribution: "The number of authors publishing n papers is approximately equal to $1/n^c$, where c is usually between 2".

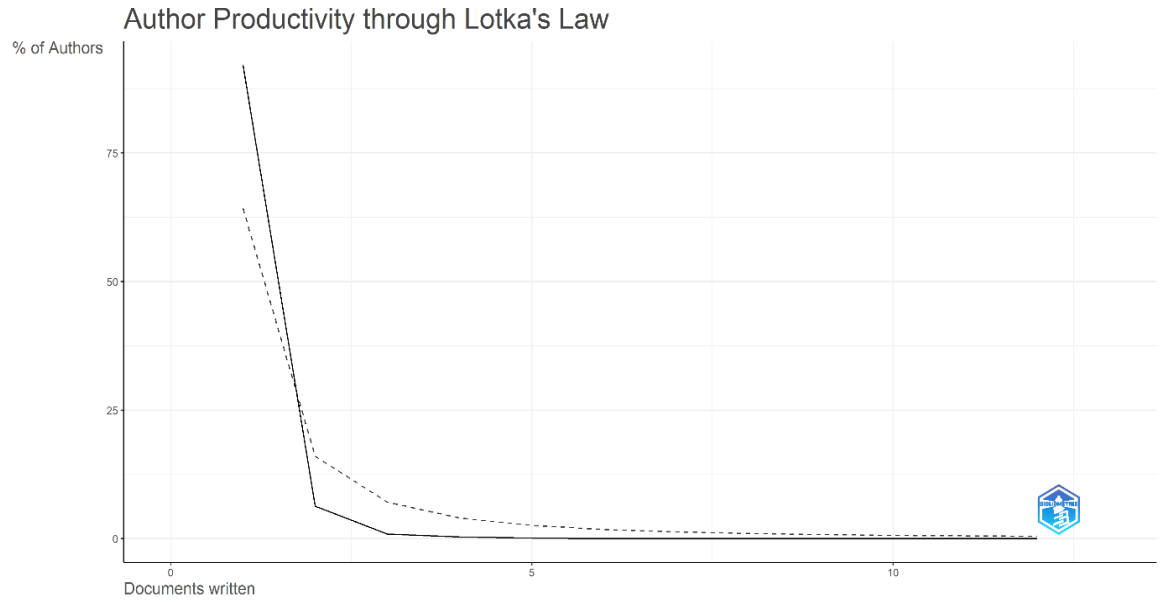


Figure 2: Author Productivity through Lotka's Law (Source: Biblioshiny)

3. Top 20 Authors based on Author Impact

The bibliometric evaluation reveals that both KONG SC and LAUPICHLER MC have the highest impact as authors (h-index 7), but KONG SC has the highest g-index (12), indicating breadth of work and significant citations. KONG SC has also published the most (12 publications), while SCHWENDICKE F has received the most overall citations from his work (830), despite a relatively small h-index, which is evidence of concentration of impact. The m-index values are reflective of the speed of influence for new authors, such as

MARTINEZ-MALDONADO R. Citation totals do not always correspond to h-index; therefore, new authors appear positioned to change the future of this field through their research.

Table 3: Bibliometric Profile on Top 20 Authors based on Author Impact

Author	h_index	g_index	m_index	TC	NP	PY_start
KONG SC	7	12	1.4	285	12	2022
LAUPICHLER MC	7	7	1.4	343	7	2022
GASEVIC D	6	8	1.5	387	8	2023
CAROLUS A	5	8	0.833	98	8	2021
CHIU TKF	5	10	1.25	453	10	2023
KIM J	5	9	1.25	113	9	2023
RAUPACH T	5	5	1	281	5	2022
SU JH	5	5	1.25	298	5	2023
WIENRICH C	5	8	0.833	98	8	2021
ASTER A	4	4	1	242	4	2023
CHAI CS	4	4	0.571	366	4	2020
KIM S	4	6	1.333	38	7	2024
MARTINEZ-MALDONADO R	4	4	2	108	4	2025
NG DTK	4	4	1	234	4	2023
RAMAN R	4	4	1.333	57	4	2024
SANUSI IT	4	5	1.333	202	5	2024
SCHWENDICKE F	4	4	0.571	830	4	2020
YAN LX	4	4	1.333	250	4	2024
YANG Y	4	6	1.333	122	6	2024
YIM IHY	4	4	1.333	154	4	2024

TC*- Total Citations, NP*- Number of Publications, PY_start*- Publication Year start

4. Top 20 Sources and their H index.

This table shows the top 20 journals along with their h-index related to AI literacy. **COMPUTERS AND EDUCATION: ARTIFICIAL INTELLIGENCE** dominates in impact (h-index 23) and productivity (65 publications) despite being very recent (2023). Established journals like **EDUCATION SCIENCES** and **SUSTAINABILITY** maintain strong contributions with moderate h-index and publication counts. Some journals, such as **HEALTHCARE** (1885 citations, h-index 5), have high total citations concentrated in fewer papers, indicating selective influence. Emerging journals, including **COMPUTERS AND COMPOSITION** (h-

index 6, PY_start 2024), demonstrate rapid early impact, highlighting shifting trends in AI and education research.

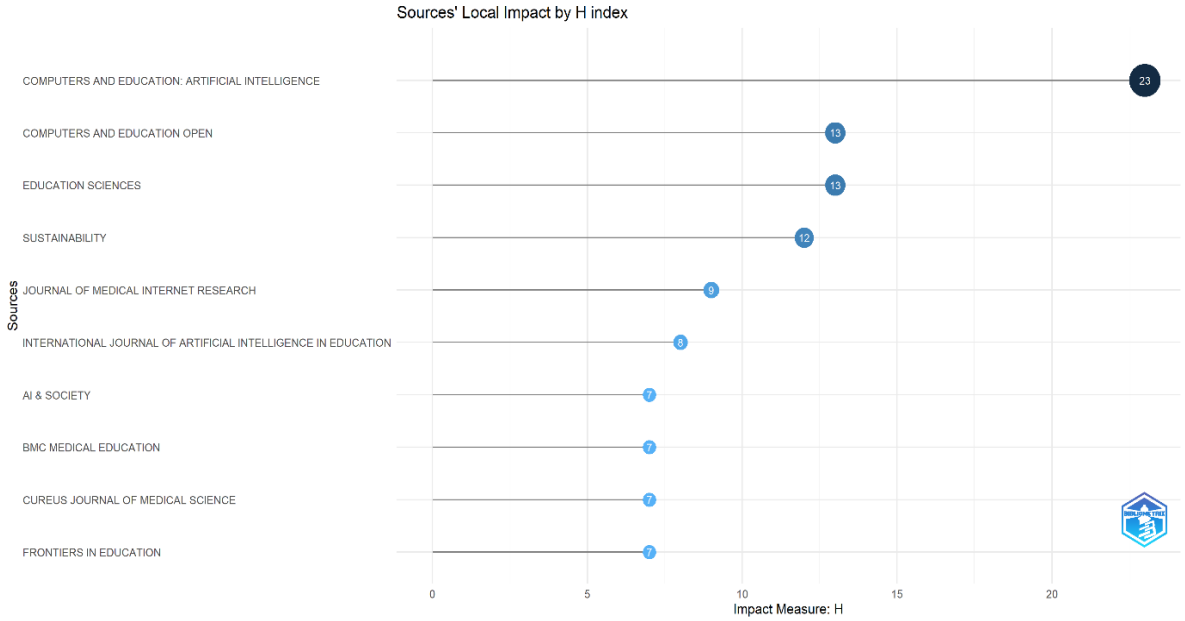


Figure 3: Source's Local Impact by h-index (Source: Biblioshiny)

Table 4: Top 20 Sources and their H index

Source	h_index	TC	NP	PY_start
COMPUTERS AND EDUCATION: ARTIFICIAL INTELLIGENCE	23	1968	65	2023
COMPUTERS AND EDUCATION OPEN	13	1023	20	2023
EDUCATION SCIENCES	13	605	53	2019
SUSTAINABILITY	12	638	40	2019
JOURNAL OF MEDICAL INTERNET RESEARCH	9	318	31	2020
INTERNATIONAL JOURNAL OF ARTIFICIAL INTELLIGENCE IN EDUCATION	8	478	17	2016
AI & SOCIETY	7	284	33	2021
BMC MEDICAL EDUCATION	7	282	29	2022
CUREUS JOURNAL OF MEDICAL SCIENCE	7	200	13	2023
FRONTIERS IN EDUCATION	7	320	53	2022
INTERNATIONAL JOURNAL OF MEDICAL INFORMATICS	7	146	13	2023
COMPUTERS AND COMPOSITION	6	83	14	2024
FRONTIERS IN DIGITAL HEALTH	6	263	17	2023

FRONTIERS IN PUBLIC HEALTH	6	127	19	2021
KUNSTLICHE INTELLIGENZ	6	243	7	2021
PLOS ONE	6	144	17	2020
TECHTRENDS	6	205	16	2023
BUSINESS AND PROFESSIONAL COMMUNICATION QUARTERLY	5	140	9	2023
COMPUTERS & EDUCATION	5	97	11	2024
HEALTHCARE	5	1885	19	2019

5. Most Cited Countries

This table shows the countries that received the highest number of citations. The total number of citations is highest in the USA (5,554) and followed by China (2,987) and Germany (2,002); however, average article citations have a different ranking, as they are highest in Jordan (116.5), UAE (25.8) and Ireland (22.3). Overall, this means that the large research systems dominate in volume of citations while smaller countries have greater per article influences, indicating that these smaller countries have had high-quality, carefully chosen contributions to the field.

Table 5: Most Cited Countries

Country	TC	Average Article Citations
USA	5554	10.80
CHINA	2987	11.60
GERMANY	2002	19.60
JORDAN	1748	116.50
AUSTRALIA	1071	13.90
CANADA	841	17.20
UNITED KINGDOM	612	7.30
INDIA	429	5.20
IRELAND	424	22.30
SPAIN	420	5.90
KOREA	386	8.00
SINGAPORE	385	19.20
SAUDI ARABIA	384	9.80
SWEDEN	296	12.30
U ARAB EMIRATES	284	25.80

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ITALY	242	5.50
NETHERLANDS	218	9.50
ISRAEL	205	12.80
INDONESIA	199	6.20
GREECE	197	7.60

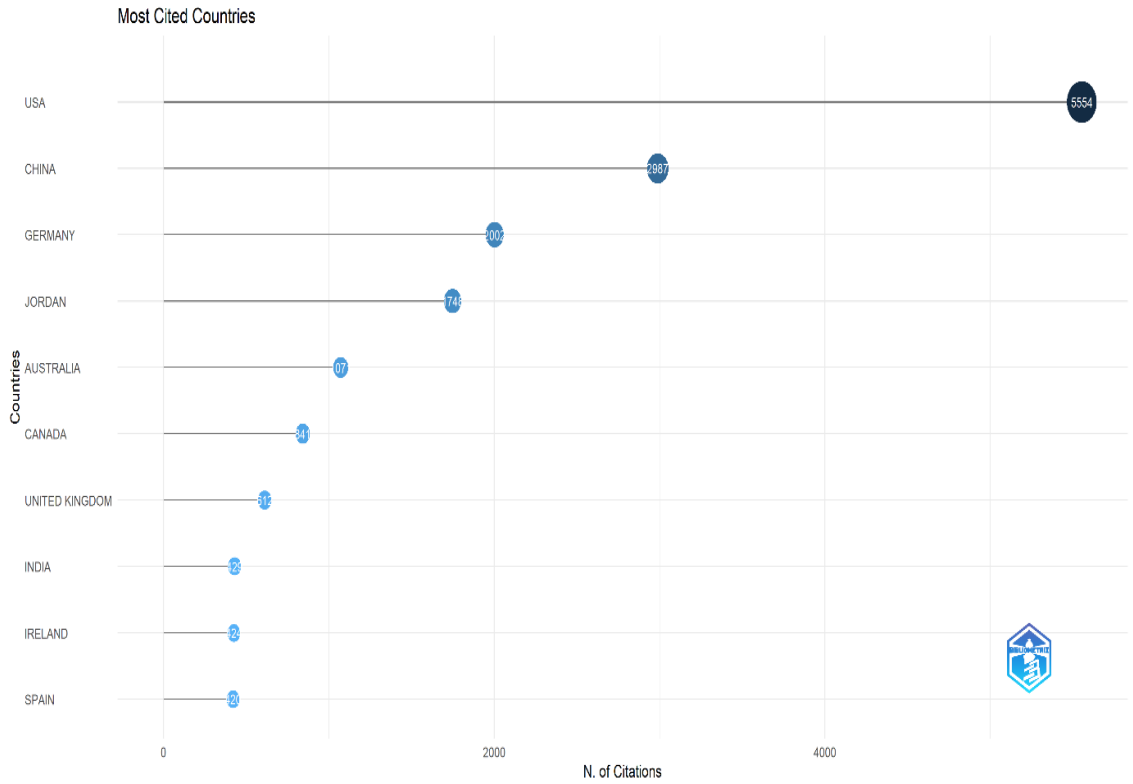


Figure 4: Most Cited Countries (Source: Biblioshiny)

6. Country Wise Scientific Production (SCP vs MCP)

This table shows country-wise scientific production, distinguishing between Single Country Publications (SCP) and Multiple Country Publications (MCP), indicating international collaboration. An examination of international distributions reveals that the United States is currently the most active research nation (515 publications; 22.5%) and has produced more publications than any other country. The next two largest country contributors are China (258; 11.3%) and Germany (102; 4.5%). The countries that are high-output producers of research publication, however, are not all producing large numbers relative to their population size; many smaller countries and/or newly emerging research systems have significant levels of international cooperation through multi-country research collaborations. Examples of this include Malaysia (MCP = 59.4 %), Saudi Arabia (51.3 %), and The Netherlands (34.8%). This demonstrates that smaller or newer research systems tend to depend on multi-country partners to develop collaborative research, thereby shaping research impact through collaborative efforts across borders.

Table 6: Country Wise Scientific Production (SCP vs MCP)

Country	Articles	Articles %	SCP	MCP	MCP %
USA	515	22.5	441	74	14.4
CHINA	258	11.3	202	56	21.7
GERMANY	102	4.5	75	27	26.5
UNITED KINGDOM	84	3.7	55	29	34.5
INDIA	83	3.6	71	12	14.5
AUSTRALIA	77	3.4	51	26	33.8
SPAIN	71	3.1	57	14	19.7
CANADA	49	2.1	41	8	16.3
KOREA	48	2.1	41	7	14.6
ITALY	44	1.9	31	13	29.5
SAUDI ARABIA	39	1.7	19	20	51.3
BRAZIL	32	1.4	22	10	31.3
INDONESIA	32	1.4	27	5	15.6
MALAYSIA	32	1.4	13	19	59.4
JAPAN	28	1.2	22	6	21.4
SOUTH AFRICA	27	1.2	20	7	25.9
GREECE	26	1.1	23	3	11.5
RUSSIA	24	1	21	3	12.5
SWEDEN	24	1	17	7	29.2
NETHERLANDS	23	1	15	8	34.8

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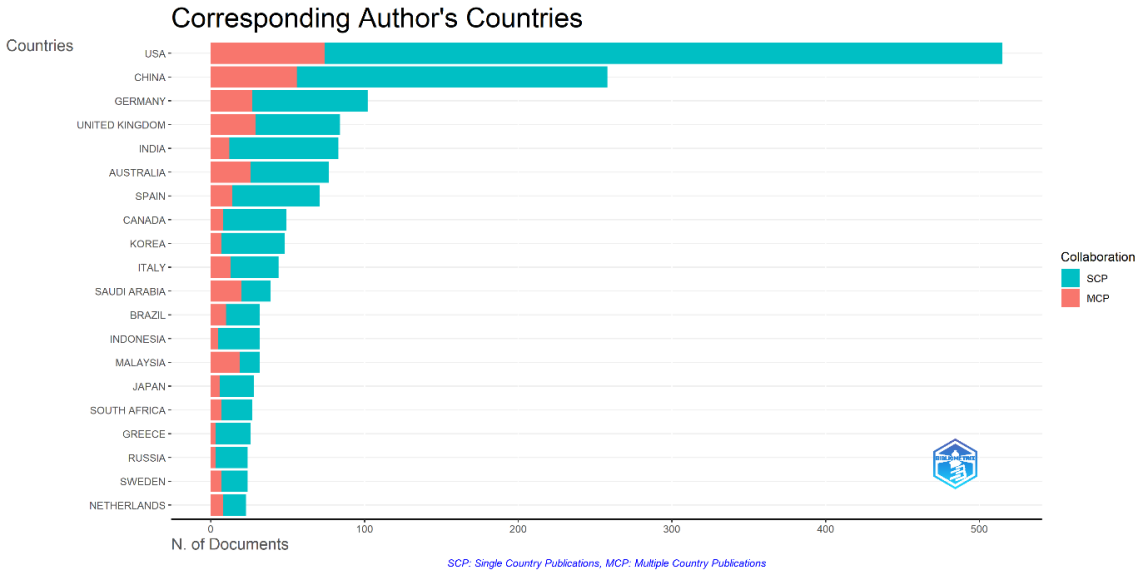


Figure 5: Country Wise Scientific Production (SCP vs MCP) (Source: Biblioshiny)

7. Keyword Co-occurrence

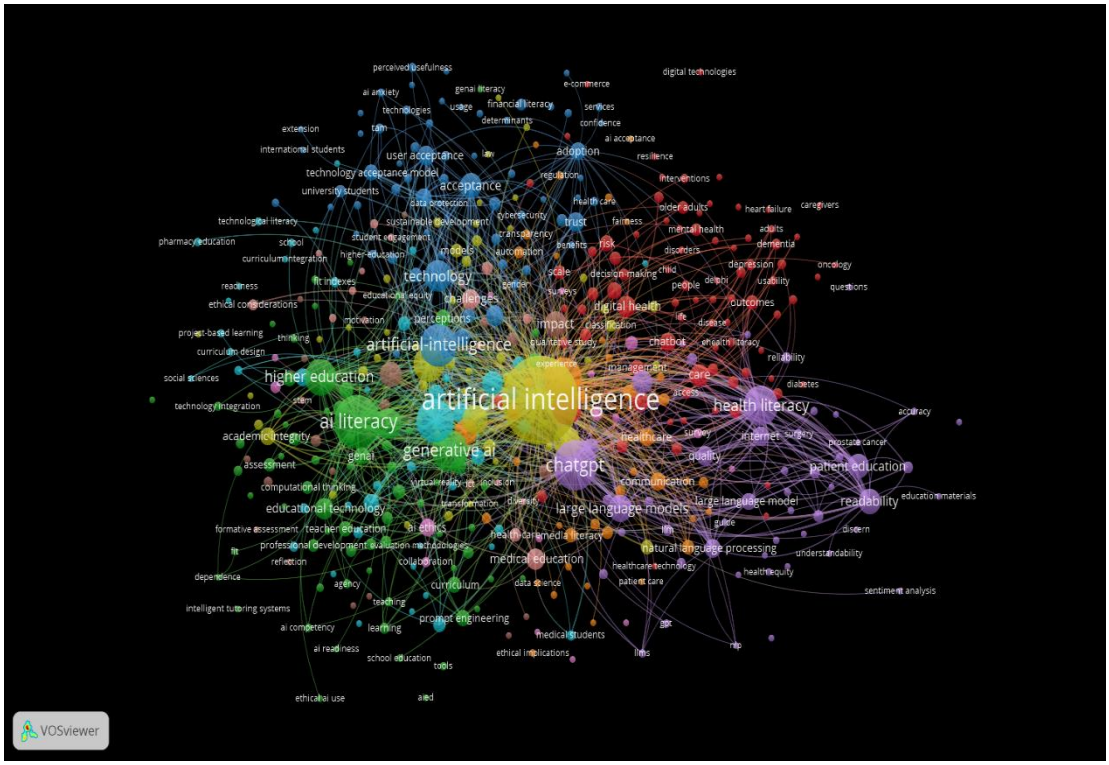
Analyzing the frequency of keywords reveals that "Artificial Intelligence" (817 occurrences) with Total link strength 1037, serves as the leading thematic anchor of the dataset along with "AI literacy" (305) and "ChatGPT" (265) which suggest there is a concerted effort to research understanding and education in AI technology, especially regarding the use of generative tools. Overall, the overall distribution is showing a movement away from the general concepts of AI to applied, educational, and ethical views of AI literacy with ChatGPT being a major driving force for new research activity recently.

Table 7: Keyword Co-occurrence

Verify selected keywords

Selected	Keyword	Occurrences	Total link strength
☑	artificial intelligence	817	1037
☑	chatgpt	265	486
☑	ai literacy	305	396
☑	education	198	351
☑	ai	204	346
☑	artificial-intelligence	191	297
☑	generative ai	185	290
☑	higher education	139	258
☑	health literacy	171	248
☑	digital literacy	134	190
☑	technology	103	173
☑	large language models	77	163
☑	machine learning	99	157
☑	generative artificial intelligence	100	156
☑	literacy	121	155
☑	ethics	75	152
☑	readability	69	149
☑	students	70	126
☑	information	59	118

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Discussion

AI literacy research has progressed from a new area of focus to a well-established area of research. The Annual Growth Rate (AGR) indicates that development has been steady until 2020, with an increase of growth after 2021 and a rapid manufacturing increase after 2023 (with the widespread use of Generative AI). The AGR for citation exceeds the publication AGR, which shows that the volume and influence of this work are expanding. The distribution of authorship follows the pattern in Lotka's Law with one narrow concentration of highly productive authors and many occasional authors. Journal analysis indicates that the number of newly developed, specialized journals is growing rapidly and providing the basis for the structure of the field. The patterns of output from different countries indicate that the large systems produce the most output but that the smaller systems produce higher average per-article impact through innovative and collaborative research. Keyword co-occurrence analysis identifies that the themes associated with AI literacy have increasingly been described in relation to their application, their teaching and learning, and their ethical components.

Conclusion

Research interest in AI literacy has seen tremendous exponential growth throughout the period from 2016-2025, beginning after 2023 with a large rise in the number and quality of citations related to AI literacy research, the concentration of authorship being dominated by a small number of institutions (over 90% of authors come from just five institutions), the emergence of new journals dedicated to AI literacy research and a continual shift towards the practical use of AI literacy in educational settings. Combined these trends demonstrate that AI literacy is aligned with today's core focus of education and technology research. Future researchers should consider how to extend this time frame beyond 2025 by conducting topic analyses to better understand how each of the discrete concepts comprising the notion of AI literacy has evolved thematically (i.e., through comparing across various databases) and qualitatively (i.e., to determine how researchers from different disciplines and countries define and understand AI literacy).

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Enhancing Information Retrieval in Libraries Using Artifical Intelligence (AI) Mechine Learning (Ml): Opportunities and Challenges

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Abstract

Artificial Intelligence (AI) and machine learning plays an important role in enhancing information retrieval in libraries. This paper presents a theoretical review of AI- and machine learning based approaches used in library information retrieval, oriented toward recommender systems, automated cataloguing, and Natural Language Processing (NLP) based search techniques. The study examines how these technologies improve retrieval efficiency and support personalized library services. It further identifies key challenges in their adoption, including privacy concerns, algorithmic bias, ethical issues, and transparency in automated systems. The paper emphasizes the need for responsible implementation of AI and machine learning in libraries to balance technological advancement with core library values and user trust.

Keywords: Digital Libraries, Artificial intelligence, Information Retrieval, Machine Learning, Recommender System.

Introduction

Libraries today are evolving in an era of digital abundance, where users expect fast, accurate, and personalized access to information. Traditional library information retrieval (IR) systems, such as online catalogues and discovery platforms, are increasingly enhanced with artificial intelligence (AI) and machine learning (ML) to meet these expectations. AI allows libraries to analyse large volumes of data, simulate human decision-making processes, and provide more user-focused services. AI-powered systems can automate tasks like cataloguing and classification, recommend relevant resources, and process natural-language queries, improving both operational efficiency and user engagement. Recent studies show a growing integration of AI into core library functions, highlighting its transformative impact on information retrieval. Key applications of AI in library IR includes as recommender systems, automated cataloguing, and natural language processing (NLP)-based search. Recommender systems suggest relevant materials by analysing user behaviour and resource similarities, providing personalized access beyond traditional catalogue searches. Automated cataloguing uses ML algorithms to organize and classify resources efficiently, reducing manual effort and errors. NLP-based search enables users to interact with library systems using natural language, enhancing retrieval accuracy and accessibility. Together, these tools help libraries to deliver faster, more accurate, and personalized information services.

However, adopting AI in libraries also raises theoretical and ethical concerns. Libraries usually focus on user privacy, intellectual freedom, and neutrality in information access. The use of complex AI algorithms can challenge these values, as automated systems may unintentionally introduce bias or affect confidentiality. Scholars stress the importance of responsible AI deployment, urging libraries to consider both benefits and potential risks when implementing AI and ML technologies. This paper examines the application of AI and ML in library information retrieval, focusing on recommender systems, automated cataloguing, and NLP-based search. It highlights the opportunities these technologies offer for improving efficiency and personalization while addressing the ethical and practical challenges of their use. By synthesizing recent research, this study provides a framework for understanding AI's transformative role in libraries and guidance for implementing these technologies responsibly.

Recommender Systems in Libraries

Recommender systems plays a crucial role among AI applications in library information retrieval, helping users efficiently identify relevant materials. These systems use machine learning algorithms to suggest books, articles, or other resources based on a patron's past behaviour, preferences, and similarities between items. By supporting conventional catalogue searches, they provide personalized recommendations, enhancing user engagement and simplifying information discovery.

These systems enhance the user experience by aligning suggestions with individual interests, ensuring patrons find materials suited to their needs while supporting better learning outcomes. They also enable libraries to highlight underutilized resources and encourage chance discovery, where users come across valuable materials unexpectedly, which may not occur through standard keyword searches. Common approaches include content-based filtering, which recommends items with similar subjects or metadata, and collaborative filtering, which suggests items preferred by users with similar interests. When combined with advanced resource through a discovery tools, AI-powered recommender systems can transform the library experience, making it more user-oriented, efficient, and enriching. By analysing circulation data, click logs, and citation patterns, these systems guide users through large collections and help them connect with resources beyond their initial queries.

Despite their advantages, recommender systems also present challenges. They depends on personal user data, such as borrowing histories, search queries, and ratings, which raises privacy concerns. Libraries must ensure responsible data collection, obtain user consent, and maintain confidentiality. Algorithms may unintentionally introduce bias or reinforce popularity-driven trends, overshadowing niche or diverse resources. "Overly narrow recommendations can create 'filter bubbles,' where users are shown only content similar to what they have previously engaged with. This limits exposure to new topics, diverse perspectives, and underutilized resources, reducing opportunities for broader learning and discovery". Effective implementation requires balancing the benefits of personalization with careful oversight of data management and algorithmic fairness. When applied responsibly, recommender systems offer libraries a substantial opportunity to enhance information retrieval while addressing ethical, practical, and privacy considerations.

Automated Cataloguing and Metadata Generation

Automated cataloguing is a critical application of AI in libraries, encompassing metadata creation, subject indexing, and resource classification. As digital collections grow at an unprecedented pace, manual cataloguing has become increasingly impractical. Machine learning techniques, particularly natural language processing and classification algorithms, allow libraries to manage cataloguing workflows efficiently while maintaining consistency and accuracy. AI-driven systems can automatically assign subject headings, classification numbers, and thematic metadata on a large scale, enhancing catalogue accuracy, search ability, and overall discoverability of resources. Techniques such as multi-label classification, mapping documents to controlled vocabularies, and automated metadata extraction enable libraries to process vast volumes of content quickly, keep catalogues current, and improve information retrieval.

Despite these advantages, automated cataloguing presents challenges. AI-generated metadata may occasionally contain errors or fail to capture subtle subject distinctions, which can compromise retrieval quality. For this reason, many libraries implement AI as an assistive tool, with human librarians reviewing and refining classifications. Maintaining these systems also requires continuous technical updates, model retraining, and skilled personnel. Ethical considerations are equally important, as biased training data may lead to underrepresentation or misclassification of certain topics, perspectives, or communities. Libraries must actively monitor AI outputs to ensure fairness, accuracy, and inclusivity.

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In conclusion, automated cataloguing and AI-generated metadata substantially enhance the efficiency, scalability, and reliability of library information retrieval. Realizing these benefits, however, depends on careful human oversight, robust system maintenance, and vigilant attention to ethical standards, ensuring that AI serves as a tool to improve access to knowledge rather than introduce bias or inequity.

Natural Language Processing for Search and Discovery

Artificial intelligence and machine learning have significantly enhanced library information retrieval through Natural Language Processing (NLP). Traditional keyword-based search systems often require users to learn complex syntax, limiting effective access to information. NLP overcomes these barriers by enabling users to search using natural language, making discovery more intuitive, inclusive, and user-friendly. Advances in language models such as BERT and GPT's allow search systems to understand context, intention, and semantic relationships, improving retrieval accuracy and supporting non-specialist users.

NLP is widely applied in AI-powered assistants and virtual reference services, which provide real-time assistance and reduce routine workload for librarians. Additionally, semantic search techniques, automated summarization, and relevance ranking enhance research efficiency and discovery. Despite these benefits, challenges such as accuracy, multilingual performance, and infrastructure requirements remain. With responsible implementation and human oversight, NLP can meaningfully strengthen library search and discovery services.

Opportunities of AI for library information retrieval

Artificial intelligence (AI) and machine learning offer significant opportunities to enhance library information retrieval by improving operational efficiency, user engagement, and the scalability of services.

- **Efficiency and Automation:** AI can significantly streamline library operations. Tasks that traditionally require considerable staff time such as cataloguing, indexing, and responding to routine reference queries that can be automated or accelerated through AI-driven tools. By handling repetitive processes automatically, libraries can manage larger workloads without increasing staff, allowing librarians to focus on more complex, high-value activities. AI-based metadata generation and automated classification can keep pace with the continuous addition of new resources, ensuring timely access to collections while reducing the workloads of cataloguing staff. “Similarly, AI-powered assistants and virtual assistants can address common user queries 24/7, effectively extending service hours and improving responsiveness. Overall, these efficiencies lead to reduced costs and quicker information delivery, which benefits both libraries and their users
- **Personalization and User Engagement:** AI enables libraries to deliver a more personalized and engaging experience for users. Machine learning algorithms track individual user's behaviours and preferences to suggest tailored recommendations and search results from relevant resources, such as books, articles, or e-books, and to prioritize search results according to the user’s needs. This tailored approach helps patrons navigate collections more efficiently, increases satisfaction, and encourages the exploration of materials they might not have discovered otherwise. By fostering a more user-oriented experience, AI-driven personalization strengthens the connection between library users and the institution’s resources.
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experience, AI-driven personalization strengthens the connection between library users and the institution's resources.

- **Scalability and Resource Optimization:** Artificial intelligence (AI) and machine learning (ML) significantly enhance the scalability and effectiveness of library information retrieval systems in the context of rapidly expanding digital information. Libraries increasingly manage large volumes of heterogeneous and interdisciplinary resources, which traditional retrieval methods struggle to handle efficiently. AI-driven techniques enable large-scale data processing, pattern recognition, and insight generation, supporting more effective organization and retrieval of information. Machine learning models can analyse user interaction and usage data to identify trends in resource demand, thereby facilitating data-driven collection development and efficient resource allocation. Furthermore, AI-based indexing and automated metadata generation support the continuous updating of digital repositories, ensuring accurate and up-to-date search results. These capabilities allow libraries to provide efficient and responsive information retrieval services to a broad and distributed user base. However, the adoption of AI and ML also presents challenges related to technical infrastructure, data quality, and ethical considerations. Overall, AI and ML offer valuable opportunities to enhance information retrieval in libraries while requiring careful management to address associated challenges.

The opportunities often by artificial intelligence (AI) and machine learning (ML) in library information retrieval are closely linked and mutually supportive. Improvements in operational efficiency enable libraries to expand personalized information services, while enhanced personalization increases user engagement and supports the justification for scaling digital collections. Evidence from studies conducted in both academic and public library settings indicates that AI-based systems can concurrently improve information accessibility, tailor services to individual needs, and optimize library operations. These benefits are no longer theoretical, as recent pilot studies and real-world implementations have demonstrated measurable impact. Libraries that adopt AI and ML in a strategic and responsible manner are better positioned to become more user-oriented, flexible, and capable of addressing emerging challenges in evolving information environments.

Challenges and Ethical Considerations

While AI offers promising opportunities for enhancing library information retrieval, its integration introduces significant challenges and ethical concerns. Addressing these issues is critical for the responsible and sustainable adoption of AI in libraries. The main challenges include:

- **Privacy and Data Security:** Libraries have a fundamental ethical responsibility to protect user privacy. AI-driven services, such as recommender systems and analytics, often depends on user data, including borrowing history, search logs, or profile information to function effectively. This raises concerns about how data is collected, stored, and used, as patrons may be uncomfortable with extensive tracking and there is always a risk of data breaches or misuse. To safeguard privacy, libraries should implement strong data governance strategies to collect only essential data, anonymize or aggregate information where possible, obtain informed consent, maintain transparency about data usage, and secure personal data against unauthorized access. AI systems should operate in secure environments, with clear policies ensuring data is used only for intended purposes.
- **Algorithmic Bias and Fairness:** The success of AI in library information retrieval relies on the quality of its data and the design of its systems. A significant challenge is algorithmic bias, which can result in unfair outcomes and disadvantage certain users or types of content. For example, recommender systems may disproportionately favour popular materials, search algorithms might give preference to well-established publishers, and classification AI could assign outdated or biased subject headings.
  Systematically reducing this bias is essential for the responsible use of AI in libraries. Strategies include using diverse and representative datasets, conducting regular algorithmic audits, and incorporating

human oversight or user feedback to correct biased outputs. AI systems must also ensure equitable performance for all users, including minority groups and individuals submitting non-standard queries. Continuous ethical monitoring ensures that AI not only enhances library services but also upholds fairness and promotes inclusive access to information.

- **Transparency and Interpretability:** The "black box" nature of many AI models challenges libraries' commitment to transparency and user trust. When an AI system recommends a book or provides an answer to a query, both users and librarians may wonder how or why did it give that specific result? . A lack of transparency in AI outputs can erode user confidence, particularly when recommendations or answers appear erroneous or counterintuitive. In critical scholarly environments, where evaluating the credibility and origin of information is critical, yet difficult when AI-generated results cannot be easily traced. Interpretability is therefore essential for AI-driven information retrieval. Libraries should implement AI systems that provide clear explanations for their outputs or mention the sources behind their outputs. For example, a reference assistant may indicate the document or webpage consulted, while a recommendation system might explain, "Recommended because you borrowed similar titles previously". Such transparency strengthens user trust and allows librarians to interpret, verify, and assess AI behaviour effectively. Transparency also encompasses accountability and policy considerations. Libraries should clearly inform users when AI influences services, such as indexing suggestions as "algorithmically generated." Human oversight is crucial: AI outputs should support decision-making rather than replace it. Critical functions, such as reviewing AI-generated metadata, should involve librarians, and systems should provide mechanisms for users to report errors or problematic outputs. By prioritizing interpretability, accountability, and clear communication, libraries can ensure AI enhances information retrieval while maintaining trust, ethical standards, and professional responsibility.
- **Human Expertise and Organizational Challenges:** Beyond ethical concerns, AI adoption in libraries presents practical challenges related to staff expertise and organizational readiness. Many libraries lack personnel with advanced technical skills, and the complexity of AI systems often requires additional training or specialized support, which may not be feasible for all institutions. Integrating AI into existing library systems can disrupt established workflows and face resistance from staff who may question its reliability or impact on their roles. Effective change management and professional development are therefore essential to ensure AI is perceived as a tool that supports library work rather than replaces it. Successful AI implementation also depends on alignment with institutional goals and user needs. Deploying AI without clear objectives or user readiness can limit its effectiveness. Resource constraints further complicate adoption, as AI systems require ongoing investment in infrastructure and maintenance. Clearly communicating the benefits of AI, such as improved information discovery and more efficient access, can help justify these investments and gain stakeholder support.

In light of these challenges, library and scholars emphasize a balanced, human-centred approach to AI adoption. As Barman (2025) mentions, the introduction of AI in libraries "raises ethical concerns, particularly regarding data privacy, algorithmic bias, and potential job displacement," making it essential for libraries to implement AI systems transparently and responsibly. To guide this process, professional frameworks are emerging, such as the IMLS-funded Responsible AI in Libraries project and OCLC's guidelines on responsible data science. These initiatives promote community engagement, continuous evaluation of AI outcomes, and adherence to core library values throughout the AI lifecycle. By foregrounding ethics and human oversight, libraries can effectively mitigate potential risks while harnessing the advantages of AI-enhanced information retrieval. This approach ensures that technological innovation supports equitable access to information, aligns with professional standards, and maintains user trust, allowing libraries to integrate AI responsibly and sustainably into their services.

Conclusion

Artificial intelligence (AI) and machine learning play a crucial role in enhancing library information retrieval. Tools such as recommender systems, automated cataloguing, and natural language processing can improve efficiency, personalize services, and make information more accessible. Early implementations show that AI can streamline workflows, offer tailored recommendations, and facilitate discovery through conversational and semantic search, supporting libraries' mission to connect people with knowledge effectively. At the same time, AI adoption brings ethical and practical challenges. Libraries must address privacy concerns, ensure transparency, and promote algorithmic fairness to use AI responsibly. Collaboration among librarians, technologists, and users is essential to monitor performance, correct errors, and maintain accountability. Importantly, AI cannot replace librarians, professional expertise, which provides ethical guidance, contextual understanding, and human judgment that technology alone cannot replicate.

In conclusion, AI offers significant opportunities to strengthen library information retrieval. When implemented thoughtfully, with ethical oversight and human involvement, it can enhance user experiences, increase operational efficiency, and maintain trust. Libraries that balance innovation with responsibility will be best positioned to utilize AI while maintaining their fundamental principle and responsibility to equitable access to information.

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The Role of AI in Fraud Detection in Accounting

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ABSTRACT

The emergence of Artificial Intelligence (AI) has revolutionized various industries, including accounting, where its applications have significantly enhanced fraud detection capabilities. This paper explores the pivotal role of AI in reducing risks and enhancing financial security through fraud detection in accounting. AI-powered algorithms with advanced anomaly detection and pattern recognition capabilities analyze financial data to identify suspicious activities. Real-time monitoring, NLP, and behavioural biometrics enhance the system's ability to swiftly detect and respond to fraudulent actions. Predictive analytics and data integration offer a holistic view of financial activities, reducing false positives and improving accuracy. Maintaining detailed audit trails of AI decision-making processes ensures transparency and traceability, fulfilling compliance and regulatory requirements. However, while AI is a powerful tool, it is not a standalone solution. It must be integrated with robust internal controls and human oversight to achieve optimal protection against fraud and enhance financial security. Continuous updates are crucial to stay ahead of evolving fraud tactics, making AI an essential tool in securing financial systems and organizations. The paper deals with in studying the various types AI techniques that are present in fraud detection and also presents the data regarding the effectiveness in fraud detection.

Keywords: Artificial Intelligence, Accounting Information Systems, Data Gathering, Automation, Accurate Reporting, Enhanced Efficiency, Predictive Analysis

INTRODUCTION

In recent years, the use of artificial intelligence (AI) in accounting has seen significant growth. AI technology is helping to automate tedious and time-consuming tasks, speeding up mundane processes, and helping to uncover hidden insights in accounting data (Zheng et al, 2019). Kauret al (2020) argued that by improving efficiency and accuracy, AI is making accounting more accurate and cost-saving for businesses. Rahmaniet al (2021) argued that artificial intelligence can detect fraud through a combination of predictive analytics, machine learning, computer vision, and natural language processing. Predictive analytics can be used to detect patterns in past fraud activity and make future-focused predictions about potential fraud incidents. Machine learning can be used to recognize previously unseen patterns in fraudulent activity and identify anomalies within a large dataset (Alqudah and Yaseen, 2020; Najjar et al, 2022). Based on above argument, current study aimed at examining the role of artificial intelligence (AI) (Data Gathering, Automation, Accurate Reporting, Enhanced Efficiency and Predictive Analysis) in accounting information systems (AIS) in detecting fraud from the perspective of a sample of financial and accounting managers within hotel industry in Jordan.

This study investigates the significant impact of artificial intelligence (AI) on transforming the process of fraud detection in the field of accounting. Through the utilization of artificial intelligence (AI), enterprises have the capability to examine extensive quantities of financial data instantaneously. This enables the identification of anomalies, irregularities, and behavioural patterns that serve as indicators of fraudulent actions. Machine learning algorithms facilitate the acquisition of knowledge from past data, allowing systems to enhance their capacity to differentiate between valid and fraudulent transactions over time.

Objectives of study included the following:

- Identify the concept of AI in accounting field

- Highlight the most prominent fraud detection tools
- Examine how AI can play a role in detecting and preventing fraud.

LITERATURE REVIEW

ARTIFICIAL INTELLIGENCE (AI)

According to Zhang and Lu (2021), artificial intelligence (AI) is the simulation of Human intelligence processes by machines, especially computer systems. These processes include learning (the acquisition of information and rules for using the information), reasoning (using the rules to reach approximate or definite conclusions) and self-correction. Kaulet al (2020) saw it as a branch of computer science that seeks to explain and to simulate, through mechanical or computational processes, aspects of human intelligence such as reasoning, problem solving, learning, perception, planning, and creativity.

Berenteet al (2020) argued that AI in management is the application of AI technologies to create better management decisions, processes, and systems. AI-enhanced analytics and insights can help managers gain better insights into customer behaviour and marketing strategies, enabling them to optimize products and services. AI technologies can be used to optimize operations and automate human-to-human interactions, such as customer service, for improved productivity and customer satisfaction (Gunning and Aha, 2019).

AI IN ACCOUNTING

Zhang et al (2020) argued that artificial intelligence in accounting is the use of software and data-driven algorithms to automate accounting tasks and optimize financial processes. Qasim and Kharbat (2020) noted that AI in Accounting is the use of advanced analytics, machine learning, natural language processing, robotic process automation and other technologies to help automate and optimize the task of preparing and processing accounting and financial data. Generally speaking, AI in accounting is the use of Machine Learning ML algorithms to automate the collection, analysis and interpretation of financial data. AI can help accountants automate complex tasks such as detecting fraud, creating tax reports and automating audit reports (Qasim et al, 2022). The use of AI can also free up time for CPAs to provide more value-added services to their clients (Munoko et al, 2020). There are many approaches, in which AI can be utilized in accounting as a profession. According to Ryan (2020), Leitner-Hanetsederet al (2021) and Zhang et al (2020), there are many characteristics for artificial intelligence in accounting environment, among these characteristics (Data Gathering, Automation, Accurate Reporting, Fraud Detection, Enhanced Efficiency and Predictive Analysis).

FRAUD IN ACCOUNTING

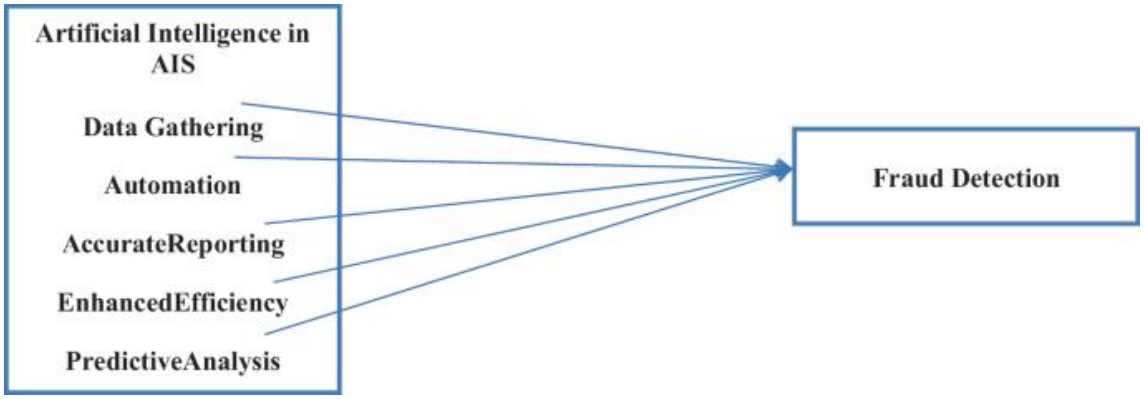
According to Kauret al (2023), fraud in accounting is any intentional misrepresentation of financial records meant to deceive or mislead investors, regulators, or auditors like misappropriation of funds, fake invoicing, investor and customer fraud, asset misappropriation, market manipulation, financial statement fraud and embezzlement. Fraud in accounting may include asset misappropriation which is a type of fraud that involves the illegal taking of company assets (Yu and Rha, 2021).

Papadakiset al (2020) on the other hand argued that fraud in accounting may appear as corruption and bribery which involve offering something of value to persuade a person or business to act in Favor of the perpetrator, while Hlawiczkaet al (2021) argued that fraud in accounting can be as accounting irregularities which are practices that are not illegal, but are not in compliance with Generally Accepted Accounting Principles (GAAP) (Alqaraleh and Nour, 2020; Alqaraleh et al, 2020; Asa'd et al, 2022). Fraud detection in AIS can appear in many different approaches like analyzing unusual behavior, analyzing unusual purchasing trends, transaction types, and timing can help identify potential fraudulent activities (FarhangGhahfarokhi et al, 2022). From perspective of Boylan and Hull (2022), fraud detection through AIS can be done through identifying

duplicate payments, in addition to bank account verification in which systems should be put in place to verify the accuracy of each bank account number on every transaction before submitting it to the bank. Mitrović and Knezevic (2020) and Guoet al (2019) saw that AIS can be of great benefits in fighting fraud by granting or contracting tracking and keeping an accurate accounting of grants, contracts, and other distributions can help detect any misuse of funds, in addition to reviewing internal documents and periodically reviewing internal documents and processes which can help management uncover any discrepancies between them and actual activity. Other way of fighting fraud by AIS is what Rashid (2022) referred to through performing audits both regular internal or external audits can help detect any financial reporting errors or irregularities.

RELATED STUDIES

Study by Bao et al (2022) discussed the potential of Artificial Intelligence (AI) in the field of fraud detection. AI can help automate the process of detecting fraud, allowing companies to identify instances of fraudulent behavior faster and more effectively than traditional methods. Sanad and Al-Sartawi (2021) noted that financial statements fraud is an ongoing issue that has serious consequences for businesses and investors. Data mining techniques can be used to detect anomalies in financial statements, making it easier to identify potential fraud or other irregularities. This article provides a review of the techniques used for financial statement fraud detection, the challenges associated with identifying fraud, and how data mining can help mitigate those challenges. Based on literature review and the chosen related studies, researcher built the following model in order to highlight the relationship between variables and extract the hypotheses of study:



From the above model, following set of hypotheses was extracted:

Main Hypothesis:

H: Artificial Intelligence in AIS has a statistically significant influence in fraud detection.

Sub-Hypotheses:

H1: Data gathering in AIS has a statistically significant influence in fraud detection

H2: Automation in AIS has a statistically significant influence in fraud detection .

H3: Accurate reporting in AIS has a statistically significant influence in fraud detection

H4: Enhanced efficiency in AIS has a statistically significant influence in fraud detection.

H5: Predictive analysis in AIS has a statistically significant influence in fraud detection.

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FORENSIC ACCOUNTING TOOLS

Forensic accounting tools are software and technology used by forensic accountants to investigate financial fraud or other financial crimes, these tools can help auditors and investigators sift through and analyze large amounts of financial data and documents, identify patterns and anomalies, and reconstruct financial transactions.

Argued that some of the common forensic accounting tools include:

- Data analytics software: These tools can sort and analyze large amounts of financial data in a short period of time.
- Computer forensic tools: These tools can recover deleted files and analyze computer systems for evidence of financial crimes.
- Document management systems: These systems help manage and organize financial documents during an investigation.
- Business intelligence software: These tools help to identify trends and detect irregularities in financial data.
- Blockchain forensics tools: These tools are becoming increasingly important in investigating crypto-currency transactions and detecting financial crimes that utilize blockchain technology

COMPARISON BETWEEN TRADITIONAL AND AI BASED DETECTION METHODS

BASIS OF DIFFERENCE	TRADITIONAL FRAUD DETECTION	AI-BASED FRAUD DETECTION
Approach	Fraudulent acts are identified by relying on predetermined criteria, thresholds, and patterns. The formulation of these regulations frequently draws upon historical data and the collective understanding of fraudulent practices. As an illustration, a regulation could identify any transaction beyond a specific monetary threshold as possibly indicative of fraudulent activity.	AI-driven methods leverage sophisticated algorithms, machine learning techniques, and artificial intelligence to scrutinize extensive datasets, discern intricate patterns, and identify anomalies that may elude specified rules. Artificial intelligence (AI) possesses the capability to effectively detect changing fraud schemes by adapting and learning from new data.
Data Handling	Traditional methods are designed to operate on data that is organized in a structured manner and follow predetermined rules. They exhibit reduced proficiency in managing unstructured or non-standard data forms.	Artificial intelligence (AI) has the capability to effectively handle and examine various types of data, such as structured and unstructured data, encompassing textual information, visual content, and even auditory data. The inherent flexibility of artificial intelligence enables it to effectively identify concealed patterns and indicators of fraudulent activity across a wide range of data sources.

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Adaptability	Conventional approaches exhibit a lack of dynamism and may encounter difficulties in accommodating novel fraudulent schemes or shifting tactics. Manual upgrades are necessary for rule-based systems.	Artificial intelligence (AI) possesses the capability to consistently acquire knowledge and adjust its behaviour based on newly acquired data, so enabling it to proactively anticipate and counteract evolving fraudulent tactics. The system has the capability to identify patterns and abnormalities that have not been observed before.
Real-Time Detection	Traditional approaches frequently utilize batch processing, a procedure that may result in the detection of fraudulent activities occurring after they have taken place, hence leading to a subsequent delay in reaction.	Artificial intelligence (AI) systems have the capability to offer real-time or near-real-time fraud detection, hence facilitating prompt intervention to prevent or minimize fraudulent activity.

CONCLUSION

In conclusion, the correlation between artificial intelligence and Accounting Information Systems is strong and growing rapidly. More businesses are realizing the potential of AI to revolutionize the role of AIS, from helping to provide analytical insights to automating tasks.

In particular, AI can provide a specialized set of skills to help accountants and businesses improve their operational efficiency. AI-enabled AIS can help streamline data entry and pull-out insights much faster than more traditional methods of analysis. Theoretical implications of current study may help in better understanding of how AI can be applied to improve fraud detection, it could also contribute to the development of more sophisticated and effective accounting information systems that are better able to identify and prevent fraud. Practical implications of study help in reducing the risk of financial fraud in organizations. This is because, with the help of AI, organizations can develop patterns and trends that are not usually noticeable by humans, and these patterns may indicate potential fraud.

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Role of Artificial Intelligence in Digital Customer Interaction

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ABSTRACT

The rapid advancement of digital technologies has significantly transformed customer service and experience management across industries. In an increasingly competitive and customer-centric business environment, organizations are under constant pressure to deliver fast, personalized, and efficient services. Artificial Intelligence (AI) chatbots have emerged as an effective technological solution to address these demands by enabling automated and intelligent interactions between businesses and customers. Powered by technologies such as natural language processing, machine learning, and data analytics, AI chatbots are capable of understanding customer queries, providing instant responses, and learning continuously from past interactions. This paper examines the role of AI chatbots in enhancing customer experience by exploring their functional capabilities, technological foundations, and impact on service efficiency, customer satisfaction, and engagement. The study highlights key benefits of AI chatbots, including round-the-clock service availability, reduced waiting time, cost efficiency, scalability, and consistent service delivery.

KEYWORDS: Artificial Intelligence (AI), Chatbots, Digital Customer Experience, Personalized Service Customer Engagement.

INTRODUCTION

Customer experience has become a critical factor influencing customer satisfaction, retention, and business success. With the expansion of digital platforms, customers expect quick responses and seamless service across multiple channels. Traditional customer service systems often struggle to meet these expectations due to limited resources and operational constraints. AI chatbots have emerged as a powerful solution to enhance customer experience by providing automated, scalable, and intelligent customer support.

CONCEPT OF AI CHATBOTS

AI chatbots are computer-based applications designed to simulate human conversation using artificial intelligence technologies. They utilize natural language processing to understand user queries and machine learning to improve responses over time. Unlike rule-based chatbots, AI-powered chatbots can adapt to changing customer needs and deliver more accurate interactions. Their ability to operate in real time makes them effective tools for customer engagement.

EVOLUTION OF CUSTOMER SERVICE THROUGH AI CHATBOTS

Traditional Customer Service Models

Traditional customer service relied mainly on human agents and call centers. These models often involved long waiting times, limited working hours, and inconsistent service quality. Such limitations negatively affected customer satisfaction.

Digital Transformation in Customer Support

Digital transformation introduced automated systems and online support channels. AI chatbots emerged as a key innovation by enabling instant responses and self-service options. This shift significantly improved service accessibility and efficiency.

TECHNOLOGICAL FOUNDATION OF AI CHATBOTS

Natural Language Processing: Natural language processing enables chatbots to understand and interpret human language. It helps identify customer intent and context accurately. This improves the quality of interactions and response relevance.

Machine Learning and Artificial Intelligence: Machine learning allows chatbots to learn from previous interactions and customer feedback. Artificial intelligence enables intelligent decision-making and continuous performance improvement. These technologies enhance chatbot accuracy and adaptability.

KEY FEATURES OF AI CHATBOTS

Real-Time Interaction

AI chatbots provide immediate responses to customer queries. Instant communication reduces customer waiting time and frustration. This contributes to higher customer satisfaction.AI chatbots with real-time interaction respond instantly, enabling smooth back-and-forth conversations. They understand natural language on the fly, remember context, and handle multi-turn dialogues seamlessly. They can fetch and update live data from backend systems and provide dynamic, personalized responses across platforms. This makes interactions feel human-like and highly responsive.

Multichannel and Multilingual Support

Chatbots can operate across websites, mobile applications, and social media platforms. They also support multiple languages, allowing organizations to serve diverse customer groups. This improves accessibility and inclusiveness.AI chatbots with multichannel and multilingual support can interact with users across websites, apps, messaging platforms, and social media seamlessly. They understand and respond in multiple languages, catering to a global audience. This ensures consistent user experience regardless of platform or language. Businesses can reach wider audiences and provide personalized support instantly.

Personalization of Services

AI chatbots analyze customer data to deliver personalized responses and recommendations. Personalization increases customer engagement and trust. It enhances the overall customer experience.AI chatbots enable personalized services by remembering user preferences, past interactions, and behavior patterns. They tailor responses and recommendations to each individual, making interactions more relevant and engaging. This enhances user satisfaction, builds loyalty, and can boost conversion or engagement for businesses.

ROLE OF AI CHATBOTS IN ENHANCING CUSTOMER EXPERIENCE

Improved Accessibility and Availability

Chatbots offer 24/7 customer support without time limitations. Customers can access services anytime and from anywhere. This improves convenience and service reliability.They are accessible across multiple platforms like websites, apps, and messaging services, and can support multiple languages, reaching a wider audience. This ensures users can quickly find information or complete tasks without delays, enhancing convenience and satisfaction.

Faster Problem Resolution

AI chatbots quickly identify customer issues and provide appropriate solutions. Faster resolution enhances customer satisfaction. It also reduces workload on human support teams.AI chatbots enable faster problem resolution by instantly understanding user queries and providing accurate answers or solutions. They can access real-time data and handle routine tasks without human intervention, reducing delays. By guiding

users step-by-step and escalating only complex issues, they speed up the overall support process, improving efficiency and customer satisfaction.

Consistent Service Quality

Chatbots deliver standardized and accurate responses. Consistency in service improves customer confidence and trust. It minimizes human errors.AI chatbots ensure consistent service quality by delivering uniform responses to all users, regardless of time or channel. They follow predefined rules and AI learning, reducing human errors or variations in service. This guarantees a reliable and professional experience, strengthening customer trust and satisfaction.

BENEFITS OF AI CHATBOTS

Cost Efficiency

AI chatbots reduce operational costs by automating routine customer service tasks. Organizations can optimize resources and reduce labour expenses. This improves overall efficiency.AI chatbots provide cost efficiency by handling a large volume of customer queries without needing additional staff, reducing operational expenses. They automate routine tasks and FAQs, allowing human agents to focus on complex issues. This lowers support costs while maintaining high-quality, scalable service.

Scalability and Efficiency

Chatbots can handle a large number of customer queries simultaneously. They easily scale during peak demand periods. This ensures uninterrupted service.AI chatbots enhance scalability and efficiency by handling thousands of interactions simultaneously without delays. They automate repetitive tasks, streamline workflows, and allow human agents to focus on complex issues. This ensures quick, reliable service even as demand grows, improving overall operational efficiency.

Data Collection and Business Insights

Chatbots collect valuable data on customer interactions. This data helps organizations understand customer preferences and behavior. It supports strategic decision-making.AI chatbots support data collection and business insights by recording user interactions, preferences, and behavior patterns in real time. This data helps businesses analyze trends, identify common issues, and understand customer needs. By turning interactions into actionable insights, chatbots enable better decision-making, targeted marketing, and improved service strategies.

IMPACT OF AI CHATBOTS ON CUSTOMER SATISFACTION AND LOYALTY

Enhanced Customer Engagement

Interactive chatbot conversations improve customer involvement. Engaged customers develop stronger relationships with brands. This leads to higher loyalty.Enhanced customer engagement with AI chatbots comes from proactive, personalized interactions that keep customers connected with the brand. Chatbots can operate across multiple channels, delivering timely recommendations, reminders, or promotions. They make experiences interactive through quizzes, feedback requests, or gamified elements.

Improved Customer Retention

Positive chatbot experiences reduce customer dissatisfaction. Improved retention contributes to long-term business growth. Loyal customers enhance brand value.Improved customer retention through AI chatbots happens by providing fast, consistent, and personalized support that keeps customers satisfied. Chatbots help resolve issues quickly, send timely reminders, and offer tailored recommendations, making customers feel

valued. By maintaining continuous engagement and reducing frustration, they encourage repeat purchases and strengthen long-term loyalty.

LIMITATIONS AND CHALLENGES OF AI CHATBOTS

Lack of Emotional Intelligence

AI chatbots cannot fully understand or respond to human emotions. This limits their effectiveness in handling sensitive issues. Emotional gaps may affect customer perception.Lack of emotional intelligence often shows as difficulty understanding or managing one's own emotions and those of others. People may struggle with empathy, misinterpret social cues, or react impulsively in stressful situations. It can lead to conflicts, poor communication, and strained relationships. Essentially, it's the challenge of connecting emotionally in a way that's constructive and aware.

Complexity in Handling Advanced Queries

Chatbots may struggle with complex or ambiguous customer questions. Incorrect interpretations can lead to poor responses. Human intervention becomes necessary.Complexity in handling advanced queries arises when problems involve multiple layers of information, ambiguous requirements, or nuanced context. It requires integrating knowledge, reasoning critically, and anticipating exceptions or hidden variables. Such queries often demand careful analysis, prioritization of relevant data, and adaptive problem-solving strategies. The challenge grows when solutions must balance precision, efficiency, and clarity simultaneously.Data privacy and security issues occur when sensitive information is at risk of unauthorized access, misuse, or breaches. This can include personal data, financial records, or confidential business information. Weak security measures, poor data handling practices, or cyberattacks can compromise privacy, leading to identity theft, financial loss, or reputational damage.

Data Privacy and Security Issues

Chatbots handle sensitive customer information. This raises concerns regarding privacy and data protection. Strong security measures are essential.

HUMAN-AI COLLABORATION IN CUSTOMER EXPERIENCE

Role of Human Agents

Human agents provide empathy and critical thinking. They handle complex customer issues that chatbots cannot resolve. Human involvement ensures service quality.The role of human agents is to provide judgment, empathy, and decision-making that machines or automated systems cannot fully replicate. They handle complex or sensitive tasks, interpret nuanced situations, and offer personalized support. Human agents bridge the gap between technology and human needs, ensuring interactions remain ethical, effective, and emotionally intelligent. They are crucial for problem-solving, customer service, and maintaining trust in systems.

Hybrid Customer Service Model

A combination of AI chatbots and human support improves efficiency. Chatbots manage routine queries, while humans handle exceptions. This balance enhances customer experience.A hybrid customer service model combines human agents and automated systems, like AI chatbots, to handle customer interactions efficiently. Routine queries are managed by automation for speed and consistency, while complex or sensitive issues are escalated to human agents for personalized attention. This approach improves response times, reduces costs, and enhances customer satisfaction by blending technology with human empathy and judgment.

FUTURE SCOPE OF AI CHATBOTS

Emotion-Aware and Intelligent Chatbots

Future chatbots may incorporate emotion recognition and sentiment analysis. This will enable more empathetic interactions. It will improve customer satisfaction.Emotion-aware and intelligent chatbots can detect and respond to users' emotions through language cues, tone, and context. They provide more empathetic, personalized interactions, improving user satisfaction and engagement. By understanding emotional states, these chatbots can adapt responses, handle sensitive situations, and offer support that feels more human-like.

Integration with Advanced AI Technologies

Integration with generative AI and predictive analytics will enhance chatbot capabilities. Chatbots will become proactive and intelligent service agents. This will transform customer engagement.Integration with advanced AI technologies allows systems to leverage machine learning, natural language processing, and predictive analytics for smarter decision-making. It enables automation of complex tasks, personalization of user experiences, and real-time insights from large datasets. Such integration enhances efficiency, accuracy, and adaptability across industries, making services more responsive and intelligent.

CONCLUSION

AI chatbots play a vital role in enhancing customer experience by providing fast, personalized, and consistent customer support. They offer significant benefits such as cost reduction, scalability, and improved service efficiency, despite challenges related to emotional intelligence and data privacy. A balanced integration of AI chatbots with human support systems can overcome these limitations and ensure high-quality customer service. With continuous advancements in artificial intelligence technologies, AI chatbots will remain an essential component of future customer experience management strategies.

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Role of AI in Enhancing Digital Literacy among Engineering College Students

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ABSTRACT

In an age when artificial intelligence (AI) and technological advancements are driving, digital literacy has emerged as a critical competency for engineering students. The quick adoption of AI tools in the classroom has changed how students get, assess, and use knowledge. This study looks at how artificial intelligence might improve college engineering students' digital literacy. It investigates how data-driven customization, intelligent tutoring, adaptive learning systems, and AI-driven platforms support the development of critical digital abilities. The report also identifies issues, including the requirement for faculty readiness, data protection, ethical difficulties, and uneven access. The study concludes that, when used properly, AI can greatly close the digital divide and provide engineering students with the essential digital skills they need to succeed academically and be prepared for the workforce.

KEYWORDS: Artificial Intelligence, Digital Literacy, Engineering Education, AI in Education, Digital Divide

INTRODUCTION

Higher education, especially engineering education, has been profoundly changed by the quick development of digital technology and artificial intelligence (AI). In addition to mastering technical knowledge, engineering students are required to acquire excellent digital literacy abilities that will allow them to use digital technologies to efficiently access, assess, produce, and convey information. To succeed academically, be employable, and pursue lifelong learning, digital literacy has become essential.

With its intelligent, flexible, and data-driven solutions that promote individualized learning and skill development, artificial intelligence has become a potent educational facilitator. Engineering schools are progressively using AI-driven technologies, including analytics-based evaluation systems, virtual assistants, adaptive learning platforms, and intelligent tutoring systems. This study looks at how AI can help engineering college students become more digitally literate and how it can help close the digital gap while tackling moral and practical issues.

CONCEPT OF DIGITAL LITERACY

The capacity to efficiently, critically, and responsibly use digital technology for work, learning, and social engagement is known as digital literacy. It encompasses a broad variety of competences, including media literacy, data literacy, information literacy, communication skills, and ethical awareness, and extends beyond simple computer usage.

Digital literacy for college students studying engineering comprises:

- The capacity to access and assess digital sources of information
- Expertise with internet resources and technical software
- Proficiency in digital communication and teamwork
- Knowledge of privacy, ethics, and cybersecurity

Digital literacy improves students' capacity for creativity and problem-solving while enabling them to adjust to new technology in the contemporary classroom.

ARTIFICIAL INTELLIGENCE IN EDUCATION

The application of intelligent systems and algorithms to enhance instruction, learning, and academic administration is known as artificial intelligence in education. AI systems use learner data analysis to deliver real-time feedback and individualized learning experiences.

Common AI applications in engineering education include:

- Intelligent tutoring systems that guide students step-by-step
- Adaptive learning platforms that adjust content based on learner performance
- Chatbots and virtual assistants for academic support
- Learning analytics for monitoring student progress

ROLE OF AI IN ENHANCING DIGITAL LITERACY

AI contributes significantly to enhancing digital literacy among engineering students through multiple dimensions.

Personalized and Adaptive Learning

AI-powered learning systems evaluate student performance and behavior to tailor instructional materials. This promotes individual learning and lets students acquire digital skills at their own speed.

Intelligent Tutoring and Academic Support

Chatbots and AI-based tutors offer immediate support, guiding students via digital platforms, granting them access to online resources, and effectively answering their academic questions.

Development of Information Evaluation Skills

AI technologies help students recognize reliable sources of information, spot false information, and develop their critical thinking and data analysis abilities.

Virtual Labs and Simulations

Engineering students may practice technical skills digitally using AI-powered virtual laboratories and simulations, which improve their problem-solving and experiential learning capabilities.

Inclusive and Accessible Learning

AI promotes digital inclusion by supporting flexible learning settings, bilingual education, and accessible tools for students with impairments.

ROLE OF ENGINEERING COLLEGES AND ACADEMIC LIBRARIES

When it comes to putting AI-driven digital literacy efforts into action, engineering universities are essential. Digital learning is greatly aided by academic libraries.

Libraries can:

- Provide access to AI-enabled databases and digital resources
- Conduct workshops on digital literacy and AI awareness
- Promote ethical information use and academic integrity
- Support faculty and students in adopting emerging technologies

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CHALLENGES IN IMPLEMENTING AI-BASED DIGITAL LITERACY

Despite its advantages, AI implementation in engineering education faces several challenges.

- **Digital Divide:** Unequal access to devices and internet connectivity limits effective AI adoption.
- **Infrastructure Constraints:** Lack of advanced technological infrastructure affects implementation.
- **Faculty Readiness:** Insufficient training among educators restricts effective AI integration.
- **Cost Factors:** High costs of AI tools and maintenance pose financial challenges.

ETHICAL CONSIDERATIONS AND DATA PRIVACY

When using AI in education, ethical considerations are crucial. Large amounts of student data are gathered and analyzed by AI systems, which raises privacy, consent, and security issues.

Key ethical considerations include:

- Protection of student data and confidentiality
- Transparency in AI decision-making processes
- Avoidance of algorithmic bias and discrimination
- Promotion of responsible and ethical technology use

CONCLUSION

By converting conventional teaching-learning methods into individualized, flexible, and technologically advanced experiences, artificial intelligence has become a potent facilitator for improving digital literacy among engineering college students. Students acquire critical digital skills, including information assessment, problem-solving, and efficient use of digital technologies, using AI-based learning platforms, intelligent tutoring systems, virtual laboratories, and data-driven academic assistance. By meeting a variety of learning demands, these technologies also support inclusive education and aid in closing the digital divide in engineering education.

However, issues with infrastructure, faculty preparedness, data protection, and ethical considerations must be carefully considered to successfully include AI into digital literacy programs. Establishing explicit ethical principles, adopting responsible AI methods, and funding ongoing training for teachers and students are all necessary. AI may greatly equip engineering students with the digital skills and awareness required for professional competence, academic success, and responsible involvement in a technology-driven society when used wisely and ethically.

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Navigating the Integration of Artificial Intelligence in Academic Libraries

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Abstract

The role of the library is undergoing a fundamental shift from a static repository of information to a dynamic, predictive knowledge ecosystem. The study highlights key challenges in AI implementation, such as ethical considerations, data privacy, and infrastructural constraints. Findings suggest that while AI holds immense potential to enhance digital library services, a balanced, user-centered, and ethically aware approach is essential for sustainable development. This paper also explores the "Agentic Era" of Artificial Intelligence (AI) in libraries, moving beyond simple chatbots to autonomous AI agents that handle metadata management, predictive collection development, and personalized research assistance. Further this study evaluates current trends, ethical imperatives, and the evolving role of the librarian as an "AI Navigator."

Key words: Artificial Intelligence- Integration of AI- Navigation of AI-Machine learning- Library Automation- Digital Libraries- Library Developments-AI Navigator.

Introduction

In the digital era, libraries are undergoing rapid transformation, shifting from traditional physical repositories to sophisticated digital knowledge hubs. The integration of Artificial Intelligence (AI) in digital library services has revolutionized the way information is organized, accessed, and utilized. The Fourth Industrial Revolution has reached the library stacks. Historically, libraries have been early adopters of technology—from the transition to OPACs to the digitization of archives. However, the current wave of Artificial Intelligence represents a paradigm shift. AI is no longer just a tool; it is becoming a collaborator that enhances the Five Laws of Library Science, particularly Ranganathan's fourth law: *"Save the time of the reader."*

Need for the study

With the exponential growth of information and digital resources, libraries face challenges in organizing, retrieving, and delivering relevant information efficiently. Traditional methods often fall short in handling large-scale data and diverse user needs. AI has emerged as a potent tool to overcome these challenges by automating processes and enhancing user experience. Investigating AI's role in libraries is crucial to understanding its impact, identifying best practices, and addressing potential barriers to adoption, ensuring libraries remain relevant and effective in the digital era.

Objectives

The following important objectives of the study are;

- To review existing AI applications in libraries worldwide.
- To analyze the benefits of AI in improving library efficiency and accessibility.
- To examine limitations and risks associated with AI adoption.
- To propose recommendations for effective AI implementation in libraries.

Related Reviews

In the past few decades, there has been tremendous growth in some AI methods, like current and conventional neural networks.

Williams (2019) described "the AI-powered assistants Alexa by Amazon, Siri by Apple, Cortanan by Microsoft, and Google Assistant by Google to ease searching for information in daily lives. Though these assistants were developed as consumer products and not for librarians, they can improve the search functions of databases and make it easier for researchers to find what they are looking for more quickly".

Wheatley et al. (2019) conducted an environmental scan on academic libraries' engagement with AI by reviewing scholarly articles, university libraries' strategic plans, and library programming to determine if any reference to AI was being made and in what context. Findings indicated a lack of response or awareness of the current AI trend, though a small number of institutions were found to be participating in or creating their own AI hubs. AI combines with the Internet of Things (IoT) in various ways, enabling big data applications, machine learning algorithms, deep learning, knowledge discovery, neural networks and other technologies".

Schreur (2020) states, "The transition from card catalogue to the MARC formats has proven enormously helpful to libraries and their patrons. Similarly, linked data and AI hold the same promise. By converting metadata surrogates (cataloguing) to linked open data, libraries can dline.info/jitr 127 Journal of Information Technology Review Volume 15 Number 4 November 2024 represent their resources on the Semantic Web. But to provide controlled access to unstructured data, libraries must reach beyond traditional cataloguing to new tools such as AI to provide consistent access to a growing world of full-text resources".

Lund et al. (2020) observe that "AI is refined, practical uses of the technology to improve the transfer of information are increasingly investigated, developed, and adopted in various public environments, including libraries. Though it is of relatively recent origin, AI presents an opportunity to investigate the emergence of public perceptions toward innovation and the relationship this holds with adopting emerging technologies, as envisioned in Roger's Diffusion of Innovations model. Their paper describes the results of a survey of practising librarians regarding the adopter category (innovator, early adopter, early majority, late majority, laggard) with which they identify and the relationship of this identification with perceived knowledge and perceptions of AI technology within and outside the library environment".

Phungar Prashant Lakshmanrao (2023) explores the multifaceted role of AI technologies such as machine learning, natural language processing, and robotics in enhancing library functions, including cataloging, reference services, user interaction, and digital resource management. It assesses the benefits, challenges, and evolving trends in AI adoption, highlighting how AI-driven tools contribute to personalized experiences, automated workflows, and improved accessibility. The paper also discusses ethical concerns and future prospects, emphasizing the strategic importance of AI for library transformation in the digital age.

Kumar, D.N. (2025) examined both theoretical insights and practical applications, the paper investigates how AI is reshaping cataloguing, metadata generation, semantic search, user personalization, and automated assistance. The study also highlighted key challenges in AI implementation, such as ethical considerations, data privacy, and infrastructural constraints. Findings suggest that while AI holds immense potential to enhance digital library services, a balanced, user-cantered, and ethically aware approach is essential for sustainable development.

Methodology of the study

This study is based on the **descriptive and analytical research design**. The descriptive approach is adopted to systematically describe and present the existing status, patterns, and characteristics of the subject

under investigation. It helps in outlining trends, distributions, and relationships as they appear in the collected data, without manipulating any variables.

The analytical method is employed to critically examine and interpret the collected information in order to draw meaningful inferences and conclusions. Through analysis, the study identifies relationships, comparisons, and underlying implications relevant to the research objectives.

For the purpose of this study, **only secondary data have been collected**. Secondary data refer to data that have already been gathered and published by other researchers, institutions, or organizations. These data sources include scholarly journals, books, conference proceedings, reports, official statistics, databases, and credible online resources.

Overall, the integration of descriptive and analytical methods with secondary data provides a systematic and reliable framework for examining the research problem and achieving the objectives of the study.

Core Applications of AI in Libraries

- Automation of Routine task
- Enhanced Information Retrieval
- Personalized User Experience
- 24/7 Reference Services via Chatbots
- Improved Accessibility and Inclusivity
- Efficient Management of Digital Collections
- Predictive Analytics for Collection Development
- Smart Library Environments
- Enhanced Metadata Quality
- Reduction in Operational Costs
- Supports Research and Data Analysis
- Real-Time User Feedback and Adaptation
- Facilitation of Multimodal Search
- Enhanced Collaboration and Networking
- Supports Open Access and Digital Scholarship
- Enables Proactive Library Services

Some important Challenges of AI Technology

1. Technical complexity and skill gap
2. Data privacy and security concerns
3. Overdependence on technology
4. Transparency and explainability issues
5. Integration with legacy systems
6. Maintenance and continuous updating requirements
7. Limited contextual understanding
8. Potential for misinformation

Discussion

The integration of AI in libraries presents a transformative opportunity to enhance operational efficiency and user engagement. AI applications like chatbots, personalized recommendations, and intelligent search engines address user needs more effectively than traditional methods. However, successful implementation requires addressing challenges such as high costs, data quality, and ethical concerns. Training and involving

library professionals in AI adoption is critical to mitigating resistance and ensuring responsible use. Collaboration between librarians, technologists, and policymakers will shape the trajectory of AI in libraries, emphasizing inclusivity, transparency, and sustainability.

Emerging Technology Trends to Watch

- **Agentic AI:** Unlike traditional Generative AI, Agentic AI can execute multi-step tasks autonomously, such as conducting a comprehensive literature review or managing inter-library loans without human intervention.
- **Physical AI and Robotics:** Many central libraries are now employing "Smart Shelf" technology and robotic retrieval systems to automate inventory management and minimize human error in large-scale archives.
- **AI-Enhanced Accessibility:** Real-time translation and AI-generated alt-text for visual archives are making libraries more inclusive for international patrons and the visually impaired.

The Evolving Role of the Librarian

The 2026 librarian is no longer just a curator but a **Knowledge Architect**. Essential skills now include:

- **Prompt Engineering:** Guiding patrons to interact effectively with AI tools.
- **Data Literacy:** Understanding the "black box" of AI algorithms to ensure transparency.
- **Ethics Custodianship:** Establishing guardrails for privacy and intellectual freedom in an automated environment.

Conclusion

Artificial Intelligence has become an indispensable tool in modern libraries, driving innovation in service delivery, resource management, and user interaction. While the benefits are substantial, challenges related to cost, ethics, and human factors necessitate careful planning and ongoing evaluation. The future of librarianship will increasingly intertwine with AI, making it essential for libraries to embrace these technologies strategically while maintaining their core values of openness, privacy, and equitable access.

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The Use of Blockchain Technology and its Implications for Libraries

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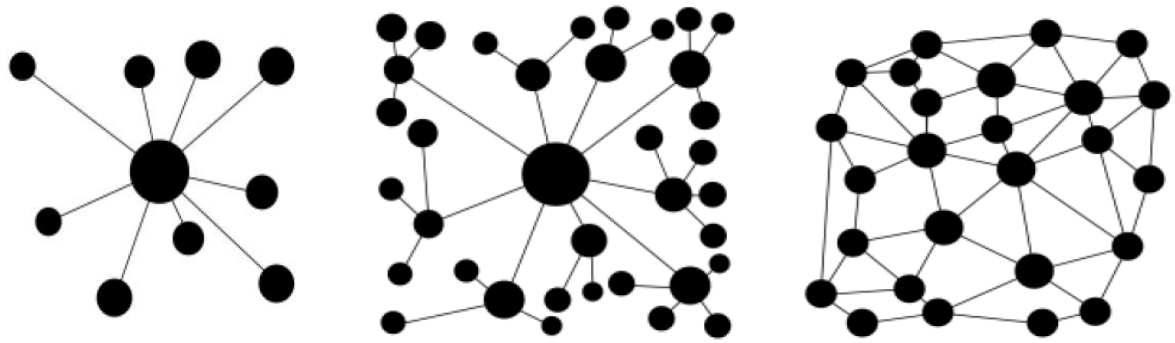
Abstract

The initial cryptocurrency, Bitcoin, gave rise to the idea of blockchain technology. It is a relatively new, sophisticated, and reliable technology, and academics are always trying to figure out how to use this game-changing tool in many contexts. To improve library and information services both now and in the future, this chapter provides a brief overview of the blockchain and how it is being applied in libraries and information centres. This chapter provides a brief overview of blockchain technology, here we discuss about its types, features, benefits, and how it will benefit or help in libraries and education in their routine activities. The technology known as blockchain because it has the capacity to transform society. This technology is decentralized and secure, making it impossible to modify, duplicate, or falsify transactions. The purpose of writing this paper is to inform library professionals about this innovative futuristic technology and help them to take the necessary steps for adopting blockchain technology within libraries.

Keywords: Blockchain Technology, Types of Blockchain, Smart Library, Digital Library Management.

What is Blockchain Technology

Block chain technology is previously known as Distributed Ledger Technology (DLT). Distributed Ledger Technology is an emerging technology that leverages decentralization to ensure the validation and transparency of digital assets, enabling the digital conversion and storage of currencies and other data by processing information in segments. This includes connecting one block to another. These blocks are unable to be hacked. It is a permanent record of transactions that cannot be altered deleted or destroyed. Blockchain technology is intended to keep papers digitally secure.



A. Centralized Network **B.** Decentralized Network **C.** Distributed Network

An analysis of centralized, decentralized and distributed networks by its topographical structure.

It's an out of the reach of any individual entity, person or organisation, nobody has the power to alter or erase a transaction history. It is inaccessible. All previous transactions made using this technology cannot be change or removed. Therefore, is gives clear and accurate information.

Introduction

Block chain is distinguished as the “Foundational Technology or Core Technology”, and widely used for cryptocurrencies such as Bitcoin and Ethereum, and its implications extend far beyond digital currency,

areas such as secure transactions, smart contracts, supply chain management, and digital identity verification, demonstrating its applications across various industries.

The term Bitcoin, a cryptocurrency, was first explained in 2008 in his work, **"**Bitcoin: A Peer-to-Peer Electronic Cash System**"**, by Satoshi Nakamoto.

Blockchain was first proposed in 1991 as a research project, but in the year 2009, Blockchain was used in bitcoin. Bitcoin is a cryptocurrency which is built based on Block technology. Blockchain has since been used in the creation of various cryptocurrencies, decentralized finance applications (DeFi), non-fungible tokens (NFTs), and smart contracts.

In 1991 block chain was suggested as a research project, but it was used for bitcoin in the year 2009. By using block technology bitcoin, a cryptocurrency was built. Blockchain has been used for the formation of various cryptocurrencies, decentralized finance applications (DeFi), non-fungible tokens (NFTs), and smart contracts. It's use is not limited to financial domain but also in the non-financial domains as well. Thus, it can be used as a catalyst in the development of the library too. Unlike traditional centralized systems, blockchains are decentralized, transparent, inclusive, immutable, and safe, help us to innovate and exchange value in ways previously impossible, to transforming the value of the modern society.

Evolution blockchain technology

In 1970s a computer scientist called Ralph Merkle patented Hash trees or Merkle trees, These trees are a computer science structure for storing data by linking blocks with cryptography in this period blockchain technology was originated.

This was the first time in the history of blockchain that was the end of 1990s Stuart Haber and W. Scott Stornetta employed Merkle trees to build a system, akin to using cryptographic hash trees or hash-based structures for secure data verification and timestamping.

The technology has continued to evolve over these three generations:

- **First generation – Bitcoin and other virtual currencies**

  In 2008, an anonymous individual or group of individuals known only as Satoshi Nakamoto introduced blockchain technology in the form it is today. Satoshi proposed the Bitcoin blockchain, which employed 1 MB blocks of information for Bitcoin transactions. Many elements of Bitcoin blockchain systems continue to be an essential to blockchain technology today.

  ******Blockchain1.0 refers to digital currency (day-to-day digital payment-based systems)

- **Second generation – Smart contracts**

  A few years after first-generation currencies emerged, developers began to examine blockchain uses other than bitcoin. For example, the creators of Ethereum chose to leverage blockchain technology in asset transfer operations. Their major contribution was the smart contract functionality.

  ******Blockchain 2.0 to digital finance (whole economic market: Traditional transactions like bonds, stocks, shares and smart contracts).

- **Third generation – The future**

  As organisations find and implement new uses, blockchain technology evolves and expands. Companies are tackling restrictions of size and processing, and the prospects are endless in the current blockchain revolution.

******Blockchain 3.0 to digital society (e-governance, digital health records, digitally vote counting, science, literacy, culture and digital art)

- **Fourth generation – The future and beyond**

  According to the literary works, the current era of blockchain will use Artificial Intelligence (AI) to provide autonomous or smart services, reducing the need for human administration. In addition, it will improve upon the third generation in terms of energy management, scalability, usability, performance, and consensus efficiency. Furthermore, its applications will traverse other areas and potentially combine with other technologies such as cloud computing, resulting in Blockchain-as-a-Service (BaaS).

  ******Blockchain 4.0 will accommodate other complex data file formats such as PDF, video, audio and other file formats that have not been previously associated with blockchain.

Blockchain timeline

- **2008:** Satoshi Nakamoto, a pseudonym for a person or group, publishes "Bitcoin: A Peer to Peer Electronic Cash System."
- **2009:** The first successful Bitcoin (BTC) transaction occurs between computer scientist Hal Finney and the mysterious Satoshi Nakamoto.
- **2010:** Florida-based programmer Laszlo Hanycez completes the first-ever purchase using Bitcoin — two Papa John's pizzas.
- **2011:** 1 BTC = 1 USD, giving the cryptocurrency parity with the US dollar.
- **2011:** Electronic Frontier Foundation, Wikileaks and other organizations start accepting Bitcoin as donations.
- **2013:** BTC market cap surpasses $1 billion, and Bitcoin reaches $100/BTC.
- **2013:** Buterin publishes the "Ethereum Project" paper, suggesting that blockchain has other possibilities besides Bitcoin (like smart contracts).
- **2014:** The first-known NFT is minted.
- **2015:** Number of merchants accepting BTC exceeds 100,000.
- **2015:** NASDAQ and San Francisco blockchain company Chain team up to test the technology for trading shares in private companies.
- **2016:** Tech giant IBM announces a blockchain strategy for cloud-based business solutions.
- **2017:** Bitcoin reaches $1,000/BTC.
- **2017:** Cryptocurrency market cap reaches $150 billion.
- **2018:** IBM develops a blockchain-based banking platform with large banks like Citi and Barclays signing on.
- **2019:** China's President Ji Xinping publicly embraces blockchain as China's central bank announces it is working on its own cryptocurrency.
- **2019:** The New York Stock Exchange (NYSE) announces the creation of Bakkt, a digital wallet company that includes crypto trading.
- **2020:** BTC almost reaches $30,000 by the end of 2020.
- **2020:** PayPal announces it will allow users to buy, sell and hold cryptocurrencies.
- **2020:** The Bahamas becomes the world's first country to launch its central bank digital currency.
- **2021:** Bitcoin surpasses $1 trillion in market value.
- **2021:** Popularity for the implementation of Web3 rises.
- **2022:** Cryptocurrency loses $2 trillion in market value, due to economic inflation and rising interest rates.
- **2022:** The U.K. government proposes safeguards for stablecoin holders.

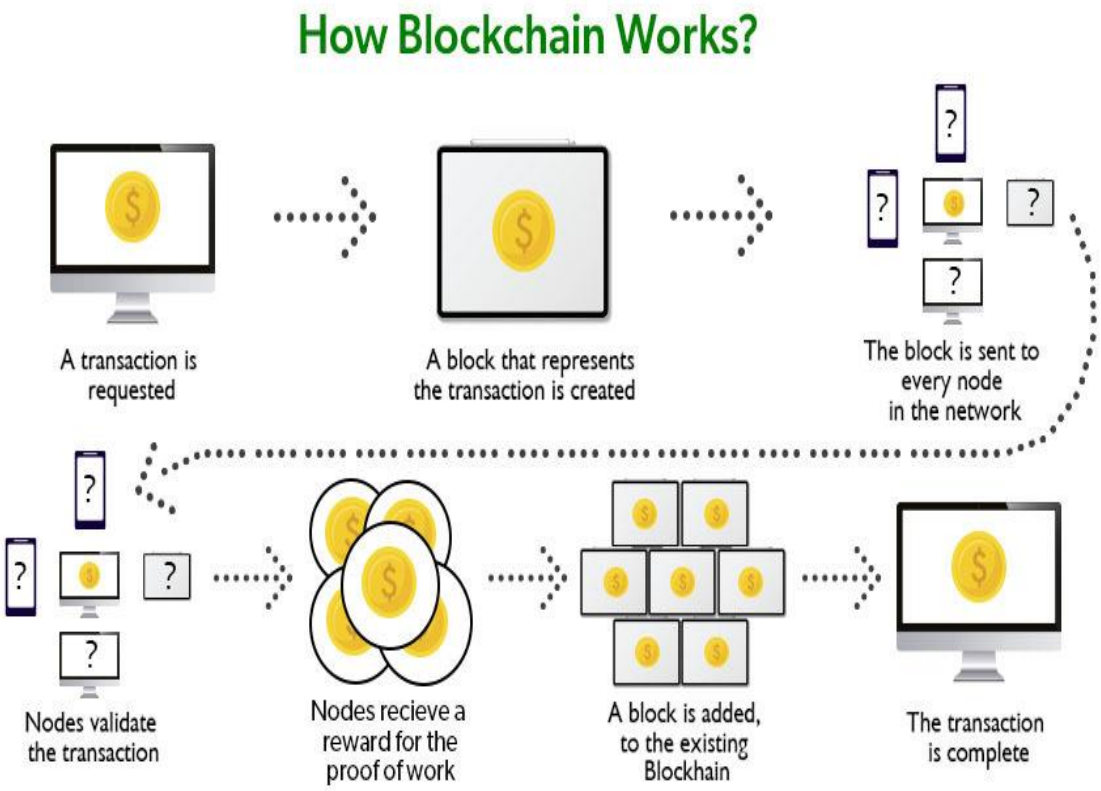
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- **2022:** The FTX collapse sends shockwaves through the crypto market while igniting general distrust of cryptocurrencies.
- **2023:** Do Kwon, co-founder and CEO of Terraform Labs, is charged with running a fraud scheme and ordered to pay $4.5 billion in damages the following year.
- **2023:** Crypto entrepreneur Justin Sun and his companies are charged with fraud by the Securities Exchange Commission.
- **2023:** Sam Bankman-Fried, the founder of FTX, is tried on fraud and conspiracy charges, then sentenced to 25 years in prison in early 2024.
- **2024:** Bitcoin reaches $100,000 in value for the first time ever.

How does blockchain works

Three elements is necessary for building block in a block chain is ***Data***, ***Hash***, ***Previous Hash***/ ***Parent Hash*** for the hash of the preceding block, it's an important that the last block must be connected in the chain of each block, along with a cryptographic hash of its own.

The core element of a blockchain is a ***block.*** A block is a collection of information, content or data. those blocks are tied to together in sequential order; to form a chain of linked blocks, the data is added to the block in the block chain. Because of this, it forms a sequential database of transaction which is transfer by different networks nodes, such as PCs or servers. To resolve a cryptographic challenge and form the sequence of block in the chain, miners select a unique number called ***Nonce*** that is added to a hashed or encrypted block and can only be used of once. we call if ***Proof Work***.



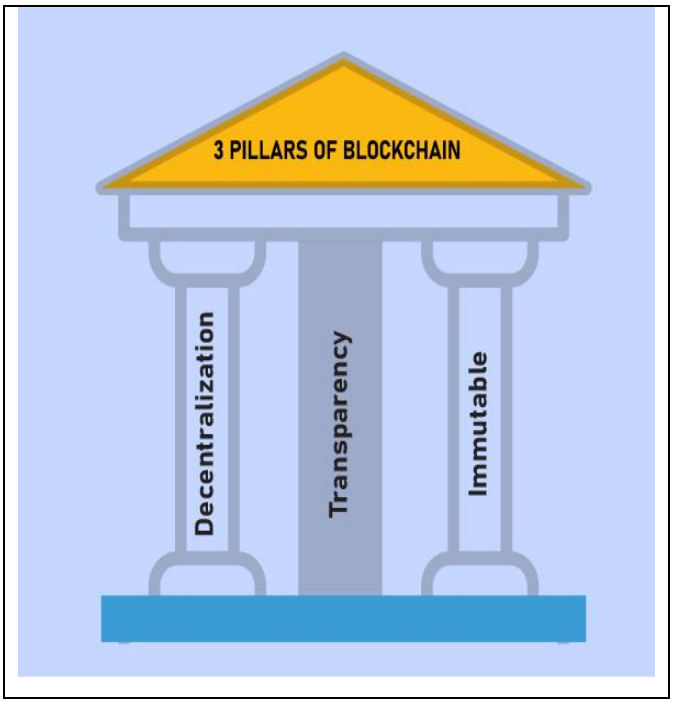
For every transaction in blockchain a special number or alphanumeric code is generated it's called ***hash***. The hash itself has been created on its own data, the timestamp, and all the hash is linked with its each previous hash in a chain.

Blockchain transactions are documented in blocks, its must be authenticated and verified before being added to the chain. A systematic protocol or procedure must be follow for the recognition of block's identity, after recognition of block's identity it must be verified by the nodes (clients or servers) with the greatest stack in the distributed network must validate the block, and unique code or hash is generated after a block's validation, serving as a digital fingerprint that confirms the block's integrity and authenticity. Blocks is also notified by ***their header hash, block number, or block height.***

A computer algorithm ***hash function*** is used for the unification and identification of data contained within each block. This feature makes the data unchangeable and locks it so that only participants in the Blockchain can view it. Each block has a hash function of its own. Data stored on a blockchain is permanently stored and cannot be altered. A minor modification creates a new block in the chain. Blockchain uses time stamps to prevent information from being tampered with, acting as a digital notary.

The three pillars or Main properties of blockchain technology

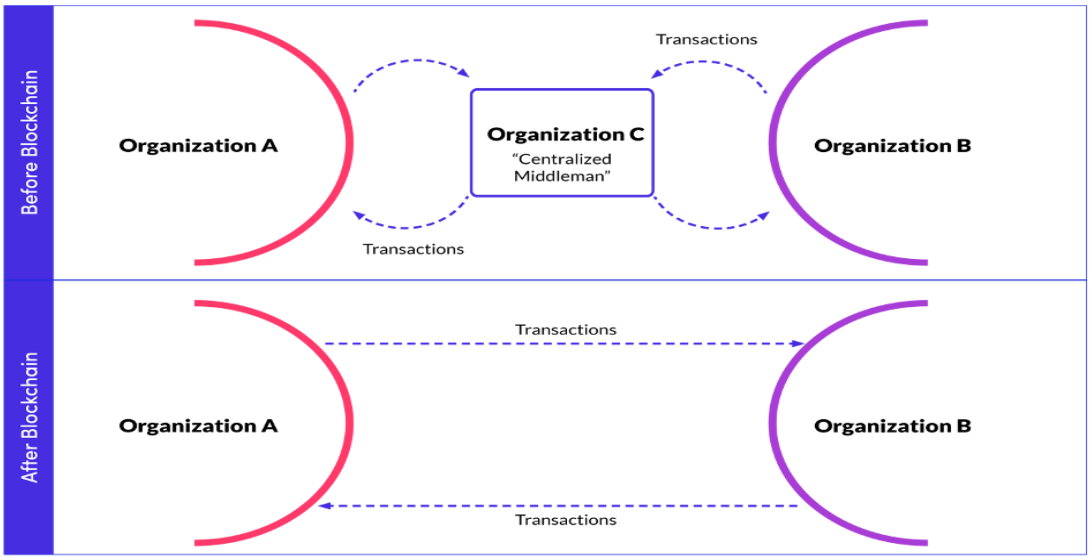
The three main properties of Blockchain Technology which have helped it gain widespread acclaim are:



Decentralization

- **Business decentralization**

If you wish to communicate with a friend in a decentralised network, you can do so directly without using a middleman. That was the core principle of Bitcoin. You are the only one in control of your finances. Without using a bank, you can send your money to anybody you like.



- **Physical decentralization**

The main distinguishing feature of Blockchain is physical decentralisation. As a peer-to-peer gateway, no single organisation can command the blockchain network. It's simply managed by a group of coders and powered by an open network of dedicated computers spread around the globe.



For example, Bitcoin was designed to be censor-resistant—if you have a bitcoin then no one can stop you from spending it on the bitcoin network. For main networks, it is therefore essential to have a large, diverse group of users (*often strangers*) running the nodes of the network. These strangers are incentivized to do this because they are paid to run your transaction (*technically the process is called "mining", and they often must compete to win the token prize by creating the best block of transactions*).

Running a single, global network of blockchain servers ("*main networks*") is a big undertaking, especially if you want the network to be independent and self-sustaining. Broad, physical decentralization is a must for public blockchain main networks but comparatively less significant for a private blockchain.

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Transparency

One of the most fascinating and misunderstood notions in blockchain is "transparency." A person's identity is disguised behind advanced cryptography and represented solely by their public address. The following snapshot of Ethereum transactions depicts as what it shown:

TxHash	Block	Age	From	To	Value	[TxFee]
0x2d055e4585ae2a...	5629306	16 secs ago	0x003e3655090890...	0x2bdc9191de5c1b...	0,004741591554641 Ether	0.000294
0xb4d37c791ff4cde...	5629306	16 secs ago	0x6c3b4faf413e0e4...	0xf14cb3acac7b230...	0,744767225 Ether	0.000294
0x9979410dcb5f4c...	5629306	16 secs ago	0x99bcd75abbac05...	0x2d42ee86390c59...	0,016294 Ether	0.000294
0x189c4d4aae09be...	5629306	16 secs ago	0x175cd602b2a1e7...	0xd39681bb0586fb...	0,01 Ether	0.000294
0xda0e9bbb11fb77...	5629306	16 secs ago	0x73a065367d111c...	0x01995786f14357...	0 Ether	0.00150007
0x6be498fafad9acb...	5629306	16 secs ago	0xa3eb206871124a...	0x8a91cac422e55e...	0,029594 Ether	0.000294

The term blockchain transparency refers that every transaction is publicly accessible, and can be viewed by anyone, like using a blockchain explorer to see all activities associated with a public wallet address. Blockchain explorer allows anyone to view all transactions linked to a public wallet address.

Immutability

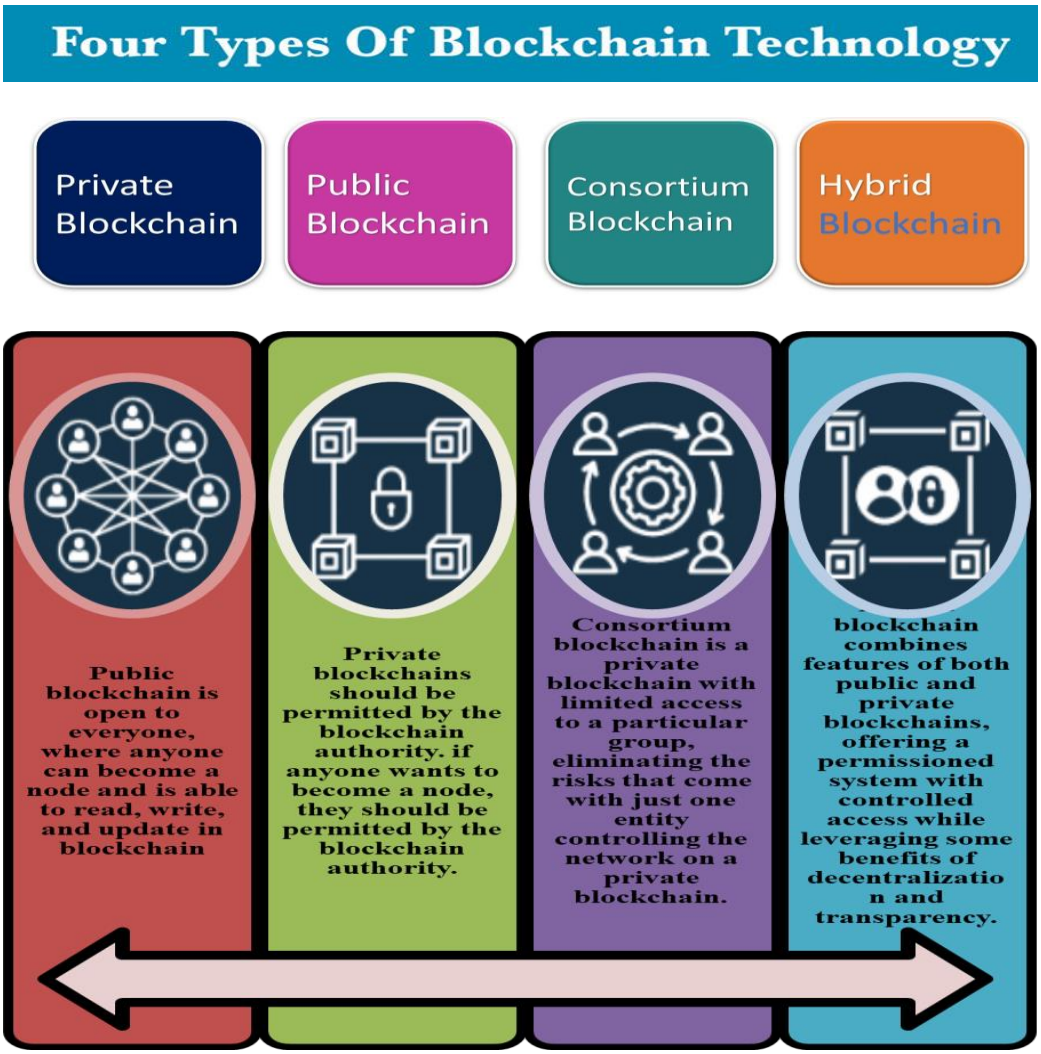
The structure of the blockchain reliability is highly based on immutability, because when a transaction is recorded on a blockchain, it is considered permanent and cannot be modified or erased. This ensures that data used in blockchain app development is tamper-proof, promoting trust and increasing security. This immutability is achieved using cryptographic hashing.

In simple terms, hashing means taking an input string of any length and giving out an output of a fixed length. Each block in the chain has a unique hash, and changing any data modifies the hash, making the block invalid.

INPUT	HASH
Hi	3639EFCD08ABB273B1619E82E78C29A7DF02C1051B1820E99FC395DCAA3326B8
Welcome to blockgeeks. Glad to have you here.	53A53FC9E2A03F9B6E66D84BA701574CD9CF5F01FB498C41731881BCDC68A7C8

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Types of blockchain technology



Advantage, Disadvantage and Usage of Four Types of Block Chain technology				
	PUBLIC	**PRIVATE**	**CONSORTIUM**	**HYBRID**
ADVANTAGES	**Independence Transparency Trust**	**Access control Performance**	**Access control Security Scalability**	**Access control Performance Scalability**
DISADVANTAGES	**Performance Scalability Security**	**Trust Auditability**	**Transparency**	**Transparency Upgrading**
USAGE	**Cryptocurrency Document Validation**	**Supply Chain Asset Ownership**	**Banking Research Supply Chain**	**Medical Record Real Estate**

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What is blockchain protocols?

Blockchain platforms of various kinds are available for the development of applications. The fundamental blockchain concepts are modified by each blockchain protocol to be suitable for particular sectors or uses. Some examples of blockchain protocols are provided in the following subsections:

- **Bitcoin Protocol**
  The original cryptocurrency, which is mostly used as digital money, allows peer-to-peer transactions without middlemen through a decentralised ledger.
- **Hyperledger fabric**
  Hyperledger fabric is a permissioned blockchain framework with modular architecture and adjustable consensus that is intended for enterprise applications. Because of these characteristics, it can be used for a wide range of purposes, including supply chain tracking and tracing, trade financing, loyalty and incentives, and financial asset clearing and settlement. Libraries are among the sectors that use it. healthcare and supply chain for safe data exchange.
- **Ethereum**
  Ethereum is a decentralised open-source blockchain platform that enables users to create public blockchain applications. Ethereum Enterprise is intended for corporate use cases.
- **Corda**
  Corda is a scalable and permissioned peer-to-peer (P2P) distributed ledger technology (DLT) platform. Corda allows you to create interoperable blockchain networks that transact in tight secrecy and provide digital trust between participants in regulated marketplaces. Corda's smart contract technology enables businesses to deal directly and with value. Many of its users are financial institutions.
- **Quorum**
  An open-source blockchain technology called Quorum is based on Ethereum. It is specifically made to be used in either a consortium blockchain network, where several members each control a section of the network, or a private blockchain network, where just one person owns all the nodes.
- **Ripple (XRP)**
  A digital payment system designed to facilitate quick and cost-effective cross-border transactions. Its innovative consensus method enables speedy transaction validation and settlement.

Benefits of blockchain technology

- **Security**
  If your data is sensitive, crucial, or significant, blockchain technology can alter your perception of critical information. The blockchain helps to avoid fraud and unauthorised conduct by providing an immutable record that is encrypted end-to-end. There is no single point of failure, and no one user may modify the transaction records.
  On the blockchain, you may solve privacy concerns by anonymising personal data and implementing access controls. Information is stored over a network of computers rather than a single server, making it difficult for hackers to access.
- **Transparency**
  Blockchain stores data and transactions in various places in a same manner using a distributed ledger. Furthermore, complete transparency is ensured as all network users with authorised access view the same data simultaneously. Every transaction is time- and date-stamped and permanently documented.
  This feature effectively removes any chance of fraud and allows subscribers to see the complete transaction history.
- **Collaboration**
  It permits every party to interact directly with one another while not requiring third-party negotiation.

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- **Traceability**
  Blockchain generates an audit trail for every document and asset at each stage of its journey.
  With the use of blockchain, organisations must be able to protect, produce, exchange, preserve, and reconstruct e-transactions in an auditable manner; this helps to offer proof, and data and sources may be shared directly with consumers.
  Traceability data may also identify vulnerabilities in any supply chain—where products may languish on a loading dock awaiting transit.
- **Increased efficiency and speed**
  Business-to-business transactions can take a long time and result in operational bottlenecks, especially when compliance and third-party regulatory bodies are involved. Blockchain's transparency and smart contracts enhance and speed up the efficiency of commercial transactions.
- **Automation**
  "Smart contracts" can automate transactions, enhancing efficiency and speed. When the predefined requirements are satisfied, it automatically initiates the next stage in the transaction or process. Smart contracts remove the need for human interaction and rely on third parties to ensure that contract requirements are met. Blockchain confirms and verifies the identity of all interested parties. This eliminates duplicate records, lowering rates and expediting transactions.
  In insurance, for example, if a consumer has given the required evidence to file a claim, the system will automatically settle and pay the claim.

What types of industries use blockchain & Why?

Blockchain offers solutions to challenges that traditional systems fail to overcome, and its diverse applications unlock new opportunities in finance, healthcare, manufacturing, and beyond.

Here's why major sectors are embracing this technology:

- **Finance** - Fraud prevention, faster cross-border payments, and smart contracts.
- **Healthcare -** Secure data sharing and streamlined insurance claims.
- **Manufacturing -** Real-time tracking of goods and reducing operational inefficiencies.
- **Real estate -** Transparent property transactions and reduced paperwork.

Blockchain for libraries

Why blockchain technology used in library

Libraries have a major opportunity to use blockchain technology to advance privacy for users, increase collaboration, and transform the way they work with each other and their communities. By keeping up to date, libraries can evaluate blockchain opportunities and make the best use of this technology.

Areas of implementation of blockchain technology in libraries

Blockchain technology is opening new opportunities. A part from its application in financial services, blockchain-based systems may be implemented in other fields related to Libraries, like it can be used to safeguard library user records, retrieve libraries document and improve collection management, identification and discovery of unique holdings, and more:

- Digital preservation and tracking
- Community-based collections to share objects, tools, and services
- For managing library operations
- Secure user records in libraries
- Library acquisitions, and improve collections maintenance

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- Blockchain-based currencies for international financial transactions (IFLA)
- Inter Library Loan and Voucher System
- Library verification of credentials (information literacy)
- Library card
- Archives/special collections where provenance and authenticity are essential
- Corporate library records keeping
- Organizational data management
- Intellectual property for R&D, etc.
- Scientific writing & Scholarly Publishing where researchers can record and time-stamp ideas and spread information
- Digital Rights Management: Publishers have imposed draconian, often unworkable DRM tools on libraries and consumers to prevent copying of their materials
- Secure user records in libraries, document library acquisitions, and improve collections maintenance.

Literature Review

Blockchain case studies in the library context

- **Blockchain-based digital rights management (DRM)**
  Fujimura et al. were among the first to propose blockchain-based DRM, introducing a system known as "Digital Rights Management using Blockchain (DRMB)". DRMB stores copyright information on a private blockchain, while transactions and payments are recorded on a public blockchain. The authors developed a proof-of-concept utilising the Bitcoin and Hyperledger Fabric platforms, demonstrating the practicality of their technique.
- **Library of Alexandria's blockchain-based digital archiving**
  The Library of Alexandria, Egypt, launched a blockchain-based Digital Archiving, Using blockchain technology to keep a record of the data stored on a decentralized cloud service could be exactly what the historical and archive industries need to protect our collective human history from destruction, pillage and faulty record-keeping.
- **Blockchain-based Cataloguing and metadata management**
  The Public Libraries 2020 initiative in Europe explores blockchain-based solutions for decentralized cataloguing and archival preservation. By distributing cataloguing tasks across a network of participants, libraries can ensure redundancy and integrity in their metadata records, thereby safeguarding cultural heritage for future generations.
  Another example of the blockchain project of San Jose State University explores the technology for building an enhanced metadata system for the libraries, protecting digital first sale rights, host digital peer- to- peer sharing *(Ways to Use Blockchain in Libraries, 2017)*
- **Blockchain-based Copyright management system for digital music**
  The system automates music file registration, licensing, and distribution using smart contracts. The authors also implemented a reputation-based incentive mechanism to encourage users to use the system and report copyright infringements.

These case studies show how blockchain technology may increase the efficiency, security, and transparency of library operations while also improving the user experience.

Different examples of blockchain case studies across various industries

- **Supply chain management- Walmart**

Walmart uses blockchain to track food products from farm to store, improving transparency and traceability. The system allows for rapid identification of the source of food safety issues, ultimately reducing waste and ensuring consumer safety.

- **Finance- Ripple**
  Ripple is a blockchain platform that enables fast and cost-effective international money transfers. Financial institutions use Ripple's technology to enhance cross-border transactions, reducing time from days to seconds while minimizing transaction fees.
- **Healthcare- MediLedger**
  The MediLedger Project uses blockchain for pharmaceutical supply chain management, ensuring the integrity of drug inventories and preventing counterfeit medications. It enables secure sharing of data among stakeholders while maintaining regulatory compliance.
- **Voting- Voatz**
  Voatz utilizes blockchain technology to facilitate secure and tamper-proof voting processes, allowing users to cast votes via mobile devices. This platform aims to increase voter participation while ensuring the transparency and security of elections.
- **Intellectual property- Ascribe**
  Ascribe is a blockchain-based platform that allows creators to register and manage their digital assets, ensuring proper attribution and ownership. This helps artists and authors maintain control over their work in the digital space.
- **Real estate- Propy**
  Propy provides a blockchain-based platform for real estate transactions, streamlining the buying and selling process. It enables secure and transparent property transfers, reducing paperwork and the possibility of fraud.
- **Energy- Power ledger**
  Power Ledger is a blockchain platform that enables peer-to-peer energy trading, allowing consumers to buy and sell excess renewable energy directly. This promotes decentralized energy markets and increases the use of green energy.
- **Insurance- Etherisc**
  Etherisc leverages blockchain technology to create decentralized insurance applications, simplifying claims processing and ensuring that policies are transparent and tamper-proof.

Conclusion

Blockchain technology is an emerging solution that enables reliable confirmation of transactions, including the involved parties, date and time of submission, and transaction content, without the need for third-party verification. By adopting blockchain, libraries stand to significantly enhance the security, transparency, and accessibility of their collections, while also redefining digital preservation and intellectual property management. As libraries evolve in the digital era, embracing blockchain has the potential to bring about transformative changes in library services.

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Emerging Technological Trends

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Abstract

Emerging technologies such as Artificial Intelligence (AI), Machine Learning (ML), the Internet of Things (IoT), automation, cloud computing, data analytics, and Virtual Reality (VR) are transforming the way people live and work. These technologies enable intelligent decision-making, improve efficiency, and create innovative solutions across various sectors including healthcare, education, industry, and entertainment. AI and ML allow systems to learn from data and make predictions, while IoT connects physical objects to the digital world for real-time monitoring and interaction. Automation and robotics enhance productivity by performing repetitive and complex tasks. Cloud computing and data analytics support large-scale storage and processing, enabling organizations to make informed decisions. VR and AR provide immersive experiences that are reshaping training, learning, and recreation. Together, these technologies represent the future of digital transformation.

Key Words - Optimization, Versatility, Interactivity, Integrity, and Statistics

Introduction

Technology has become an inseparable part of modern life. Rapid advancements in digital systems are reshaping industries, education, healthcare, communication, and governance. Emerging trends such as Artificial Intelligence, Machine Learning, Internet of Things, cloud computing, automation, data analytics, and virtual reality have introduced smarter ways of performing tasks that once required human intelligence and effort.

Role of Artificial Intelligence in Emerging Technologies

Artificial Intelligence refers to the ability of machines to perform tasks that normally require human intelligence, such as reasoning, learning, problem-solving, and decision-making. Machine Learning, a subset of AI, enables systems to learn from experience and improve performance without explicit programming. IoT connects everyday devices to the internet, allowing them to collect and exchange data. Automation and robotics reduce human workload by handling repetitive or dangerous tasks, while cloud computing provides scalable storage and processing power. Data analytics helps in identifying patterns and trends for better decision-making, and VR creates immersive digital environments for training and entertainment. These technologies collectively contribute to economic growth, improved efficiency, and innovative problem-solving.

Explore the Pro Con debate

Most individuals believe that man's conduct is intellectual, although particularly complicated behaviour among bugs is thought to be instinctual. The excavation mite, when instance, has a set schedule for carrying nourishment into its hole. The insect repeatedly follows an identical procedure whenever the nourishment is shifted. This demonstrates the fact the lady wasp is unable to adapt its responses to novel circumstances. Being able to adjust as well as react accordingly when it is situations changes is a sign of honesty. Intellectual ability is derived from a variety of skills rather than just one. These pertain to linguistic studying, logical tackling issues, plus awareness.

Effective artificial intelligence vs. Poor artificial intelligence

Depending on the degree that technologies mimic the mind of humans, their exist two primary categories of machine learning. Poor artificial intelligence, referred to as restricted AI, is probably the most prevalent kind

of AI in use presently and is made to perform only certain functions. This includes electric cars that drive themselves and voice-activated devices like Amazon's Echo. These mechanisms perform admirably, nevertheless only for certain regions. Advanced artificial intelligence, sometimes referred to as simply broad AI, is the ability of robots to reason, study, and behave like beings in a wide range of operations. There is currently no real-world use for such forms of Intellect; it is still purely notional. Currently, the use of powerful AI is limited to SF films such as Ripley as well as WALL- E.

Distinctions between neural networks, machine learning, with artificial intelligence

Although AI, deep learning, meaning computer science (AI) may be utilized interchangeably, there do not mean identical. Algorithms was a generic term for technology behaving resemble people. Many innovations created during this period are included within it. One aspect associated with artificial intelligence that permits neural networks to gather knowledge through historical records is neural networks. Requiring being explicitly designed, it assists frameworks with identifying trends in addition forecasting. Having a lot of evidence obtainable is beneficial for predictive modelling. A unique kind of data mining called "deep learning" makes use of neural nets that resemble an individual's brain. Critical breakthroughs in artificial intelligence notably augmented reality as well as autopilots are made possible by it.

Four categories involving artificial intelligence

Computer vision is divided under four classifications, which encompass sophisticated avatars whose are still not real to the job-oriented machines we use today.

The categories are as follows:

Type 1: Disruptive Devices

Since they lack cerebral cortex, artificial neural networks are limited to responding with the circumstances at hand. For Deep Blue of IBM, whose performed billiards however was unable to absorb information following past matches, they are made towards specialized jobs.

Type 2: Cognitive Limitations

When choosing actions, this kind of machine learning can draw on historical data. Intelligent automobiles whose use past journeys to increase protection are a specific instance.

Type 3: Concept of Brain

It is predicted that the proposed Computer would comprehend human beings and feelings. Although these technologies remain to be developed, they could improve realistic human- machine interaction.

Type 4: Being conscious of oneself

With awareness, such artificial intelligence systems will become aware of their very presence. This particular form of AI is still conceptual and is not yet implemented.

The differences between simulated and intelligent augmentation

The idea of "intelligent technology" is frequently affected by current events including films that might lead to overinflated beliefs concerning its capabilities. As a result, the acronym "extraordinary brainpower" is preferred by certain specialists. This emphasizes the fact that in contrast against the completely autonomous computers portrayed in the futuristic movies, contemporary artificial intelligence (AI) mostly aids and supports people.

Analysis augmentation

Leveraging machine learning as a complement to the skills of people in lieu of substituting them is known as enhanced intelligence. The systems in question were developed to assist perform particular duties to simplify labor. In some cases, professionals might pinpoint important elements in court papers or underline significant information in presentations. These days, multiple disciplines adopt products comprising Mercury along with Chat GPS Train extensively. This suggests human beings have become more relaxed utilizing Technology to help with deciding.

Intelligent automation

The use of AGI constitutes the ultimate sophisticated program that is referred to as Agi. Residents can better grasp the distinction through present-day AI and its long-term objectives by doing technology. Intelligent automation is associated with the concept of the artificial singularity, a scenario in which algorithms surpass cognitive abilities. Despite the prevalence of this concept in fantasy novels, several scholars are at present actively pursuing it.

The computerized Narrative

Turing, also known as Turing, first proposed neural networks circa 1948 while he questioned how robots ought to possess human-like thought processes. His studies established the groundwork for future study on Intelligence. A lifetime of development involving researchers and technologists in various domains have produced the artificial intelligent system that exists these days.

The period between 1940 and 1980: Throughout the decades between 1940 and 1950, researchers started creating the first concepts of cognitive science, including how to assess the abilities of machines using neural implants. The next decade saw the development of several basic AI applications, such as robots along with preliminary neural systems. Most these different techniques' weaknesses were ultimately identified by specialists. AI development halted on account of insufficient financing as well as subpar systems, triggering the initial "AI snow.

Alongside federal sponsorship, qualified medical algorithms, especially improved neural nets and were capable of learning upon instances, artificial intelligence gained popularity once more throughout the late 1980s. subsequent financial problems and subpar business outcomes caused fascination with Intelligence to decline once more, leading to a subsequent "AI freeze." Once IBM's artificially intelligent Deep Purple defeated pieces prodigy Kasparov in the final in that year, the study of AI was given new life.

From 2007 until 2018, the internet of things facilitated the implementation of efficient machines with algorithms for AI, accelerating the development of AI. Mechanisms including Omega and complex neural networks from Alexe demonstrated computers might learn and operate quite successfully upon themselves. Bots that talk like ChatGPT (Global Positioning System) gained popularity into twenty-22 with having authentic discussions, which rekindled people's curiosity in Robotics.

The risks that does AI pose to companies?

- **Emissions involving information:** Systems powered by AI don't have secure locations to keep confidential especially sensitive data. Private knowledge or programming that you personally supply may eventually appear or affect human reactions.
- **Erosion regarding information sovereignty:** After sharing statistics using a virtual assistant program, consumers lose all power over its utilization. Perhaps giving a robot access to a hidden recipe can aid in publishing material, nonetheless the technique themselves might ultimately be kept confidential.

Additional dangers

Reduced Payment for Genuine Content

A smaller number access authentic pages to others as algorithms provide immediate answers to requests. As a result, visitation to websites declines and the material producers lose money from marketing strategies.

Delusions

AI sometimes creates incorrect or false information while responding. If this information is used without checking, it can damage trust and reputation.

Excessive Dependence from Intelligence to Determining Decisions

Over-reliance on Automation may end in bad choices. This occurs as a result of artificial brain data frequently not being truthful or trustworthy.

What's involved in machine learning?

Systems are able to profit about insights requiring explicit programming thanks to data mining processing, a branch of computer science. By absorbing additionally information while also gaining understanding via expertise, it enhances its abilities. Within industries such medical care, banking, as well as travel, predictive modeling is used frequently to improve forecasts along with decision-making.

What companies are applying data mining

Regarding businesses including Amazon in addition Microsoft, since it enhances listings and makes material recommendations, data science seems crucial. Whilst a few companies still don't know able to employ it correctly, individuals merely apply it in tiny capacities. Determining which obstacles are appropriate over data mining is frequently simple, according to professionals. Every employment may be impacted by data mining, according findings, yet the technology will complement folks versus completely replace employees.

The Worldwide Web of Everything: what exactly is it?

Electronic equipment designed are capable of gathering and transmitting knowledge via the web needing anyone's help are referred to as the Network if Contents (IoT). It encompasses additionally cell phones and laptops nevertheless commonplace items integrating detectors plus web access. Such as heart-monitoring medical equipment, wildlife- tracking recordings, plus vehicles to notify occupants to potential hazards. To put it simply, the Digital Age about Things comprises every gadget that the can transmit info and interface through the world's largest web.

Implications for the Internet of Things

On any given day, trillions of gadgets communicate via the global web to exchange knowledge. Connected home goods, safety gadgets, along with sophisticated defense-related tracking devices are among them.

Connectivity for consumers

These devices encompasses accessories and individual technological devices which are connected to the web, like automated homes alongside wristbands.

Network of Devices in Industry (IIoT)

The Industrial Internet of Things entails wireless devices that are utilized to increase productivity and monitor performance in sectors such production and energies.

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The Internet of Things for Business

Organizations help universities deploy marketing wifi to evaluate processes, organize metrics, and boost medical or client relations.

The automaton

The discipline of automation is concerned with creating, constructing, manufacturing utilizing machinery. For drones function efficiently, it integrates fields including circuitry, computation, plus construction. Automation assist individuals across a variety of professions by carrying out hazardous, challenging, or tedious tasks. Anyone whose develops, explores, develops supervises machinery is known as a computer scientist.

Key justifications behind purchasing construction automated machinery:

- Assists manufacturers in swiftly adapting output to limited quantities with demand shifts.
- Boosts performance under peak times or unforeseen issues such COVID-19 Through operating better, it conserves energy and resources.
- Boosts output while rendering workers' jobs healthier and simpler.
- Lowers the overall cost of hardware and operations
- Raises the grade of goods
- Expands manufacturing volume and quickness
- Conserves manpower in pricey plant spaces

In general, computers enhance efficiency by assisting businesses in working quicker well as effectively. These aid in the competitiveness of companies, including medium-sized businesses which sustain multiple nations. Faster technology creation and shipment also helps large businesses. Corporations can even use machines to send employment returning within their own nations rather than depending on inexpensive workers abroad.

Renewable Energies meets Robotic devices

Drones are helpful resources than are capable of being employed in a variety of fields, such as services and business sectors. They possess an enormous opportunity to help civilization achieve the goals for sustainable development set forth by the UN's General Assembly. Resilience is more than concerning ecology or the financial sector. Through 2030, it further aims to eradicate destitution, safeguard the planet, to bring about universal harmony and happiness.

Describe the use of cloud computing.

With the help of cloud computing, customers can execute applications that store information on websites rather than on your personal machine. Folks don't have to take care of hardware because these computers are located within data center facilities. Individuals are able to get to personal documents and applications via every gadget as consequence.

Cloud-based computing kinds

The cloud-based system can be divided into the following main categories: Equipment for an Application, Platform is a Service, and IT as a service in question A varying degree of autonomy and

adaptability is provided by all of them. Clients are better able to select online products which finest meet their specifications thanks to technology.

Digital Analytics: What exactly Is It? Which categories of analysis of information exist?

Finding variations and interesting facts via collected and analyzed data is known as data science. That facilitates the method of finding answers, gaining opinions, ultimately improving data-driven decision-making. After learning the definition of statistical analysis, that we may examine the following primary categories: exhaustive, therapeutic, foreseeable, as well as evocative.

Analytical predictive

Analyzing past records to determine something happened before is known as statistical economics. It entails gathering information, compiling the data, and pinpointing basic trends. Summaries or infographics which are straightforward for consumers to comprehend serve to display outcomes. The rationale for an event is overlooked by that sort of inquiry; it merely reports the facts.

Informatics for diagnosis

Discovering the cause of the incident is the main goal of analytics for diagnostic purposes. Scientists search detect unusual statistic changes, like a sharp decline in profits. Investigators next investigate additional applicable information to identify potential causes to this shift. Analytical diagnosis aids in identifying the explanations underlying previous outcomes through analyzing linkages or similarities.

Informatics for prediction

For predicting what is most anticipated to occur throughout the years to come, forecasting is employed. It helps businesses generate superior choices by using historical trends and information. Accuracy lessens uncertainty, even though monitoring may not always be flawless. Forecasting analytics is used by firms to estimate potential earnings, goods in demand, including customer behavior.

Prescriptive analytics

Through recommending courses of execution, analytical guidance advances a little higher. This aids companies to figure out how effectively they adapt to anticipated results. Numerous possibilities when eventualities are examined in that sort of consideration. Despite its complexity, analytics may significantly enhance corporate outcomes & selection through the use of instruments comprising neural networks in addition predictive modeling. The nature that information you've got will determine what sort of investigation yourself select. Understanding the various stages that comprise measurement—nominate, average, standard period, etc ratio—is essential to comprehending concept.

Digital realistic prospects

Numerous businesses make investments in mixed reality other intend for using it for instruction while commercial uses, which is why its growth is so rapid. Consumption of augmented reality and virtual reality will likely increase, for applications for these technologies are moving below gaming to include ability cultivation and instruction. Large IT firms are working on revolutionary cordless augmented reality (AR with excellent images. Cognitive computing, better processing, as well as 5G smartphone compatibility might all be features to come in subsequent VR systems. Alongside this development, virtual reality is emerging as an essential technology for the foreseeable future.

What exactly is augmented reality?

With a virtual reality device, consumers are able to fully lose within an artificially created space known as virtual reality (VR). It creates genuine scenarios across competition, entertainment, including healthcare education. VR started during the decade of 1950 via an experimental gadget nicknamed a device called Sensor despite its seeming modernity. VR gadgets plus their users are constantly substantially enhanced by firmware as well as technological advancements throughout history.

Conclusion

Emerging technologies are revolutionizing every aspect of human life. Artificial Intelligence, Machine Learning, IoT, automation, cloud computing, data analytics, and immersive technologies are driving innovation, improving efficiency, and enabling smarter decision-making. While these technologies offer enormous benefits, they also require ethical use, strong security measures, and responsible implementation. When used wisely, emerging technologies can significantly contribute to sustainable development, economic growth, and improved quality of life in the future.

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Digital Transformation of Academic Libraries in the AI Era

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ABSTRACT

The rapid growth of digital technologies and Artificial Intelligence (AI) has significantly influenced the functioning of academic libraries. Digital transformation in libraries does not aim to replace physical library spaces, but to enhance traditional services through digital tools and intelligent systems. The adoption of AI technologies such as Machine Learning, Natural Language Processing, and automation has improved information organization, search efficiency, and user services in academic libraries. Digital platforms, e-resources, online catalogs, and AI-based library management systems support faster access to scholarly information and effective knowledge dissemination. This paper discusses how AI-enabled digital transformation strengthens academic libraries by improving service quality, supporting library professionals, and meeting the evolving information needs of users. The study highlights the role of AI as a supportive technology that complements existing library practices and contributes to the sustainable development of academic libraries in the AI era.

INTRODUCTION

Academic libraries are no longer just places with books—they are becoming smart centers of knowledge that help students and researchers access information quickly and easily. Digital transformation, supported by Artificial Intelligence (AI), allows libraries to provide services that match the needs of each user, organize information efficiently, and give easy access to digital resources. AI helps libraries understand what users need, improve research support, and make library work faster and more effective. It also allows library systems to connect with other digital platforms, making information sharing and collaboration easier. At the same time, libraries focus on fairness, privacy, and accessibility to ensure everyone can benefit from their services. By using AI and digital tools in smart ways, academic libraries are becoming more helpful, inclusive, and important for learning and research in today's world.

OBJECTIVES

The main objective of this paper is to explore how academic libraries are transforming in the digital age with the integration of Artificial Intelligence (AI). It aims to examine the ways AI enhances library services, streamlines resource management, and improves the overall experience for students, researchers, and library professionals. The study also seeks to highlight the benefits of digital platforms and e-resources, demonstrating how they support seamless access to information and effective knowledge discovery. Additionally, it analyzes the impact of digital transformation on library operations and the evolving skill sets required for professionals in the AI era. Finally, the paper identifies emerging trends and best practices that can ensure academic libraries remain inclusive, efficient, and sustainable knowledge centers in the modern educational landscape.

ROLE OF ARTIFICIAL INTELLIGENCE IN ACADEMIC LIBRARIES

Artificial Intelligence introduces a qualitative change in academic library services by enabling libraries to operate as intelligent knowledge ecosystems rather than passive information providers. One of the unique contributions of AI lies in its **ability to transform raw usage data into meaningful insights** that support strategic planning and service innovation. By analyzing user interaction patterns, AI helps libraries identify emerging academic interests, anticipate future information demands, and align collections with institutional research priorities.

AI-driven systems also support content lifecycle management by assisting in digital preservation, format migration, and long-term accessibility of scholarly resources. Intelligent tools can detect outdated or low-use

materials, suggest content enhancement strategies, and improve the visibility of underutilized resources. In addition, **AI enables multilingual access** and inclusive information services by supporting automatic translation, voice-based search, and adaptive interfaces for diverse user groups.

From an operational perspective, AI contributes to the optimization of workflows by balancing resource allocation, reducing repetitive administrative tasks, and supporting real-time decision-making. These capabilities allow library professionals to transition from operational roles to strategic and advisory functions. Through such advanced yet supportive applications, AI strengthens the academic library's capacity to function as a resilient, innovative, and future-ready institution in the digital era.

AI promotes ethical information use, supports research impact and open access, and strengthens knowledge organization and digital preservation, positioning academic libraries as reliable knowledge stewards.

Transforming Library Services

Artificial Intelligence (AI) is reshaping academic libraries by turning them into intelligent knowledge ecosystems rather than just information storage centers. AI tools help automate cataloging, indexing, and metadata management, making library operations more efficient and accurate.

Personalized User Experience

AI enables intelligent search and personalized recommendations, guiding students and researchers to relevant resources quickly. It reduces information overload and supports adaptive learning, where content is tailored to user needs and preferences.

Analytics and Research Support

AI-powered analytics track resource usage patterns, emerging research trends, and collection performance, helping libraries make data-driven decisions. This ensures that collections stay aligned with academic priorities and institutional research goals.

Accessibility and Inclusivity

AI supports inclusive library services by enabling text-to-speech, voice search, multilingual access, and adaptive interfaces, ensuring all users, including those with disabilities, can efficiently access information.

Vision for the Future

With AI, academic libraries can function as strategic, research-oriented partners rather than passive information providers. They become smart knowledge hubs that support learning, research, collaboration, and innovation in the AI era.

E-RESOURCES AND DIGITAL PLATFORMS IN ACADEMIC LIBRARIES

Digital transformation has changed how academic libraries deliver knowledge by shifting focus from collection ownership to smart access and intelligent delivery. E-resources enable libraries to respond quickly to academic needs by supporting on-demand learning, real-time research, and interdisciplinary study. Digital platforms act as knowledge connectors, linking users with trusted academic content across multiple formats and sources.

E-resources change academic libraries by focusing on speed, access, and usefulness rather than only collection size. Digital platforms help users find the right information quickly instead of searching through large physical collections. Students and researchers benefit from instant availability, remote access, and multiple formats that support modern learning habits.

AI-supported platforms reduce information overload by filtering relevant content and guiding users toward trusted academic sources. Libraries use digital platforms to track usage patterns, improve resource

selection, and avoid unnecessary duplication. These platforms also support open access, helping institutions share research globally and increase academic visibility.

Through smart digital platforms, academic libraries move from information storage to active knowledge support, strengthening learning, research quality, and academic productivity in the AI era.

Open Educational Resources (OER) in Academic Libraries

OER are freely accessible, high-quality learning and teaching materials that transform the way academic libraries support education and research. OER include e-books, lecture notes, videos, simulations, and online courses that can be shared, adapted, and reused by students, educators, and researchers. By integrating OER with digital platforms and AI tools, libraries can personalize learning experiences, track resource usage, and recommend content based on user needs. OER also fosters global collaboration, knowledge sharing, and institutional visibility, allowing libraries to extend their impact beyond campus boundaries. By supporting equity, accessibility, and innovation, OER positions academic libraries as inclusive, adaptive, and forward-thinking centers of knowledge in the AI era.

Key Points about OER in Academic Libraries

- **Free Access** – OER are learning and research materials that anyone can access without cost.
- **Inclusive Learning** – They help all students, including those with limited resources, to learn equally.
- **Global Collaboration** – Libraries can share and exchange OER with other institutions worldwide.
- **Personalized Learning** – AI can recommend OER materials based on a student's learning needs.
- **Research Support** – OER provides extra resources for research and interdisciplinary studies.
- **Institutional Visibility** – Using and sharing OER increases the library and institution's global presence.
- **Sustainability** – OER reduces dependency on paid resources and supports long-term access to knowledge.

SHIFT FROM TRADITIONAL TO DIGITAL LIBRARIES

Traditional Library System

Traditional academic libraries primarily relied on physical books, printed journals, and manual registers to organize and provide access to information. Users had to visit the library in person, and library staff manually cataloged, tracked, and managed resources. While this system supported learning and research, it was limited in flexibility and accessibility.

Limitations of Traditional Libraries

The traditional library system faced several challenges:

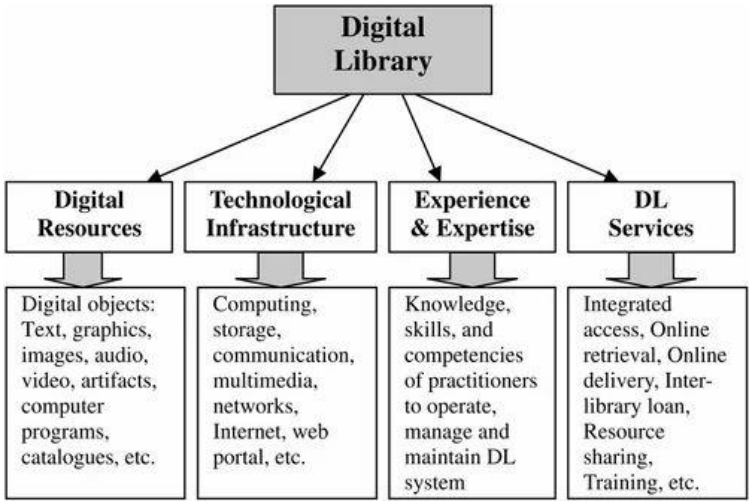
- **Restricted access hours** – Users could only use the library during fixed times.
- **Time-consuming searches** – Finding resources required checking manual catalogs or physically browsing shelves.
- **Space constraints** – Physical storage limited the number of books and materials available.
- **Dependence on physical presence** – Remote learning or off-campus access was not possible.

Evolution to Digital Libraries

With the advancement of technology, libraries transitioned into **digital libraries**. This includes:

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- **Digital Catalogs (OPAC)** – Online Public Access Catalogs allow users to search for books and resources digitally.
- **Online Databases** – E-journals, research articles, and e-books can be accessed remotely.
- **Institutional Repositories** – Centralized digital storage of theses, dissertations, and academic publications.



Benefits of Digital Libraries

Digital libraries provide numerous advantages over traditional systems:

- **24/7 Access** – Students and researchers can access resources anytime.
- **Remote Learning Support** – Resources are available from anywhere, supporting online education.
- **Space and Time Saving** – Reduces dependency on physical space and allows faster information retrieval.
- **Enhanced Efficiency** – Staff can focus on advisory and research support roles rather than manual tasks.

AI AND AUTOMATION IN LIBRARY OPERATIONS

AI-Powered Library Services

Artificial Intelligence enhances academic library services by enabling **intelligent, user-centric interactions**.

- **Chatbots** assist users by answering routine queries related to library timings, resource availability, and database access, providing instant support without human intervention.
- **Smart search and recommendation systems** analyze user behavior and research interests to suggest relevant books, articles, and digital resources, improving discovery and research efficiency.

Automation Tools in Library Operations

Automation plays a vital role in improving operational efficiency and accuracy in libraries.

- **RFID technology** is used for efficient book tracking, inventory management, and theft prevention.
- **Automated circulation systems** handle issue, return, and renewal of resources, reducing manual workload and saving time for both users and library staff.

AI in Knowledge Organization and Academic Integrity

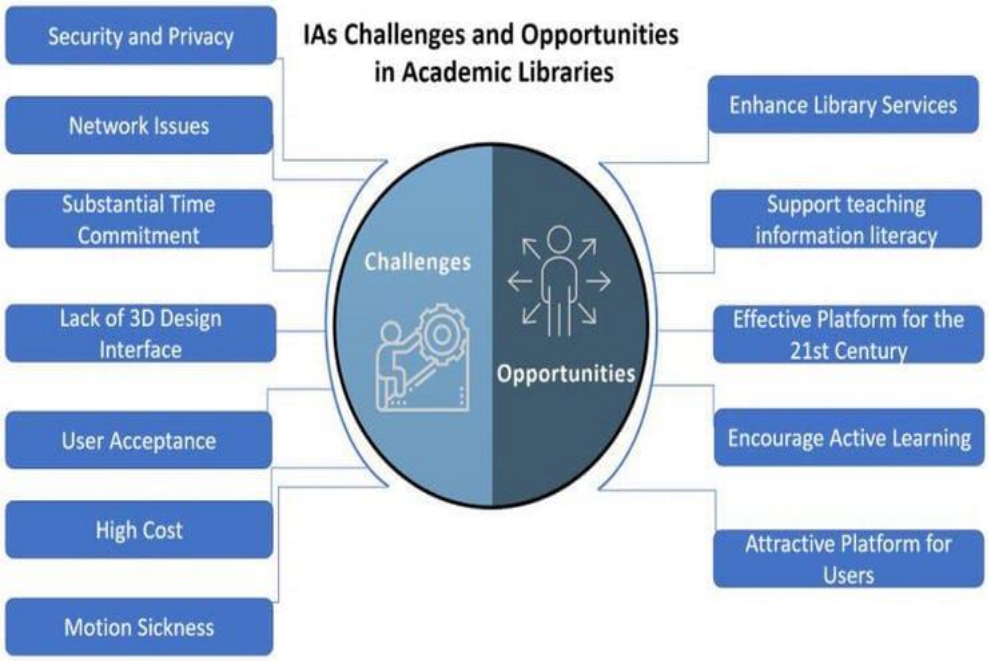
AI supports core intellectual functions of libraries by enhancing content organization and quality control.

- Indexing and classification are improved through AI algorithms that assign subject categories accurately and consistently.
- Metadata generation is automated, ensuring faster and standardized description of digital resources.
- Plagiarism detection tools help maintain academic integrity by identifying content duplication in research and academic submissions.

Strategic Value of AI and Automation

By combining AI and automation, academic libraries move beyond routine service delivery and become efficient, intelligent, and research-oriented knowledge centers. These technologies allow library professionals to focus on advanced research support, digital curation, and academic collaboration, strengthening the overall academic ecosystem**.**

CHALLENGES IN DIGITAL TRANSFORMATION OF ACADEMIC LIBRARIES



Digital Divide

One of the major challenges in digital transformation is the digital divide. Not all users have equal access to high-speed internet, digital devices, or technological resources. This gap can limit the effective use of digital and AI-enabled library services, especially for students from rural or economically weaker backgrounds.

Data Privacy and Security Issues

With increased use of digital platforms and AI tools, libraries handle large volumes of user data and academic information. Ensuring data privacy, secure access, and protection from cyber threats is a critical challenge. Improper data handling may lead to security breaches and loss of user trust.

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High Cost of Technology

The adoption of AI systems, automation tools, digital platforms, and infrastructure requires significant financial investment. Costs related to software, hardware, maintenance, and system upgrades can be a major barrier, particularly for smaller or underfunded institutions.

Resistance to Change

Digital transformation often faces resistance from staff and users who are accustomed to traditional library systems. Fear of technology, lack of awareness, and comfort with manual processes can slow down the adoption of digital and AI-based solutions.

Lack of Technical Expertise

Effective implementation of AI and digital technologies requires skilled library professionals with knowledge of data management, digital tools, and emerging technologies. A lack of training and technical expertise can limit the successful transformation of academic libraries.

Need for Standardization and System Coordination

As academic libraries adopt multiple digital and AI-based platforms, the need for standardized frameworks and better system coordination becomes essential. Proper alignment of technologies can enhance efficiency, data consistency, and seamless service delivery in digital library environments.

CONCLUSION

The digital transformation of academic libraries in the AI era represents a meaningful shift from traditional information storage to intelligent knowledge support systems. Rather than replacing physical libraries, AI and digital technologies enhance existing services by improving access, efficiency, and user engagement. Through AI-powered tools, digital platforms, e-resources, and automation, academic libraries are better equipped to meet the evolving needs of students, researchers, and educators.

This transformation also redefines the role of library professionals, enabling them to move toward strategic, research-oriented, and advisory responsibilities. While challenges such as the digital divide, data security, cost, and skill gaps remain, thoughtful planning, standardization, and continuous learning can address these concerns effectively.

Overall, the integration of AI within academic libraries strengthens knowledge dissemination, supports inclusive learning, and promotes sustainable development. As technology continues to evolve, academic libraries will remain essential academic partners—serving as intelligent, ethical, and future-ready knowledge hubs in the digital age.

"By using AI as a supportive and ethical tool, academic libraries can successfully connect traditional values with digital innovation."

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Online Library Resources: An Overview

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Abstract

Online library resources are digital platforms that provide users with access to a wide range of academic, educational, and informational materials, including e-books, journals, databases, and multimedia content. These resources have revolutionized the way information is accessed, making it possible for users to engage with scholarly materials anytime and anywhere with an internet connection. Online libraries support various learning styles and research needs by offering diverse formats and up-to-date content. Despite challenges such as digital accessibility and the need for reliable internet, the advantages of online library resources, such as convenience, wide accessibility, and the ability to support remote learning and research, have made them essential in modern education. As technology continues to evolve, the role of online library resources in fostering learning and academic progress is expected to grow even further.

Keywords: Online Library Resources, Open Library Resources. Free Library Resources, Meaning of Online Resources, Benefits of Online Library Resources

Introduction

Online libraries offer a wide range of digital resources that are easily accessible for research, learning, and leisure reading. Online library resources refer to digital platforms and services that provide access to a wide range of educational materials, such as books, articles, journals, videos, and databases, all available over the internet. These resources enable users, students, researchers, and lifelong learners to access information remotely, often without the need to visit a physical library. This paper is discuss about overview of online library resources.

Online Library Resources

This is the online library resources

E-books

- Libraries often offer a vast collection of e-books, which you can borrow just like physical books. Platforms like OverDrive or Libby let you check out e-books and audiobooks.

Academic Databases

- These are essential for research, especially for students and academics. Examples include:
  - **JSTOR** – A digital library for scholars, researchers, and students.
  - **ProQuest** – A comprehensive database with journals, newspapers, dissertations, and more.
  - **Google Scholar** – While not a library per se, it provides access to scholarly articles and papers.
  - **PubMed** – A database for life sciences and biomedical research.etc

Audio books and Podcasts

- Many online libraries also provide access to audiobooks and podcasts, offering a great way to enjoy literature or learn on-the-go.

Streaming Services for Educational Videos

- Some libraries offer access to educational video streaming services like **Kanopy**, which provides movies, documentaries, and educational films for learning.

Digital Magazines and Journals

- Libraries often subscribe to digital versions of popular magazines, journals, and newspapers. Services like **Flipster** and **RBdigital** provide access to a variety of magazines.

Research Tools & Citation Guides

- Many online libraries offer tools to help with academic writing, including citation guides (e.g., **MLA**, **APA**, and **Chicago** styles) and even access to plagiarism checkers.

Language Learning Resources

- Libraries may offer access to platforms like **Rosetta Stone** or **Mango Languages**, providing tools for learning new languages.

Local Resources

- Some libraries provide unique collections of local history, regional archives, or digitized versions of old newspapers and documents.

Public Domain and Classic Works

- Many libraries offer free access to public domain books. Websites like **Project Gutenberg** provide thousands of free e-books, especially classics.

Interactive Learning Platforms

- Online library resources might also include access to educational platforms like **Lynda.com** (now LinkedIn Learning) or **Coursera**, which offer online courses and tutorials.

Online Library Platforms

Here are some popular online libraries and platforms where you can access books, academic resources, audiobooks, and more:

OverDrive/Libby

- **What it is**: A free app that lets you borrow e-books, audiobooks, and digital magazines from participating public libraries.
- **How to use**: All you need is a library card from a participating library. You can borrow items directly from the app.

Project Gutenberg

- **What it is**: A digital library offering over 60,000 free eBooks, primarily focusing on classic literature and public domain works.
- **How to use**: Simply visit Project Gutenberg, browse their collection, and download books in various formats.

Internet Archive

- **What it is**: A non-profit library offering free access to a wide range of digital resources, including books, movies, music, and even software. It's a huge collection of both modern and historical works.

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- **How to use**: Visit Internet_Archive, search for the book or resource you're looking for, and borrow it for free.

Google Books

- **What it is**: Google Books allows you to browse, preview, and purchase books, but also includes a vast collection of public domain works that can be read for free.
- **How to use**: Visit Google Books, and search for specific titles. Some books have full or partial free access.

JSTOR

- **What it is**: A digital library for scholars, offering access to academic papers, journals, and primary sources across various disciplines.
- **How to use**: Many universities and public libraries provide free access to JSTOR. You can also access a limited number of free articles each month.

HathiTrust

- **What it is**: A partnership of academic and research institutions offering access to millions of digitized books, primarily from university libraries.
- **How to use**: Visit HathiTrust and search for the books you need. Some books are available for full text, while others may have limited access.

Open Library

- **What it is**: A part of the Internet Archive, Open Library aims to create a web page for every book ever published, offering millions of free and borrowable books.
- **How to use**: Visit Open Library and create a free account to borrow digital copies of books.

DPLA (Digital Public Library of America)

- **What it is**: DPLA provides access to millions of photographs, manuscripts, books, and more from libraries, archives, and museums across the U.S.
- **How to use**: Visit DPLA, search for resources, and explore items that are available for free access or download.

Bibliotheca

- **What it is**: A digital library service for public libraries that provides access to e-books, audiobooks, and other digital content.
- **How to use**: Access is available through participating public libraries. Once you register, you can borrow books digitally.

WorldCat

- **What it is**: WorldCat is the world's largest library catalog, connecting you to over 2 billion items in libraries worldwide.
- **How to use**: Visit WorldCat to search for books and locate them in nearby libraries.

Kanopy

- **What it is**: A streaming service providing access to thousands of movies, documentaries, and educational videos.
- **How to use**: Available through participating libraries. Register with your library card to stream content for free.

LibriVox

- **What it is**: A collection of free audiobooks, mostly public domain texts, read by volunteers from around the world.
- **How to use**: Visit LibriVox and listen to audiobooks for free.

Purpose of Online Library Resources

The purpose of online library resources is to provide users with convenient access to a wide range of educational materials, research tools, and information sources via the internet. These resources typically include e-books, academic journals, articles, databases, multimedia, and other digital content. Here are some key purposes:

1. **Access to Information**: Online libraries make it easier to find and access scholarly articles, research papers, and other educational resources that might otherwise be difficult to obtain.
2. **Convenience and Flexibility**: They allow users to access materials anytime and from anywhere, removing the need for physical visits to a library. This is especially helpful for people with busy schedules or those in remote areas.
3. **Support for Research**: They provide powerful databases and search tools that help users conduct in-depth research across various subjects and disciplines, aiding students, researchers, and professionals.
4. **Cost Efficiency**: Many online libraries offer free or subscription-based access to valuable resources, which can be more affordable than purchasing individual books or journals.
5. **Collaboration and Sharing**: Some online library platforms allow users to collaborate, share, and discuss resources with others, which can enhance learning and promote knowledge exchange.
6. **Preservation and Archiving**: Digital resources can be easily archived and preserved, ensuring long-term access to important information, even as physical materials may deteriorate over time.

Benefits of Online Library Resources

Online library resources offer a variety of benefits, making them incredibly valuable for students, researchers, professionals, and casual learners. Here are some of the key advantages:

1. **24/7 Accessibility**: You can access online library resources anytime and from anywhere with an internet connection, making it easy to study or conduct research outside of traditional library hours.
2. **Wide Range of Resources**: Online libraries provide access to a vast array of materials, including e-books, articles, journals, databases, and multimedia resources. This makes it possible to explore a broader range of topics and perspectives.
3. **Cost-Effective**: Many online library resources are available for free or at a lower cost than purchasing physical copies of books or journal subscriptions. Universities and institutions often provide access to premium resources at no additional cost to students.

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4. **Convenience and Time-Saving**: Online libraries eliminate the need to travel to physical locations, browse shelves, or search through stacks of books. The digital nature of these resources allows for quick searches and easy access to specific content.
5. **Search and Filtering Tools**: Online platforms often include powerful search and filtering features, which can help users narrow down results and find relevant information more efficiently. You can search by keywords, authors, subjects, or publication dates, saving time and effort.
6. **Collaboration and Sharing**: Many online libraries allow for collaborative features, such as sharing resources, annotating documents, or discussing materials with peers and colleagues. This fosters a sense of community and knowledge exchange.
7. **Regular Updates**: Online resources are often updated more frequently than printed materials, ensuring that users have access to the latest research, articles, and publications.
8. **Sustainability**: By shifting to digital resources, online libraries reduce the need for paper production, contributing to environmental sustainability.
9. **Multimedia and Interactive Features**: Many online libraries offer multimedia content, such as videos, podcasts, and interactive tools, which can enhance the learning experience.
10. **Remote Learning Support**: For students and educators, online libraries support remote and distance learning by providing resources that can be accessed from home or any other location, ensuring continuity in education.

Disadvantages of online library resources

There are some disadvantages to consider:

1. **Access Issues**: Not everyone has reliable internet access or the necessary devices to use online resources effectively, which can create a digital divide.
2. **Limited Resources**: Some books, journals, and materials may not be available online or may have limited access due to licensing or copyright restrictions.
3. **Quality Control**: Not all online resources are peer-reviewed or accurate, making it harder to assess the credibility of sources.
4. **Distraction and Focus**: The digital environment can be distracting, with notifications and easy access to unrelated content making it harder to concentrate on studying or research.
5. **Technology Dependence**: If there's a system error or a website goes down, access to materials can be temporarily unavailable, which can disrupt study plans.
6. **User Interface**: Some online library platforms are not user-friendly, which can make navigation and resource discovery difficult.
7. **Loss of Social Interaction**: Traditional libraries provide spaces for study groups, face-to-face interaction, and networking, which online resources can't fully replicate.
8. **Overwhelming Choices**: With such a wide range of material available, users may feel overwhelmed by the sheer amount of content, which can make it harder to find what they need.

Conclusion

Online library resources have transformed the way we access and interact with information. Offering a wealth of materials from e-books and academic journals to multimedia and databases, these digital platforms make learning, research, and information gathering more convenient and accessible than ever before. They

break down geographical barriers, provide round-the-clock availability, and support various learning styles and preferences.

While challenges such as internet access and navigating digital interfaces remain, the benefits far outweigh the limitations, especially as technology continues to improve. Online libraries have become an indispensable part of modern education and research, empowering users with the tools they need to succeed in an increasingly digital world.

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Digital surge during Covid-19 pandemic: A study of the Private College students of Tarai and Doors area, West Bengal, India

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Abstract

The epidemic has ignited global shifts in education delivery that will last for millennia. To ensure a smooth transition with more flexible but effective online teaching methods, the researcher has undertaken research to study the prospects in educational transition. This will allow them to make informed pedagogical decisions. The objective of this study is to critically examine the pandemic's direct effects on the education industry and comprehend how they contributed to a radical shift in how we view education. In this study, private college students from the Tarai and Doors area of West Bengal experienced a digital upsurge during the Covid-19 pandemic. One thousand and two hundred students from five private colleges are participating in this study. For the purpose of gathering the data, a survey about random structures has been sent. The data was analyzed by MS Excel and statistical software after being collected.

Keywords: Digital surge, College students, Tarai and Doors, Covid-19, Pandemic, Facebook, Tik-tok.

Introduction

The research focuses on two main issues: the increase in Covid-19 issues coupled with the increase in digitalization, as well as their interaction over time. Throughout the Covid-19 pandemic-induced lockdown, the 'New Normal' for people to socialise, work on projects together, and pursue their academic interests was the digital world. Education's growth curve didn't stagnate; instead, it improved. The use of digital media and video interface platforms, such as YouTube, Tik-Tok, Face book, and Instagram, for instilling new skills and learning current trends, as well as video conferencing platforms, such as Google Meet, Zoom, Microsoft, Skype, etc., which served as a source for the educational graph collaboration, was another trending element in the same vein. There is a wide range of appearances and effects on teachers, students, parents, management, and administrators as a result of these digitalized platforms' entire propensity for the educational sector and their impact on these groups of people. The study found out that through the digital media the students of Tarai and Dooars area, improved their education and day to day activities.

Literature review

The review of the literature, one of the most important steps in the research procedure, informs the researcher of the research process and the gaps in the field that need to be filled. Shahid Minhas, Tasaddaq Hussain, Abdul Ghani, and Kiran Sajid identified the development of online classes for students living in Pakistan in their research study. Pakistan's Higher Education Commission has permitted universities to start offering classes using the Zoom video-conferencing programme. The study enquires the viewpoints of students from three Universities in Pakistan and thoroughly comprehends each student's personal journey throughout the Zoom application's online learning environment, which is widely regarded as the best online learning tool. The students have a strong preference for the application's screen sharing and lecture recording features. (2021) (Dr. Minhas, Hussain, Ghani, & Sajid). Deepa Rajesh and V Krishna Priya's research study has highlighted the detrimental impacts of excessive use of new media platforms on people's mental health. Websites that allow users to post opinions and comments on any information are known as platforms for new media. In the last ten years, social communication has undergone a digital revolution that has altered social interaction and cooperation. Most of the participants in the study, which investigates the impact of new media platforms on students' mental health, say they spend more than four hours per day in front of screens. The study asserts a relationship between the prevalence of New Media platforms and the signs and symptoms of depression and draws parallels between episodes of anxiety and depression. There is evidence linking the frequency of feeling

anxious and being actively engaged on platforms. As a result, students are experiencing anxiety and depression due to the increased use of New Media and the number of websites, in 2020, Rajesh and Priya in their research project.

In an effort to understand the role of new media as a collaborative strategy for the traditional classroom, Jamal Abdul Nasir, Ansari, and Nawab Ali Khan (2020) have conducted research. The use of New Media platforms is crucial for the exchange of information and interaction with academics based in esteemed educational institutions. A study that looked at how group projects, interactions with other students, and interactions with faculty affected students' attitudes towards mobile devices and new media included 360 respondents from a university in Eastern India. The effect of these factors was also estimated by the study. The study found that students' online sharing of content and interactions with teachers and other students were significantly influenced by their use of new media platforms.

The goal of Neeru Saini, Garima Sangwan, Madhur Varma, Adarsh Kohli, Manmeet Kaur, and P.V.M. Lakshmi's (2020) research study was to examine how new media applications affected the students' quality of learning journeys. The influence of the Internet, New Media platforms, and persuasive communication techniques on people's physical, mental, and spiritual well-being. A cross-sectional survey of 220 college-bound Chandigarh-based students, ages 18 to 21, conducted for the study revealed that 98% of the participants use the Internet. Regular users were better able to manage relationship and work-related stress than non-users, according to a comparison study. However, there is no discernible difference between daily users of digital media and non-users in terms of life quality.

Jaswinder Singh (2020) has made an effort to assess the effect of utilising New Media platforms by considering the current Covid-19 pandemic and the subsequent lockdown implemented to stop the spread of the disease. Platforms for the New Media were built from the ground up for interaction and exchange. They are crucial to the situation and significantly outweigh the drawbacks. Audio-visual aids, seminars, and group discussions will be used to educate the younger generations. Activities like debates, tests, and other games are essential for shaping young people's opinions. In addition to playing a significant role in Indian politics, new media is the primary source of education, communication, and entrepreneurship as well as online shopping and entertainment. But too much use of new media platforms can lead to health problems like anxiety, depression, irritability, loneliness, sadness, etc. Invasion of privacy, cyberbullying, and a disproportionately negative effect on adolescents are other ways that the use of new media platforms can negatively affect people's lives.

Based on a geographically specific study that was limited to Georgia, Giorgi Basilaia and David Kvavadze's research study highlighted the impact of the Covid-19 pandemic-induced scenario on the education sector. The study looks at how online learning platforms in general, like Zoom, Google Meet, Slack, and EduPage, are used for education and communication, as well as platforms used by Government schools, like online portals, TV Schools, and Microsoft Teams. The research included a case study of a school with 950 respondents to obtain a thorough statistical analysis. The findings demonstrate that the transition from the traditional classroom model of instruction to the online format has been successful. The paper also suggests that the online teaching format can be used in the post-pandemic period and that more research regarding the effectiveness of online learning needs to be done (Basilaia & Kvavadze,2020).

The Covid-19 pandemic and its significant effect on the Global community, particularly the education sector, have been highlighted by Hendri Pratama, Azman M.N.A, G.K. Kassymova, and Shakizat in their research study. To stop the outbreak, the current format has changed to online education. The study looks at how teachers and students can more easily complete learning goals outside of a traditional classroom setting by using online meeting tools. After conducting a descriptive analysis, qualitative methods were used to conduct the research study. The study found that during the Covid-19 pandemic, learning via video conferencing on online learning platforms was more efficient, practical, and significantly safer than traditional classroom instruction.

According to Pratham, Azman, Kassymova, and Duisenbayeva (2020), the study also recommends using the applications in circumstances other than just disasters.

In their research study published in 2020, Agung Setyawan et al. investigated the impacts of the Google Meet Assisted lecture method, focusing on student learning and achieving the academic goals when the learning takes place in an online format. The study, which used a pretest-posttest control group design and was conducted in a quasi-experimental format, involved 96 first-year students from the University of Trunojaya Madura. The study was conducted for the 2019–2020 academic year. When it comes to enhancing students' knowledge in light of the new normal situation, the research's findings indicate that using Google Meet for lectures has a significant impact on the learning graph.

Methodology

Both quantitative and qualitative research methods were used in this study, and their respective tools were used to achieve the goals. The researcher collected questionnaire data from college students before conducting a review of the literature and analyzing the secondary data. The socio-demographic information was first gathered by the questionnaire, which then asked about media usage patterns, attitudes towards smartphones and social media, education and digital media, perceptions of education, the use of digital media in teaching and learning, as well as the difficulties of online education. The primary information was gathered using a pre-designed questionnaire. The structured questionnaire made it easier for the study to respond to each research question.

Objectives of the study

The main objectives are:

1. To determine how students used digital media during the COVID19 crisis.
2. To find out the media ownership of the students of Tarai and Dooars.
3. To find out the Inter access of the students.
4. To find out the Gadget own by the students.
5. To find out the challenges and issues encountered by students when using social media.

Data analysis

Respondents for the study were selected from students at five private colleges in the Tarai and Dooars region of West Bengal. These respondents were used in this study to explore the impact of new media on academic activities, understand the differences or digital surge in Internet usage between and within different types, and assess the role of digital media usage. The findings from the survey that was carried out to look at how students felt about using digital media. The data were examined using the Standard Statistical Package for Social Sciences (SPSS) version 20.0 programme.

Table 1: Questionnaire Distributed and Responded based on Gender among students

Sl. No.	Gender	Questionnaire distributed	Responded	% of response
1	Male	1050	759	72.28
2	Female	890	441	49.55
Total		1940	1200	61.85

This table shows the Questionnaire Distributed and Responded based on Gender among students. The majority of the respondents, 759(72.28%) students were male, and only 441(49.55%) of them were female, as shown in this table, which represents the overall sample of the data gathered from students. The 1940 questionnaire was distributed among the students, and a total of 1200 students responded to this study.

Table 2: Distribution of study respondents Students based on age N=1200

Age wise Distribution and Respondents										
Sl No	**Number of Schools**	**Total Respondent**	**Age group**							
			20-22 years		**23-25 years**		**26-28 years**		**29-30 years**	
			No	**%**	**No**	**%**	**No**	**%**	**No**	**%**
1	Male	759	370	48.74	170	22.39	124	16.33	95	12.51
2	Female	441	222	50.34	109	24.71	84	19.04	26	5.89
3	Others	0	0	0	0	0	0	0	0	0
4	Total	1200	592	49.33	279	23.25	208	17.33	121	10.08

This table shows the distribution of study respondents Students based on age. The students' age distribution, about 279(23.25%) people in the population were in the age range of 23 to 25. The range in age of 20 to 22 years is represented by about 592(49.33%) of the student respondents to the study, who came from graduate, from 26 to 28 years, 208(17.33%) and 29 to 30 years, 121 (10.08%) students responded for this study.

Table 3: Distribution of Students' Family Income N=1200

Sl no	Family Income	Frequency	Percentage
1	Below 15000	353	29.41
2	15000 to 30000	310	25.83
3	30000 to 60000	327	27.25
4	Above 60000	210	17.5

This table shows 3 Distribution of Student's Family Income. The student's family's reported median annual income is Rs. 15,000. A total of 310 (25.83%) students stated that their family's annual income ranged from Rs. 15000 to Rs. 30000. The students reported that their family incomes were between Rs. 30,000 and Rs. 60,000, which is 327(27.25%), and above Rs. 60,000, are 210 (17.5%), respectively.

Table 4: Distribution of Media Ownership N=1200

Sl .no	Media	Yes	Percentages	No	Percentages
1.	Newspaper	995	82.2	205	17.08
2.	Magazine	226	18.84	974	81.16
3.	TV set	1158	96.5	42	3.5
4.	DTH/Cable	526	43.84	674	56.16
5.	Radio set	436	36.34	764	63.66

6.	FM Band	333	27.75	867	72.25
7.	Own computer/Laptop	850	70.84	350	29.16
8.	Smart phone	1075	89.59	125	10.41
9.	Own internet connection	820	68.34	380	31.66
10.	Comfortable using electronic gadgets	719	59.92	481	40.08

This table shows the distribution of Media Ownership. All of the participants in the survey are shown in the table above, and 1075 (89.59%) indicated that they own smartphones. In response, 1158(96.5%) said they have a TV. Only 820(68.34%) of the students responded that they had an internet connection, 226(18.84%) to own magazine. Access to the newspaper is available to 995(82.2%) students. Using all of the respondents, TV sets are more common among all students and that the Smart phones are used more frequently.

Table 5: Distribution of Internet Access N=1200

Sl .no	Internet Route	Yes	Percentages	No	Percentages
1.	Connection at home	964	80.33	236	19.66
2.	Connection of relative home	471	39.25	729	60.75
3.	Dongle	237	19.75	963	80.25
4.	Mobile Internet	1102	91.83	98	8.16
5.	Open-access internet	725	60.41	475	39.58
6.	Internet café	630	52.5	570	47.5

This table shows the distribution of Internet Access. The distribution of student internet connections is shown in the table above. And roughly 471 (39.25%) of the students access the internet via a connection from a relative's home. 237(1975%) of the students connect to the internet using the dongle. A whopping 91.83% of students use mobile internet. The preference of 725(60.41%) students is for open-access networks. 630(52.5%) students decide to access the internet at an internet café. The table clearly shows that the primary method for student internet connectivity is their mobile devices.

Table 6: Distribution of Gadgets Owned by Students N=1200

Sl .no	Gadgets	Yes	Percentages	No	Percentages
1.	Personal computer	761	63.41	439	36.58
2.	Personal Laptop	421	35.08	779	64.91
3.	Personal Tablet	217	18.08	983	81.91
4.	Smart phone	1023	85.25	177	14.75
5.	Internet in the University computer Lab	620	51.66	580	48.33
6.	Parents Laptop/Computer	331	27.58	869	72.41
7.	Friends Laptop/Computer	422	35.16	778	64.83

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This table shows the distribution of Gadgets Owned by Students. In the table above, a list of the devices owned by students is provided. 1023(85.25%) students are smartphone owners. 620 (51.66%) of the students use the internet in the college computer lab, and only 217(18.08%) of the students have a personal tablet. Many students use a friend's laptop or computer. Additionally, it should be noted that 421(35.08%) of the students own a personal laptop.

Table 7: Summary of Money Spent on the Internet N=1200

Sl. no	Money	Frequency	Percentage
1	< Rs. 100	253	21.08
2	Rs. 100 to 300	210	17.5
3	Rs. 300 to Rs. 600	127	10.58
4	Rs. 600 to Rs. 1000	210	17.5
5	> Rs.1000	400	33.33

This table shows a summary of Money Spent on the Internet. The amount that students pay each month for internet costs is summarized in the table above. Less than Rs. 100 is spent online by 253(21.08%) of the students. 400(33.33%) spent more than Rs. 1000. About 210(17.5%) of the students spend between 100 and 300 rupees per month online, and 127(10.58%) spend between 300 and 600 rupees.

Table 8: Students' perspectives on social media and higher education N=1200

.Sl No	Factors	No of Respondent					Mean score	% score
		Strongly Agree	Agree	Not able to decide	Disagree	Strongly Disagree		
1	To establish and sustain relationships with students, parents and Alumni	356	210	334	191	109	2.57	51.45
2	To build and maintain relationships with prospective students	193	207	388	235	177	2.99	59.93
3	To tell the story of our institution	289	212	216	308	175	2.89	57.8
4	To communicate the institution's brand, mission and vision	317	155	280	128	320	2.98	59.65

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5	To engage current students in scholarly activity	210	190	329	226	245	3.08	61.76
6	Faculty to interact with the students outside the classroom	177	256	290	247	230	3.08	61.61
7	Compared to students who don't use social media, those who do use it are more engaged in their college experience.	245	170	210	249	326	3.20	64.01
8	To construct deeper meaning and knowledge of course topics	235	220	235	317	193	3.01	60.21
9	Detrimental to students' studies	312	276	247	155	210	2.72	54.58
10	Reduce the separation between the instructor and the students, which leads to a shady connection	229	274	171	205	321	3.09	61.91

This table shows Students' perspectives on social media and higher education. The response from the students to the assessment of the relationship between social media and higher education is shown in the above table. 356 students strongly agree that to build and hold relationship with students, parents and Alumni,388 students not able to decide that to build and maintain relationship with prospective students, 308 disagree that to tell the story of own institution, 320 students disagree to communicate an institution's brand, mission and vision, 329 not able to decide that to engage current students in scholarly activity,177 students strongly agree faculty to interact the students outside the classroom, 326 students vehemently dispute that social media users participate in their college experiences more than nonusers do,317 students disagree that it is necessary to have a deeper understanding of the course material, 312 students strongly agree detrimental to students studies, and reduce the separation between students and teachers, which 321 students vehemently oppose doing, leading to a relationship that is in doubt.

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Table 9: Education and digital media use among students' perspectives N=1200

Sl No	Factors	No of Respondent					Mean score	% score
		Strongly Agree	Agree	Not able to Decide	Disagree	Strongly Disagree		
1	Teachers understand and support the use of technology	289	212	216	308	175	2.89	57.8
2	Enjoy doing assignments/College work on the computer	210	190	329	226	245	3.08	61.76
3	Learning and understanding in the classroom is easier	193	207	388	235	177	2.99	59.93
4	Learning and understanding in an online classroom is easier	317	155	280	128	320	2.98	59.65
5	Encourages learning anytime, anyplace, anywhere	229	274	171	205	321	3.09	61.91
6	Computers keep focus and attentive	245	170	210	249	326	3.20	64.01
7	Facilities provide more ways to learn	356	210	334	191	109	2.57	51.45
8	encourages the student to think about and control their own learning	312	276	247	155	210	2.72	54.58
9	Engaged and excited by learning	212	175	308	216	289	3.16	63.25
10	The teacher provides customized attention in the classroom.	230	290	177	256	247	3	60
11	The teacher in an online classroom gives each student individual attention.	249	326	245	170	210	2.80	56.1

This table shows Education and digital media use among students' perspectives. The table above provides a summary of how students feel about the usage of digital devices in the classroom. 308 students disagree that Teachers understand and support to use technology,329 students not able to decide that taking pleasure in using a computer to do coursework and other schoolwork,193 students agree that it is simpler to learn and understand

in a classroom,317 agree that learning and understanding in online classroom is easier,321 students disagree that Encourages learning anytime, anyplace, anywhere,170 students agree that Computers keep focus and attentive,356 students strongly agree facilities more ways to learn, 312 students firmly concur encourages the student to think about and control their own learning, 308 students not able to decide engage and exited by learning, 326 students believe that the teacher gives each student their undivided attention in the online classroom, whereas 256 students disagree.

Table 10: Challenges faced during online learning – Comparison between students and teachers N=1200

Sl No	Challenges	No of Respondent					Mean score	% score
		Strongly Agree	Agree	Not able to Decide	Disagree	Strongly Disagree		
1	Affordability of Technology	210	190	329	226	245	3.08	61.76
2	Institute support for training of technology	312	276	247	155	210	2.72	54.58
3	Gadget shortage and crashing system	356	210	334	191	109	2.57	51.45
4	Connectivity	156	195	234	245	370	3.39	67.96
5	Computer literacy	281	234	276	239	170	2.81	56.38
6	Adjusting of online courses	245	170	210	249	326	3.20	64.01
7	Data privacy	211	325	225	238	201	2.91	58.21
8	Security	115	289	234	280	282	3.27	65.41
9	Lack of interaction	177	163	216	274	370	3.41	68.28
10	All subjects cannot be taught online	193	207	388	235	177	2.99	59.93
11	Not all teachers/students are tech savvy	211	250	229	275	235	3.06	61.21
12	Lack of standardized content for regional languages	229	274	171	205	321	3.09	61.91
13	Increase in screen time	147	276	275	248	254	3.15	63.1

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14	Lack of formality	317	155	280	128	320	2.98	59.65
15	Insufficient digital infrastructure	215	270	225	220	270	3.05	61
16	Limited social interaction	230	290	177	256	247	3	60

This table shows Challenges faced during online learning – Comparison between students and teachers. From the collected data 329 students are not able to decide affordability of Technology,312 students strongly agree Institute support for training of technology,356 students strongly agree Gadget shortage and crashing system,370 students strongly disagree Connectivity,281 students strongly agree Computer literacy,326 students strongly disagree Adjusting of online courses,325 students agree Data privacy,289 students agree Security,370 students strongly disagree Lack of interaction,388 students not able to decide all subjects cannot be taught online,275 students disagree not all teachers/students are tech savvy,321 students strongly disagree lack of standardized content for regional languages,276 students agree increase in screen time,320 students strongly disagree lack of formality,225 students not able to decide insufficient digital infrastructure and 290 students agree limited social interaction.

Conclusion

Because of enhanced Internet connectivity and reduced data rates offered by network providers, the usage of social media platforms has gradually expanded along with technical advancement. As a result, social media platforms like Facebook, Instagram, YouTube, and Twitter have experienced a massive explosion in popularity. The market for smartphones, which offers more affordable products with better features, has further accelerated this. Based on personal preferences and needs, social media platforms are utilized in a variety of personal domains. From this study, it was found that after the distributed questionnaire to the five colleges of Tarai and Dooars, West Bengal, Male students are respondent most in comparison to the female students. The age group 20-22 years students were more than the other age groups. From the study, the highest 353 students belonging to the below 15000/- Rs. Family income. 1158 students own a TV set, and 1102 students have internet access in their mobiles. The findings also show that 85.25 % students have smartphones. It was observed that 33.33% students spend less than Rs.1000 for internet connection.

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Transforming Academic Libraries with Digital Innovations

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Abstract

The digital environment has revolutionized academic libraries, transforming them from traditional repositories of print resources into dynamic, technology-driven knowledge centers. Innovations such as digital libraries, institutional repositories, cloud-based management systems, discovery tools, and AI-enabled services have enhanced accessibility, efficiency, and user engagement. Academic libraries now support remote learning, e-research, and personalized services while ensuring long-term digital preservation. Despite challenges like copyright, digital divide, and cybersecurity, these innovations have redefined library roles, emphasizing information literacy, scholarly communication, and lifelong learning. Embracing digital transformation enables academic libraries to remain relevant, inclusive, and integral to the modern educational ecosystem.

Keywords: Academic libraries, Digital environment Digital transformation, E-resources, Library innovations, Information services, Digital preservation, ICT in libraries

Introduction

The digital environment has fundamentally transformed academic libraries, redefining their role in supporting teaching, learning, and research. Traditionally, libraries functioned as physical repositories of books, journals, and other print materials. Today, advances in information and communication technologies (ICT), cloud computing, digital databases, and artificial intelligence (AI) have enabled libraries to evolve into dynamic, user-centered knowledge hubs.

Digital innovations, such as electronic resource management, institutional repositories, discovery tools, virtual reference services, and mobile applications, provide seamless access to information anytime and anywhere. These developments have enhanced resource management, improved service efficiency, and personalized user experiences. Simultaneously, challenges such as copyright compliance, cyber-security, digital literacy, and equitable access require strategic planning and continuous professional development. Transforming academic libraries in the digital environment is not merely about technology adoption but also about redefining library services, promoting lifelong learning, fostering scholarly communication, and ensuring that libraries remain integral to the modern educational ecosystem.

Objectives of the Study

- To examine the impact of digital innovations on the transformation of academic libraries, focusing on services, resources, and user engagement.
- To analyze the role of emerging technologies such as ICT, cloud computing, and artificial intelligence in enhancing library operations and information services.
- To identify the challenges and opportunities faced by academic libraries in the digital environment, with reference to accessibility, digital literacy and sustainability.

Academic Libraries

Academic libraries are specialized libraries established within universities, colleges, and research institutions to support the teaching, learning, and research needs of students, faculty, and staff. They serve as central hubs for acquiring, organizing, and providing access to knowledge in diverse formats, including books, journals, databases, and digital resources.

The primary role of academic libraries is to facilitate learning and research by providing relevant information resources and services. They promote information literacy, helping users develop skills in effective information retrieval, evaluation, and ethical use of knowledge. Modern academic libraries also support scholarly communication through institutional repositories, open-access initiatives, and digital archives. With the advent of digital technologies, academic libraries have evolved into hybrid knowledge centers, offering e-resources, virtual reference services, mobile access, and learning support platforms. They also provide collaborative spaces, maker spaces, and digital labs to foster innovation and creativity. By integrating technology, professional expertise, and user-centered services, academic libraries remain essential to the academic ecosystem, supporting lifelong learning and research advancement.

Digital Transformation of Libraries in India

The digital transformation of libraries in India marks a significant shift from traditional print-based systems to technology-driven, user-centered knowledge hubs. Indian academic, public, and special libraries are increasingly adopting ICT, Integrated Library Management Systems (ILMS), cloud computing, and mobile platforms to enhance accessibility, efficiency, and service delivery. Digitization initiatives have played a central role, preserving rare manuscripts, historical documents, and institutional records while making them globally accessible.

National-level programs such as the National Digital Library of India (NDLI), INFLIBNET, and Shodhganga facilitate access to e-books, journals, theses, and dissertations, promoting open access and scholarly communication. Libraries are also implementing electronic resource management systems (ERMS), discovery tools, RFID technology, and virtual reference services to streamline operations and improve user experience.

These transformations support remote learning, digital research, and lifelong education, enabling users to access resources anytime and anywhere. Moreover, AI-driven services, chatbots, and data analytics are enhancing personalized services and informed decision-making.

However, Indian libraries face challenges such as the digital divide, copyright issues, cybersecurity threats, limited funding, and lack of trained personnel. Addressing these issues through strategic planning, professional development, and sustainable policies is essential. Overall, the digital transformation of libraries in India is redefining their role as inclusive, innovative, and technology-enabled knowledge centers, bridging traditional and modern information ecosystems.

Transformation in Libraries

a) **Past (Traditional Libraries):** Historically, libraries focused primarily on print collections, including books, manuscripts, journals, and periodicals. Services were largely manual, involving card catalogues, physical circulation, and on-site reference assistance. Access to information was limited

by geography, library hours, and the availability of physical materials. Preservation of rare and fragile documents depended on careful handling and climate-controlled storage.

b) **Transition Phase:** The mid-to-late 20th century saw the introduction of computers and automation, transforming cataloguing, circulation, and serials management. Online Public Access Catalogues (OPACs) replaced card catalogues, making resource discovery easier. Libraries began subscribing to electronic databases and digital journals, enabling partial remote access.

c) **Present (Digital and Hybrid Libraries):** Today, libraries have embraced the digital era, offering e-books, e-journals, institutional repositories, discovery tools, and virtual reference services. Automation, cloud computing, AI-based search, and mobile applications enhance efficiency and accessibility. Libraries also serve as collaborative spaces, learning commons, and innovation hubs, supporting research, lifelong learning, and scholarly communication.

Transformation of Libraries in a Changing Environment

Libraries have continuously evolved to meet the changing needs of society, education, and technology. Traditionally, they functioned as physical repositories of print resources, providing on-site reference services and lending facilities. Access was limited by geography, operating hours, and the availability of physical materials. Preservation and organization of resources relied on manual cataloguing, card systems, and human expertise.

With the advent of ICT, libraries transitioned into automated and hybrid systems. OPACs, ILMS, and electronic databases improved efficiency, organization, and accessibility. Libraries also started providing access to e-resources, online journals, and digital repositories, enabling remote learning and research.

In the contemporary digital era, libraries have become dynamic, technology-driven knowledge centers. They integrate digital platforms, cloud services, AI-enabled search tools, and mobile applications to provide seamless, user-centered services. Modern libraries support virtual reference, data analytics, scholarly communication, and collaborative learning spaces. They also address challenges such as copyright, cybersecurity, and the digital divide.

Online Public Access Catalogue (OPAC)

An OPAC is a digital database of a library's holdings, providing users with an efficient way to search, locate, and access resources. It replaces the traditional card catalogue system, allowing searches by keywords, titles, authors, subjects, or classification numbers.

OPACs, as part of ILMS, provide real-time updates on availability and location of resources. Features include advanced search options, user account management, item reservation, and access to digital resources. Integration with discovery services links multiple databases and repositories for seamless retrieval.

Benefits include improved accessibility, accuracy, efficiency, user convenience, and enhanced library management. By providing remote access and user-friendly interfaces, OPACs support learning, research, and information literacy.

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Artificial Intelligence & Technologies in Libraries

AI and advanced technologies are transforming libraries into intelligent, user-centered information hubs. AI applications like chatbots, virtual assistants, and recommendation systems help users locate resources quickly and provide personalized support. Machine learning algorithms analyze user behavior to offer tailored content, predictive services, and data-driven decision-making.

Technologies such as RFID, cloud computing, IoT, and digital repositories streamline circulation, inventory management, and digital preservation. Discovery tools and AI-powered search engines improve accessibility via semantic search, metadata enrichment, and cross-database integration. Mobile applications and cloud platforms ensure remote access and 24/7 availability.

Integration of AI and emerging technologies enhances efficiency and redefines the librarian's role, focusing on knowledge curation, digital literacy, and user engagement.

Causes of Transformation in Libraries

Transformation is driven by multiple factors:

- Advancements in ICT, cloud computing, AI, and mobile platforms.
- Rise of digital resources such as e-books, e-journals, and databases.
- User expectations for instant, remote, and personalized access.
- Globalization and collaboration in research requiring access to international knowledge networks.
- National initiatives like NDLI and INFLIBNET promoting digitization and open access.
- Need for preservation of rare and fragile materials and operational efficiency.

Role of Libraries in the Digital Era

Libraries have evolved into dynamic, technology-driven knowledge hubs supporting education, research, and lifelong learning.

- Provide access to e-resources, institutional repositories, and open educational resources.
- Promote information literacy, teaching users to search, evaluate, and ethically use information.
- Facilitate scholarly communication via digital archives, open-access repositories, and research support.
- Leverage AI, data analytics, cloud platforms, discovery tools, and virtual reference services.
- Serve as collaborative learning spaces, maker spaces, and interactive platforms for innovation.

Conclusion

The transformation of academic libraries in the digital environment reflects a paradigm shift in knowledge creation, access, and management. Modern libraries have moved beyond traditional print-based models to become technology-driven, user-centered knowledge hubs, offering e-resources, digital repositories, discovery tools, and virtual reference services.

Integration of AI, cloud computing, mobile platforms, and data analytics has enhanced accessibility, efficiency, and personalization, supporting teaching, learning, and research. Digital transformation also enables remote access, open access initiatives, long-term preservation,

information literacy, and lifelong learning. Despite challenges like copyright compliance, cybersecurity, digital divide, and staff skill gaps, strategic planning, professional development, and innovative technologies help libraries remain relevant.

Overall, transforming academic libraries ensures they continue to be dynamic, inclusive, and collaborative knowledge centers, bridging traditional and digital information ecosystems and fostering academic excellence.

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Digital Innovation and Transformational Leadership: Strategic Approaches and Organizational Outcomes

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Abstract

Digital innovation has fundamentally reshaped organizational structures, processes and leadership practices. In this rapidly evolving environment, transformational leadership plays a critical role in guiding organizations through technological change and uncertainty. This study examines the relationship between digital innovation and transformational leadership, with particular emphasis on strategic approaches adopted by leaders to foster innovation-driven organizational growth. It explores how transformational leaders encourage a shared vision, stimulate creativity, and empower employees to effectively adopt digital technologies. The paper also analyzes key organizational outcomes such as enhanced performance, employee engagement, agility, and competitive advantage resulting from the integration of digital innovation and leadership strategies. By synthesizing contemporary literature and empirical insights, the study highlights the importance of adaptive leadership capabilities, digital competence, and a culture of continuous learning. The findings suggest that organizations led by transformational leaders are better positioned to leverage digital innovation for sustainable success in a highly competitive and technology driven business environment.

Keywords: Digital Innovation, Transformational Leadership, Digital Transformation, Strategic Leadership, Organizational performance

Introduction

The rapid advancement of digital technologies has significantly transformed the way organizations operate, compete, and create value. Innovations such as artificial intelligence, big data analytics, cloud computing, and digital platforms have redefined organizational processes, decision-making mechanisms, and employee roles. In this context, leadership has emerged as a critical factor in ensuring the successful adoption and integration of digital innovation. Traditional leadership models are often inadequate to address the complexity, speed, and uncertainty associated with digital transformation, thereby necessitating more adaptive and visionary leadership approaches.

Transformational leadership, characterized by vision, inspiration, intellectual stimulation, and individualized consideration, is increasingly recognized as a suitable leadership style for managing digital change. Transformational leaders motivate employees to embrace innovation, challenge existing practices, and develop new competencies aligned with digital goals. By fostering a culture of trust, creativity, and continuous learning, such leaders enable organizations to respond effectively to technological disruptions.

Digital innovation and transformational leadership are closely interconnected, as leadership strategies influence how technologies are perceived, adopted, and utilized within organizations. Strategic approaches such as promoting digital skills development, encouraging cross-functional collaboration, and aligning technological initiatives with organizational vision play a vital role in achieving desired outcomes. These outcomes include improved organizational performance, enhanced employee engagement, operational agility, and sustained competitive advantage.

This paper explores the strategic approaches adopted by transformational leaders in driving digital innovation and examines their impact on organizational outcomes. Understanding this relationship is essential for organizations seeking to navigate digital transformation successfully and achieve long-term sustainability in an increasingly technology-driven environment.

Definitions and Theoretical Background

Leadership Style

The manner in which a leader guides, supports, motivates, and provides direction to personnel in an organization in order to achieve optimal performance is referred to as leadership style (Crowley, 2022). It is important to recognize that leaders may exhibit multiple leadership styles and may not rely on a single approach in all situations. In his seminal work on the path–goal theory, Lappalainen (2015) explains that a leader's style is influenced by several factors, including the characteristics of the leader, the attributes of followers, and the organizational environment in which both operate (Aga et al., 2016). This theory also emphasizes the mediating role of environmental and subordinate variables, highlighting the need for leaders to adapt their behavior to suit specific situational demands in order to enhance performance and employee satisfaction. Within the path–goal framework, four primary leadership styles are identified: directive, participative, supportive, and achievement-oriented (Nguyen et al., 2017).

Numerous empirical studies have consistently demonstrated that leadership plays a critical role in organizational performance and employee effectiveness. Leaders adopt diverse styles to manage and guide their workforce efficiently. Among these, transformational leadership has emerged as particularly impactful (Para-González et al., 2018). When organizational leaders effectively practice transformational leadership, employees tend to develop stronger organizational commitment and experience higher levels of job satisfaction.

Transformational Leadership

Transformational leadership is commonly described as a set of interrelated behaviors that include intellectual stimulation, idealized influence, inspirational motivation, and individualized consideration. Through inspirational motivation, leaders appeal to followers on a psychological level by articulating an engaging future vision and encouraging the development of shared goals and collective understanding. This approach enables leaders to address the individual needs of followers by providing personal attention, guidance, and timely support (Greimel et al., 2023). By exemplifying commitment and high standards, transformational leaders inspire their teams to exert exceptional effort in achieving organizational objectives.

According to Manu (2022), transformational leadership involves leaders who motivate and inspire individuals to transcend their personal interests, thereby creating a deep and meaningful impact on followers. Similarly, Deng et al. (2023) define transformational leadership as a leadership approach in which leaders encourage and persuade employees to work diligently toward the attainment of organizational goals. The advantages of transformational leadership include the ability to motivate employees across all levels of the organization without coercion, foster innovation and change, and initiate strategic organizational success that reflects a high level of leadership effectiveness. Furthermore, Manu (2022) proposed an evaluation framework for transformational leadership based on key dimensions such as inspirational motivation, intellectual stimulation, and individualized consideration.

Digital Innovation

Adapting to the contemporary digital era has become an essential stage in organizational and societal evolution. The importance of innovation and communication is strongly emphasized in the United Nations' Sustainable Development Goals (SDGs) introduced in 2015 (Felicetti et al., 2024). Discussions surrounding innovation and communication inevitably highlight the role of the internet, which has become an indispensable and widely utilized resource. This focus on digital innovation was further intensified by the COVID-19 pandemic in 2020, which affected nearly every country worldwide. During this period, digital technologies—particularly internet-based platforms—enabled individuals and organizations to sustain work, communication, and service delivery despite mobility restrictions (Shah et al., 2024). The internet facilitates connectivity between systems, processes, and stakeholders, allowing operations to continue safely and efficiently across sectors.

However, the transition to digital platforms is complex and requires a clear understanding of digital concepts and their implications. Digital transformation involves aligning organizational practices with the characteristics of digital identity and technological change (Ye et al., 2024). The widespread use of terms such as "digital" and "digitization," often in combination with business and industry contexts, reflects both growing interest and conceptual ambiguity. Business digitization can be defined as a technological transformation process that influences both organizational structures and broader social systems due to its extensive societal impact (Ciriello et al., 2018). For example, traditional service delivery models limited to physical locations have evolved into digital platforms accessible to a wider population.

To remain competitive and sustainable, organizations must continuously adapt to digital developments and manage transformation effectively (Hund et al., 2021). Emerging technologies such as artificial intelligence, robotics, and automation are reshaping work processes, while uniquely human capabilities—creativity, empathy, decision-making, and problem-solving—remain irreplaceable. The pandemic has acted as a catalyst, compelling organizations and individuals to enhance digital competencies alongside continuous learning to improve productivity and resilience.

Transformational Leadership and Digital Innovation

The digital age has introduced unprecedented opportunities and challenges, fundamentally altering organizational operations and communication. In this environment, transformational leadership has emerged as a vital approach for guiding organizations through technological disruption and continuous change. Given the complexity of digital transformation, leaders must rethink organizational structures, processes, and cultures to successfully implement digital tools and strategies for long-term growth and competitiveness (Antonopoulou et al., 2021; Pratiwi & Amini, 2023).

Leadership models in the digital era are shifting from rigid hierarchical systems to more flexible and agile frameworks. Transformational leadership, with its emphasis on vision, motivation, and empowerment, is particularly suited to fostering innovation and employee engagement in this context. Leaders play a crucial role in enabling organizations to harness the full potential of their workforce by instilling a sense of purpose and commitment, leading to higher levels of productivity and innovation (McCarthy et al., 2022).

Digital transformation also presents challenges related to data privacy, cybersecurity, and ethical considerations. Transformational leaders must proactively address these issues while cultivating a culture of adaptability and continuous improvement. Despite growing scholarly interest, empirical research examining transformational leadership within the digital context remains limited (Mayastinasari & Suseno, 2023). Consequently, this study seeks to explore the influence of transformational leadership in the digital age and its impact on organizational performance and effectiveness, thereby contributing to a deeper understanding of leadership in technologically driven environments.

Objectives of the Study

- To examine the concept and key dimensions of transformational leadership in the context of digital innovation.
- To analyze the strategic approaches adopted by transformational leaders to promote digital innovation within organizations.
- To assess the role of transformational leadership in facilitating effective digital transformation processes.
- To evaluate the impact of digital innovation–driven leadership on organizational outcomes such as performance, employee engagement, and competitive advantage.

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- To identify challenges and opportunities associated with implementing transformational leadership strategies in the digital era.

Need for the Study

The rapid growth of digital technologies has significantly transformed organizational operations, work culture, and competitive dynamics. In this context, effective leadership has become a critical factor in successfully managing digital innovation and transformation. Traditional leadership approaches are often insufficient to address the complexity, speed, and uncertainty associated with digital change. Therefore, there is a growing need to understand leadership styles that can effectively support and sustain digital transformation initiatives.

Transformational leadership is widely recognized for its ability to inspire, motivate, and empower employees to embrace change and innovation. However, despite its relevance, there is limited empirical evidence examining how transformational leadership specifically influences digital innovation strategies and organizational outcomes in the contemporary digital environment. Organizations frequently face challenges such as resistance to technological change, skill gaps, cybersecurity concerns, and ethical issues, all of which require adaptive and visionary leadership.

This study is necessary to bridge the existing research gap by systematically examining the relationship between digital innovation and transformational leadership. It aims to provide insights into strategic leadership practices that enhance organizational performance, employee engagement, and long-term sustainability. The findings of this study will be valuable to organizational leaders, policymakers, and researchers by offering practical guidance for implementing effective leadership strategies in the digital era and supporting informed decision-making for successful digital transformation.

Scope and Methodology of the Study

This study is conceptual and analytical in nature. It focuses on examining the relationship between digital innovation and transformational leadership and their influence on organizational outcomes. The scope of the study is limited to leadership strategies adopted in digitally transforming organizations across various sectors, with particular emphasis on knowledge-based and service-oriented institutions.

The study is based on secondary data collected from peer-reviewed journals, books, conference proceedings, and credible online sources related to digital innovation, leadership theories, and organizational performance. A descriptive and interpretative research approach has been adopted to synthesize existing literature and identify key themes, challenges, and best practices. The findings are derived through systematic review and comparative analysis of relevant studies, aiming to provide theoretical insights and practical implications for leaders operating in the digital era.

Challenges in Digital Innovation and Transformational Leadership

1. **Resistance to Change:** Employees may resist adopting new digital technologies due to fear of job displacement, lack of confidence, or comfort with existing work practices.
2. **Digital Skill Gaps:** Insufficient digital literacy and technical skills among employees and leaders can hinder effective implementation of digital innovation initiatives.
3. **Rapid Technological Change:** The fast pace of technological advancements makes it difficult for organizations to continuously adapt and remain competitive.
4. **Data Security and Privacy Issues:** Increased reliance on digital systems exposes organizations to cybersecurity threats, data breaches, and ethical concerns related to information handling.
5. **Cultural Barriers:** Organizational cultures that are rigid or hierarchical may limit collaboration, creativity, and innovation required for digital transformation.

6. **Leadership Readiness:** Not all leaders possess the digital competence or transformational mindset necessary to guide organizations through complex digital change.
7. **High Implementation Costs:** Digital transformation often requires substantial financial investment in infrastructure, training, and maintenance, posing challenges for sustainability.
8. **Employee Stress and Workload:** Continuous digital change may increase work pressure and stress, affecting employee well-being and productivity.
9. **Alignment of Strategy and Technology:** Ensuring that digital innovation initiatives align with organizational vision and strategic goals remains a significant challenge.
10. **Ethical and Legal Concerns:** The use of emerging technologies such as AI and automation raises ethical, legal, and social issues that require careful leadership oversight.

Suggestions

1. **Strengthen Digital Leadership Competencies:** Organizations should invest in continuous leadership development programs that enhance both digital literacy and transformational leadership skills among managers and executives.
2. **Promote a Culture of Innovation:** Leaders should encourage experimentation, creativity, and knowledge sharing to support digital innovation and reduce resistance to change.
3. **Enhance Employee Training and Upskilling:** Regular training programs should be implemented to bridge digital skill gaps and empower employees to confidently adopt new technologies.
4. **Ensure Strategic Alignment:** Digital innovation initiatives must be aligned with organizational vision and long-term strategic goals to maximize organizational outcomes.
5. **Address Ethical and Security Concerns:** Leaders should establish clear policies for data security, privacy, and ethical use of digital technologies to build trust and sustainability.
6. **Encourage Collaborative Work Environments:** Cross-functional teamwork and open communication should be promoted to facilitate effective digital transformation.

Conclusion

Digital innovation has become a central driver of organizational growth, efficiency, and competitiveness in the modern era. However, the successful adoption of digital technologies depends largely on effective leadership. Transformational leadership plays a vital role in guiding organizations through digital transformation by inspiring employees, fostering innovation, and promoting adaptability. Leaders who adopt transformational strategies are better equipped to manage technological change, address emerging challenges, and achieve positive organizational outcomes such as enhanced performance, employee engagement, and sustainability.

This study highlights the significance of integrating digital innovation with transformational leadership to navigate the complexities of the digital age. By embracing strategic leadership approaches, investing in human capital, and fostering a culture of continuous learning, organizations can fully leverage digital innovation for long-term success. The findings underscore that transformational leadership is not only relevant but essential for organizational effectiveness in an increasingly digital and dynamic environment.

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An Overview of the Impact of Digital Information on Contemporary Knowledge Systems

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Abstract

The proliferation of digital technologies has fundamentally altered the structure, function, and governance of information systems. Digital information now underpins knowledge production, dissemination, and consumption across academic, economic, and socio-political domains. While digitalization has enabled unprecedented access to information and accelerated innovation, it has also introduced complex challenges related to information integrity, epistemic trust, data security, privacy, and ethical accountability. This paper presents a critical overview of the impact of digital information on contemporary knowledge systems, examining its transformative role while interrogating the emerging risks and structural inequalities associated with its use.

Keywords: Digital Information, Knowledge Systems, Digital Transformation, Information Integrity, Data Ethics, Digital Divide

Introduction

Digital information has emerged as a defining characteristic of contemporary knowledge societies. The convergence of computing technologies, networked communication, and data-intensive systems has resulted in a paradigm shift from analog to digital modes of information creation, storage, and dissemination. This transformation has not only reshaped institutional information practices but has also reconfigured epistemological assumptions concerning authority, credibility, and access to knowledge. Understanding the impact of digital information is therefore essential for critically evaluating its implications for research, governance, and social development.

Objectives of the Study

The present study aims to:

- Examine the impact of digital information on contemporary knowledge systems.
- Analyze the role of digital technologies in knowledge production and dissemination.
- Identify challenges related to information integrity, privacy, and ethical governance.
- Explore the implications of digital information for higher education and research.

Scope of the Study

The scope of this study is limited to analyzing the conceptual, technological, and ethical dimensions of digital information in shaping contemporary knowledge systems. It focuses on academic, educational, and institutional contexts and does not include empirical field investigations.

Methodology

This study adopts a descriptive and analytical research methodology based on an extensive review of scholarly literature, policy documents, and authoritative digital resources. Secondary data sources such as journals, reports, books, and online databases were systematically analyzed to derive conceptual insights and critical interpretations.

Digital Information and Knowledge Production

The digitization of information has significantly influenced knowledge production processes. Research workflows are increasingly mediated by digital tools, including computational analytics, digital repositories, and artificial intelligence–based systems. These technologies enable large-scale data analysis, interdisciplinary

collaboration, and rapid dissemination of research outputs. However, reliance on algorithmic systems raises critical concerns regarding methodological transparency, reproducibility, and epistemic bias embedded within digital infrastructures.

Accessibility, Democratization, and Digital Inequality

One of the most widely acknowledged impacts of digital information is the expansion of access to knowledge through open-access platforms, digital libraries, and online educational resources. While these developments contribute to the democratization of information, access remains uneven due to persistent digital divides shaped by socioeconomic status, geography, and institutional capacity. Consequently, digital information may simultaneously function as a tool of empowerment and a mechanism that reinforces existing structural inequalities.

Information Management, Preservation, and Sustainability

Digital information management systems have transformed archival practices by enabling high-density storage, real-time retrieval, and distributed access. Cloud-based infrastructures and digital repositories support institutional memory and research continuity. Nevertheless, challenges related to data preservation, technological obsolescence, and long-term sustainability pose significant risks to digital knowledge continuity. These concerns necessitate robust digital curation strategies and policy interventions.

Information Integrity, Misinformation, and Epistemic Trust

The accelerated circulation of digital information has complicated traditional mechanisms of information validation. The proliferation of misinformation, disinformation, and AI-generated content undermines epistemic trust in digital environments. Maintaining information integrity requires the development of advanced verification frameworks, critical digital literacy, and ethical standards governing content creation and dissemination.

Privacy, Surveillance, and Data Ethics

Digital information systems increasingly rely on the collection and analysis of personal and institutional data. This data-centric paradigm has intensified concerns regarding privacy, surveillance, and ethical governance. Issues such as unauthorized data use, algorithmic profiling, and cross-border data flows challenge existing regulatory frameworks, demanding interdisciplinary solutions that integrate legal, technological, and ethical perspectives.

Implications for Higher Education and Research

In higher education, digital information has transformed pedagogical practices through e-learning platforms, virtual laboratories, and open research ecosystems. While these innovations enhance flexibility and collaboration, they also raise concerns about academic integrity, quality assurance, and commercialization of knowledge. Researchers and students must therefore develop advanced competencies in data management, critical evaluation, and ethical research conduct.

Conclusion

The impact of digital information extends beyond technological advancement, reshaping the foundational structures of knowledge systems and societal interaction. While digitalization offers significant opportunities for innovation, inclusivity, and collaboration, it also introduces systemic risks related to inequality, information integrity, and ethical governance. A critical and reflective engagement with digital information is imperative to ensure its responsible, equitable, and sustainable integration into future knowledge ecosystems.

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Analyzing the Impact of E-Books on Traditional Print Book Usage and Circulation in Libraries

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ABSTRACT

The emergence of e-books has reshaped library services and reading habits, influencing the use of traditional print collections. This study briefly examines the impact of e-books on print book usage and circulation in libraries. The findings suggest a decline in print circulation for certain materials, particularly reference and frequently updated content, while print books remain preferred for extended reading and academic use. E-books enhance accessibility and convenience, leading to increased overall information use. The study highlights that e-books function as a complementary resource rather than a complete replacement for print books, underscoring the importance of balanced library collection strategies.

INTRODUCTION

The rapid advancement of digital technology has significantly transformed the way information is created, accessed, and consumed. Among these changes, the introduction of e-books has had a profound impact on libraries and their traditional role as custodians of print materials. E-books offer advantages such as instant access, portability, search functionality, and remote availability, making them increasingly popular among library users. This shift toward digital resources has raised important questions about the future of traditional print books in libraries, particularly regarding their usage and circulation. While some library users prefer the convenience of e-books, others continue to value print books for their tactile experience, ease of extended reading, and reduced screen fatigue. These differing preferences have influenced circulation patterns, collection development policies, and space utilization within libraries.

Analyzing the impact of e-books on traditional print book usage and circulation is essential for understanding how libraries can effectively balance digital and print resources. This study explores changes in circulation trends, user behavior, and collection management practices, aiming to provide insights that will help libraries develop sustainable, user-centered strategies in an increasingly hybrid information.

KEYWORD

- Digital Libraries
- Collection Development
- Information Access
- Library Usage Statistics
- Reading Preferences
- Electronic Resources
- Academic Libraries
- Public Libraries
- Information Technology in Libraries
- Resource Management

OBJECTIVES

- To analyze changes in print book usage and circulation patterns
- To study user preferences between e-books and print books
- To identify challenges faced by libraries in managing both formats
- To suggest strategies for maintaining a balanced collection
- To examine the growth of e-books in library collections

SCOPE

The scope of the present study is limited to analyzing the impact of e-books on traditional print book usage and circulation in libraries. The study focuses on how the increasing adoption of e-books has influenced print collection usage, borrowing patterns, and user reading behavior in different types of libraries.

The study covers **academic, public, and special libraries**, with particular emphasis on higher educational institutions where digital resources are widely used. It examines trends in print book circulation before and after the introduction of e-books and evaluates user preferences for print and electronic formats for academic, reference, and leisure reading purposes.

The scope also includes an analysis of **library collection development policies**, budget allocation between print and electronic resources, and challenges faced by libraries in managing both formats. Issues such as licensing, access restrictions, technological infrastructure, and staff training related to e-books are considered within the study.

TYPES OF PRINTED BOOKS

1. Textbooks

- Used for academic and curriculum-based study
- Common in schools, colleges, and universities

2. Reference Books

- Provide quick factual information
- Examples: Dictionaries, encyclopedias, handbooks

3. Research Books

- In-depth scholarly works
- Used by researchers and faculty members

4. General Books

- Cover general knowledge and interests
- Includes biographies, travel books, essays

5. Fiction Books

- Literary and imaginative works
- Novels, short stories, drama, poetry

6. Non-Fiction Books

- Based on real facts and events

- History, science, self-help, philosophy

7. Periodicals (Print Form)

- Published at regular intervals
- Journals, magazines, newspapers

8. Rare and Archival Books

- Old and valuable materials
- Preserved for historical and cultural importance

TYPES OF E-BOOKS

1. Academic E-Books

- Digital textbooks and reference materials
- Widely used in academic libraries

2. Reference E-Books

- Online dictionaries, encyclopedias, manuals
- Allow quick searching and linking

3. Research E-Books

- Scholarly publications in digital format
- Used by researchers and scholars

4. Commercial E-Books

- Purchased or subscribed through platforms
- Examples: Kindle books, Google Books

5. Open Access E-Books

- Freely available online
- Published by universities and research institutions

6. Multimedia E-Books

- Include audio, video, animations, and hyperlinks

7. Interactive E-Books

- Provide quizzes, highlights, notes, and bookmarks

8. Downloadable and Cloud-Based E-Books

- Downloadable for offline reading
- Cloud-based for anytime, anywhere access

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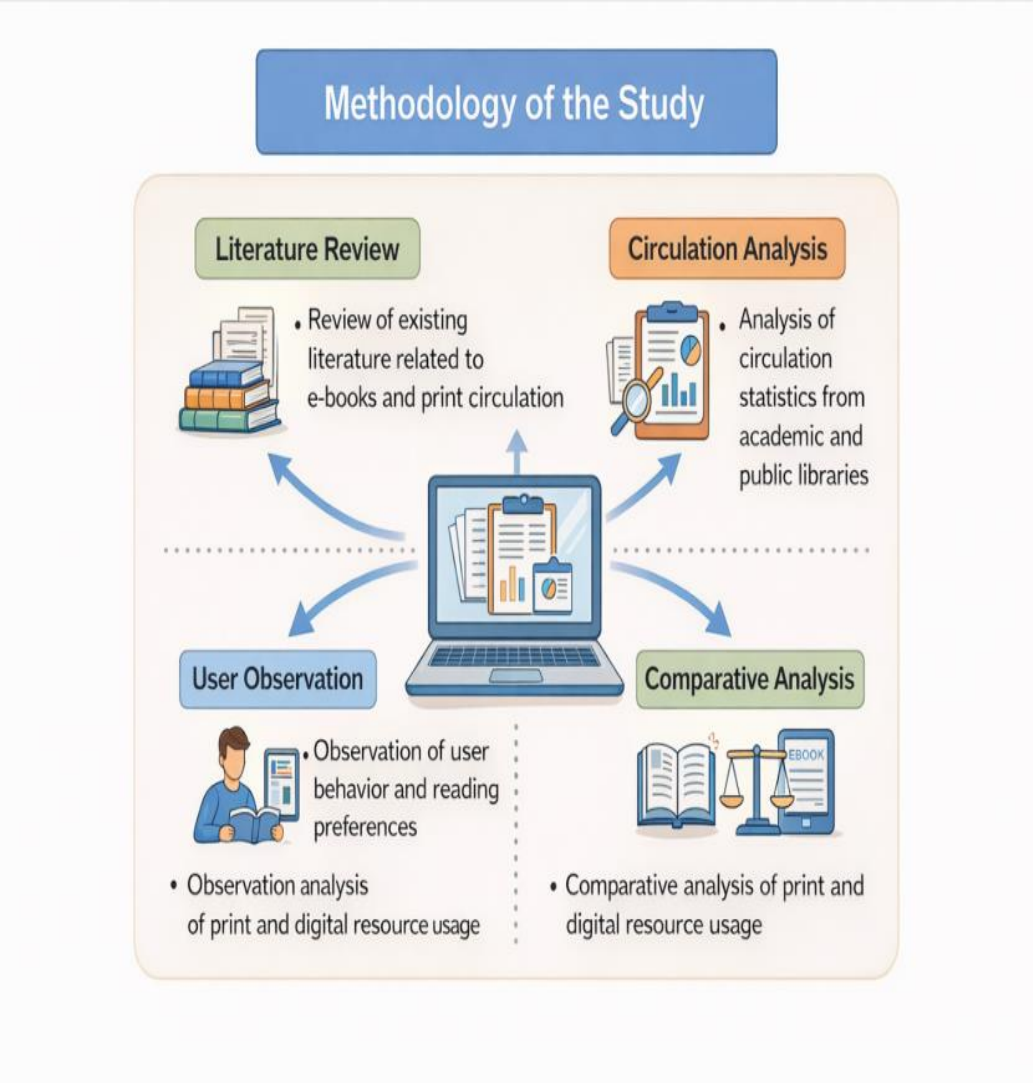


Fig: 1- PRINTED BOOKS VS E-BOOKS

S.NO	PRINTED BOOKS	E-BOOKS
1	Physical format	Digital format
2	Requires shelf space	Requires digital storage
3	Manual search	Keyword search
4	Limited copies	Multiple users access

METHODOLOGY

- ❖ Review of existing literature related to e-books and print circulation
- ❖ Analysis of circulation statistics from academic and public libraries
- ❖ Observation of user behavior and reading preferences
- ❖ Comparative analysis of print and digital resource usage.

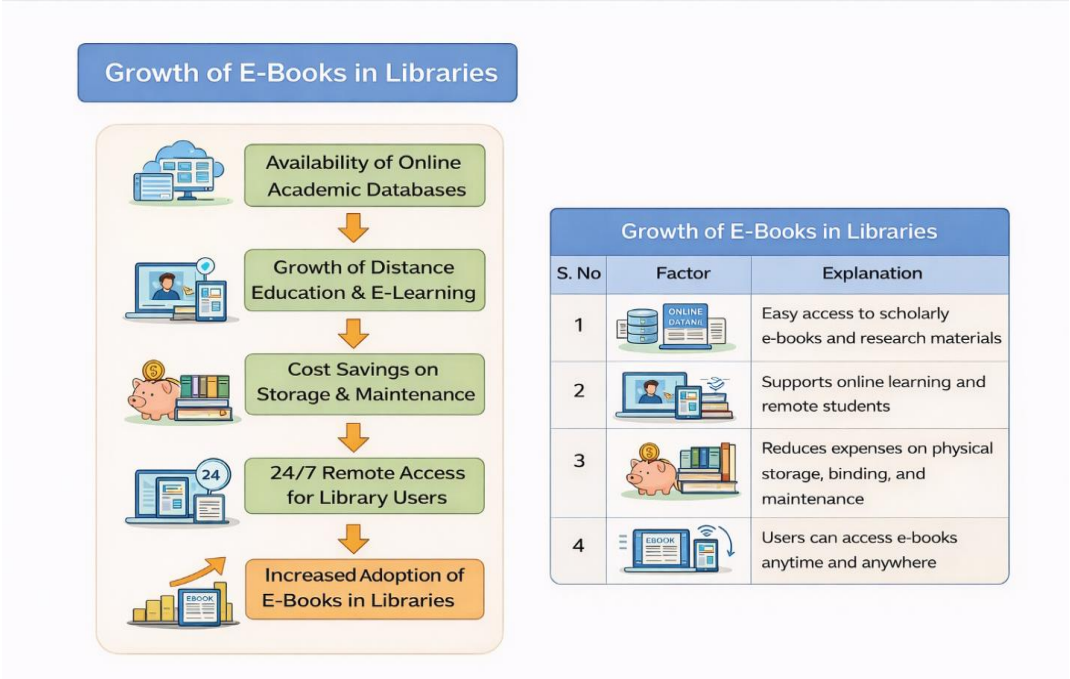


Fig: 2- METHODOLOGY

S.NO	METHODS	DESCRIPTION
1	Review of Existing Literature	Study of books, journals, research articles, and reports related to e-books and print book circulation
2	Analysis of Circulation Statistics	Examination of circulation data collected from academic and public libraries
3	Observation of User Behavior	Observation of reading habits, preferences, and usage patterns of library users
4	Comparative Analysis	Comparison of print and digital resource usage to identify trends and differences

Growth of E-Books in Libraries

- ❖ Availability of online academic databases
- ❖ Growth of distance education and e-learning
- ❖ Cost savings on physical storage and maintenance
- ❖ 24/7 remote access for users

S.NO	**IMPACT**	ASPECT
1	Textbook borrowing	Reduced
2	Reference usage	Declining
3	Library footfall	Search preference
4	Search preference	Digital keyword search

Impact on Print Book Usage and Circulation

Decline in Print Circulation

- Reduced borrowing of textbooks and reference books
- Decrease in physical footfall in libraries
- Preference for keyword searching and instant access

Global Trends & US Examples (2024/2025 Data)

- **Overall Decline:** Print newspapers face consistent drops as readers move online for "on-demand" news, noted by Statista and Pew Research.
- **US Newspapers (Major Declines):** The LA Times, Chicago Tribune, and other Alden Global Capital-owned papers saw substantial print circulation drops (over 10-20%), as reported by Press Gazette.
- **US Exceptions:** Some papers, like The Villages Daily Sun, reported slight print growth or stable circulation, as noted by Press Gazette.

Indian Newspaper Trends (2025 Data)

- **Significant Drops:** The Hindu and The New Indian Express saw substantial drops (6-10%+).
- **Digital Shift:** Younger demographics increasingly prefer online news, creating a gap for traditional print, though Indian papers are adopting cross-media strategies, according to Walsh Medical Media.

Key Drivers

- **Digital Competition:** Online news sites offer immediate updates, making print's next-day news a disadvantage, notes Walsh Medical Media.
- **Advertising Revenue Loss:** Ad budgets have shifted online, hurting print finances, notes Statista.

Data Snapshot (Print Circulation Decline)

- **US (2022-2024):** Daily print circulation fell 11% year-over-year, while digital sales grew 4% (Statistique Canada).
- **Global (Projected):** Print readership projected to fall from 2.1 billion (2017) to 1.1 billion (2030), with digital rising (Statista).

Continued Relevance of Print Books

- High demand for leisure reading and fiction
- Better readability and reduced eye strain
- Long-term preservation and archival value

Aspect	Before the Digital Era	After the Growth of E-Books	Impact on Print Books
Circulation	High borrowing rate	Reduced borrowing	Decline in circulation
User Preference	Print-oriented	Digital-oriented	Shift in reading habits
Library Footfall	High physical visits	Fewer visits	Reduced footfall
Accessibility	Limited copies	24/7 online access	Less dependency on print

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Aspect	Before the Digital Era	After the Growth of E-Books	Impact on Print Books
Academic Use	Textbooks & references	PDFs & e-books	Selective print use
Leisure Reading	Very high	Still high	Print remains relevant

User Preferences and Reading Behavior

- Students prefer e-books for quick reference and exam preparation
- Researchers use e-books for accessibility and search features
- General readers prefer print books for prolonged reading
- Senior users show a higher preference for print formats

Challenges for Libraries

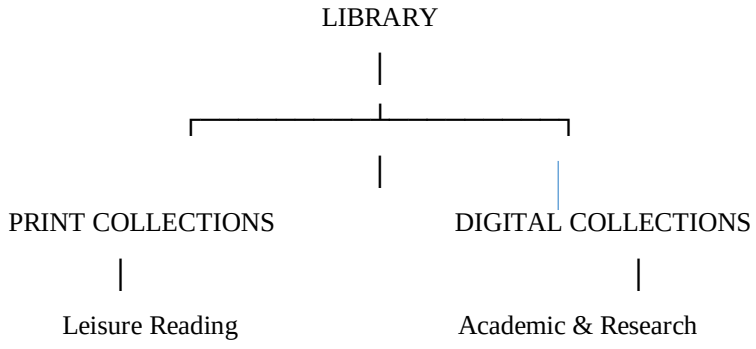
- Budget constraints and licensing costs
- Digital rights management (DRM) issues
- Technological infrastructure and training needs
- Preservation and long-term access to e-books

Role of Libraries in a Hybrid Environment

- Maintaining core print collections
- Expanding e-book access for academic needs
- User education on effective use of digital resources
- Data-driven collection development

Area	Library Role
Print Resources	Maintain core print collections
Digital Access	Expand e-book collections
User Support	Digital literacy training
Planning	Data-driven collection development

HYBRID LIBRARY



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Findings

- E-books have significantly influenced print book circulation, especially in academic libraries
- Print books are not obsolete, but are used differently
- User satisfaction increases when both formats are available
- Balanced collection development is essential

Suggestions and Recommendations

- Libraries should adopt a user-centered collection policy
- Regular assessment of circulation data should be conducted
- Print collections should focus on high-demand and archival materials
- Training programs should be provided for effective e-book usage

Conclusion

E-books have undeniably transformed library services and impacted traditional print book usage and circulation. While print book circulation has declined in certain areas, print resources continue to hold significant value. Rather than replacing print books, e-books complement them by offering alternative access modes. Libraries must embrace a balanced hybrid approach to ensure inclusive access to information and long-term sustainability.

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History of Library Science and the Transformation through Digital Technologies

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Abstract

From early record-keeping techniques to extremely complex digital information systems, library science has undergone a protracted process of intellectual and institutional growth. Libraries have served as hubs for scholarly communication, learning, and cultural preservation throughout history. The concept, organization, and services of libraries have all undergone significant change as a result of the development of digital technologies. This essay explores the influence of digital technologies on contemporary library operations and provides a thorough historical examination of library science. The evolving role of librarians, new issues, and the discipline's prospects in the digital era are also covered.

***Keywords*:** Library Science, Digital Transformation, Information Technology, Digital Libraries, Knowledge Management

Introduction

The interdisciplinary area of library science is concerned with gathering, organizing, preserving, and sharing knowledge. Libraries have constantly evolved to satisfy shifting intellectual and technological demands, from ancient civilizations to contemporary information cultures. Libraries used to be physical locations with printed books and manuscripts that catered to small user groups. However, the nature of information access and management has drastically changed due to the quick development of information and communication technology.

Libraries are increasingly dynamic information hubs with online services, electronic materials, and assistance for virtual learning thanks to the digital revolution. Examining the historical development of library science as well as the technological factors that have influenced its current state is necessary to comprehend this shift. In addition to analyzing how digital technologies have altered library science's theoretical and practical dimensions, this study attempts to give a thorough account of the field's historical growth.

Origins and Early Development of Libraries

Around 3000 BCE, the first libraries appeared in ancient Mesopotamia, where administrative and legal records were kept on clay tablets. Humanity's initial attempts at methodical knowledge preservation were reflected in these early collections (Rubin, 2016). Papyrus scrolls were kept in royal archives and temple libraries in ancient Egypt to support governmental and religious endeavours. The Library of Alexandria, founded in the third century BCE, was one of the most important ancient libraries. In keeping with the early ideas of universal knowledge organization, it sought to compile all known works of the world. Western librarianship was later impacted by the cataloguing and classifying techniques that were further developed in Greek and Roman libraries.

During the medieval period, libraries were largely concentrated within monasteries and other religious institutions, where the preservation and transmission of knowledge were considered sacred responsibilities. Scribes played a crucial role by meticulously copying manuscripts, thereby safeguarding classical and religious texts at a time when access to learning was highly restricted. Although these libraries were limited in size and reach, they provided an essential framework for intellectual continuity and scholarly tradition in Europe and parts of Asia.

Impact of the Printing Revolution

A pivotal moment in the history of libraries occurred when Johannes Gutenberg invented the printing press in the fifteenth century. Literacy, education, and intellectual activity all quickly increased as a result of the mass production of books (Johnson, 2018). Beyond places of worship, libraries are now found in public buildings, universities, and royal courts.

Systematic arrangement became crucial as collections expanded. During this time, classification methods, cataloguing guidelines, and bibliographic control gradually developed into essential elements of library science.

Emergence of Library Science as a Professional Discipline

The formal establishment of library science as a professional and academic field occurred in the nineteenth century. Public libraries were established with the goal of providing free access to knowledge for all citizens, especially in Europe and the US. To provide structured training for librarians, professional groups and library schools were established.

Information organization was transformed in 1876 when Melvil Dewey introduced the Dewey Decimal Classification. Reference services, cataloguing, and classification became common procedures. Modern librarianship in India has been greatly influenced by the work of S. R. Ranganathan. His Five Laws of Library Science placed a strong emphasis on adaptation and user-centred service, two ideas that are still very applicable in digital settings (Ranganathan, 1961).

Development of Traditional Library Services

Libraries concentrated on creating tangible collections and offering services like circulation, reference support, indexing, abstracting, and interlibrary lending during the 20th century. Librarians served as intermediaries between patrons and information resources, and libraries served as repositories of printed knowledge. But the exponential expansion of information led to problems with administration, retrieval, and storage, which eventually required the use of technology.

Introduction of Digital Technologies in Libraries

A new era in library science began with the use of computers in libraries in the 1960s. The initial automation initiatives were concentrated on circulation and cataloguing systems. Traditional card catalogues were superseded by Online Public Access Catalogues (OPACs), which provide quicker and more precise information search (Rowley, 2002).

Ownership-based collections gave way to access-based models with the advent of digital libraries. Through networked platforms, digital libraries offer electronic access to books, journals, theses, photos, and multimedia information (Arms, 2012). Initiatives for digitization also aid in the conservation of archival documents and rare manuscripts.

Libraries became international knowledge hubs as the internet became more widely used. Academic and research libraries now depend heavily on access to internet databases, e-journals, open educational resources, and institutional repositories (Borgman, 2007).

Transformation of Library Services

Almost every facet of library services has been transformed by digital technologies. Virtual platforms are now used to provide reference services, allowing for real-time communication beyond geographical borders. Hybrid library models that combine print and digital media are the outcome of collection development policies that place an increasing emphasis on electronic resources. These days, libraries actively foster research assistance, digital literacy, and information literacy. Users are taught how to assess the reliability of content, steer clear of plagiarism, and make efficient use of academic databases.

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Changing Role of Librarians in the Digital Age

Because of the digital revolution, librarians' roles have changed dramatically. These days, librarians serve as research facilitators, digital curators, metadata experts, and information managers. Managing institutional repositories, promoting open-access publishing, guaranteeing digital preservation, and handling ethical and copyright issues are among the duties (Rubin, 2016). As a result, routine technical work has given way to cognitively demanding information management and user education in librarianship.

Challenges of Digital Transformation

Despite advances in technology, libraries nevertheless confront several difficulties. High digital infrastructure costs, licensing limitations, copyright concerns, cybersecurity threats, and the digital divide between populations with and without access to information are some of these (Chowdhury, 2010). Due to the quick depreciation of technology, long-term preservation of digital content is still a major challenge.

Future Trends in Library Science

Emerging technologies, including artificial intelligence, cloud computing, big data analytics, and smart library systems, will continue to influence library science. Personalized information services and effective resource management are improved by these technologies. Libraries are evolving into cooperative learning environments that foster research, creativity, and lifelong learning.

Conclusion

The evolution of library science reflects a sustained process of adaptation to changing social contexts and technological innovations. From early manuscript repositories to contemporary digital knowledge platforms, libraries have continually transformed while upholding their core purpose of organizing, preserving, and disseminating knowledge. Rather than diminishing their significance, digital technologies have broadened the scope, accessibility, and societal relevance of libraries. A critical understanding of this historical transformation is therefore vital for designing resilient, inclusive, and future-ready library systems capable of responding to emerging information needs.

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Challenges Posed by Digital Resources: A Comprehensive Review of Literature and Its Societal Implications

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Abstract

The rapid increase of digital resources has profoundly changed how information is produced, accessed, preserved, and disseminated. These digital materials – from e-books and electronic journals to institutional repositories and open data platforms – have widened the availability of knowledge across geographical and socio-economic barriers. However, these benefits are accompanied by complex challenges involving accessibility, preservation, and copyright, reliance on technology, information overload, and social inequality. This paper offers a comprehensive review of the scholarly literature on the challenges posed by digital resources and explores their wider social implications. Through a qualitative literature review, the study synthesizes viewpoints from information science, computer science, and the social sciences. The findings indicate that while digital resources improve efficiency and democratize information access, they can also amplify problems like the digital divide, threats to content sustainability, ethical and legal uncertainties, and long-term preservation challenges. The paper concludes by highlighting the crucial role of libraries, information professionals, policymakers, and educational institutions in tackling these issues and advancing inclusive, ethical, and sustainable digital information ecosystems.

Keywords: Digital resources, Digital divide, Information society, Digital preservation, Knowledge access, Information ethics

Introduction

The digital revolution has dramatically transformed the information environment in contemporary society. Advances in information and communication technologies (ICTs) have driven a swift expansion of digital resources, such as electronic books, online journals, digital archives, multimedia content, databases, and open educational resources. These digital resources are now integral to education, research, governance, healthcare, and many aspects of daily life. They allow instant access to vast amounts of information, surpassing physical boundaries and the traditional constraints of print-based systems (Borgman, 2015).

However, this growing reliance on digital resources also raises significant concerns. Issues such as unequal access to technology, long-term preservation of digital content, copyright and intellectual property rights, authenticity of data, and ethical use of information have come to the fore. Furthermore, rapid technological obsolescence and dependence on proprietary platforms threaten the sustainability and reliability of digital knowledge systems (Chowdhury, 2016).

This paper aims to critically examine the challenges posed by digital resources through an extensive review of scholarly literature and to analyze the implications of these challenges for society. By placing digital resources within wider social, technological, and ethical contexts, the study contributes to ongoing discussions on the future of knowledge access and management.

Objectives of the Study

The main objectives of this paper are:

- To examine the nature and scope of digital resources in contemporary society.
- To identify major challenges associated with the creation, access, use, and preservation of digital resources.

- To analyze the societal implications of these challenges, particularly regarding equity, ethics, and sustainability.
- To highlight the role of libraries and information professionals in addressing these challenges.
- To propose strategic recommendations for building inclusive and sustainable digital information systems.

Research Methodology

This study employs a qualitative literature review approach. Scholarly articles, books, reports, and policy documents on digital resources were systematically examined. Sources were chosen from peer-reviewed journals in library and information science, information technology, and the social sciences. Key themes were identified through content analysis to synthesize and interpret existing research findings.

The chosen methodology emphasizes critical analysis over empirical measurement, making it well-suited for exploring conceptual, ethical, and societal dimensions of digital resources (Rowlands, Nicholas, & Huntington, 2007).

Concept of Digital Resources

Digital resources encompass information materials that are created, stored, accessed, and distributed in electronic form. Examples include e-books, e-journals, online databases, digital libraries, institutional repositories, multimedia files, and open data collections. Unlike traditional print materials, digital resources provide features such as searchability, interactivity, multimedia integration, and remote access (Tenopir, Volentine, & King, 2012).

The expansion of digital resources has been driven by initiatives such as open-access publishing, mass digitization projects, and national digital library programs. These developments have transformed the role of libraries from custodians of physical collections into facilitators of digital knowledge access.

Challenges Posed by Digital Resources

Digital Divide and Inequality

One significant challenge is the digital divide. Although digital technologies promise universal access to information, disparities in internet connectivity, device availability, and digital literacy persist across regions and social groups. As Smith (2019) observes, unequal access to digital resources often reinforces existing socio-economic inequalities rather than reducing them. Communities in rural areas, economically disadvantaged groups, and many older adults frequently encounter barriers to accessing digital information. With essential services and educational opportunities increasingly moving online, this digital exclusion becomes a pressing social concern.

Digital Preservation and Sustainability

Another critical challenge is the preservation and sustainability of digital content. Digital materials are inherently fragile; unlike printed works, they are vulnerable to technological obsolescence, format incompatibility, hardware failures, and software dependencies. The long-term preservation of digital information remains a major concern for libraries and archives (National Digital Preservation Coalition, 2015). As Chowdhury (2016) highlights, without sustainable preservation strategies, valuable digital content may be lost, creating gaps in cultural and scholarly records. Preserving digital resources requires ongoing investment in infrastructure, technical expertise, and policy development.

Copyright and Intellectual Property Issues

Copyright and intellectual property concerns pose additional challenges for digital resources. The ease of reproduction and distribution in digital form complicates traditional notions of copyright and ownership. Suber

(2012) notes that this can lead to unauthorized use, plagiarism, and disputes over content ownership. Moreover, publishers often impose restrictive licensing agreements that limit access and reuse, even for research funded by the public. These restrictions create difficulties for libraries, educators, and researchers who aim to provide equitable access to information while complying with legal frameworks.

Information Overload and Quality Concerns

The abundance of digital information leads to information overload, making it challenging for users to find and evaluate relevant, credible sources. As Lyman and Varian (2003) note, the sheer volume of digital content can overwhelm users and diminish the effectiveness of information seeking. Additionally, the proliferation of misinformation, disinformation, and low-quality content further complicates the digital environment. Consequently, strong information literacy skills are essential to navigate and assess digital resources effectively.

Ethical and Privacy Issues

Digital resources often involve the collection and analysis of user data, raising significant ethical concerns about privacy and surveillance. Floridi (2014) emphasizes that our digital "infosphere" is reshaping human behavior and social relations, which necessitates new ethical frameworks. Libraries and information providers must balance the benefits of personalized digital services with the protection of user privacy and intellectual freedom. In doing so, institutions can help ensure that digital systems respect individual rights and ethical standards.

Societal Implications of Digital Resource Challenges

The challenges of digital resources have broad societal implications. For example, unequal access to digital information undermines social inclusion and democratic participation, while failures in digital preservation threaten cultural heritage and the continuity of scholarship. Restrictions on access through copyright and licensing can limit educational opportunities, and ethical breaches in digital systems can erode public trust. Brown and Duguid (2017) argue that information systems are deeply embedded in social contexts, indicating that their impacts cannot be understood solely in technical terms.

Role of Libraries and Information Professionals

Libraries and information professionals are critical in addressing the challenges posed by digital resources. As trusted public institutions, libraries promote equitable access, digital literacy, and ethical use of information (Hjørland, 2018). Information professionals develop preservation strategies, negotiate licenses, and educate users about responsible digital practices. Initiatives such as institutional repositories, open-access programs, and digital literacy training demonstrate how libraries contribute to building sustainable digital knowledge ecosystems.

Recommendations

Based on the literature review, the following recommendations are proposed:

- Enhance digital infrastructure and connectivity to reduce the digital divide.
- Develop comprehensive digital preservation policies at both national and institutional levels.
- Encourage open-access initiatives and equitable copyright policies.
- Incorporate digital literacy training into educational curricula and public programs.
- Establish clear ethical guidelines for data use and privacy protection.

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Conclusion

Digital resources are now indispensable to modern society, offering unprecedented opportunities for accessing and disseminating knowledge. However, they also bring complex challenges related to equity, preservation, legal frameworks, and ethics. This review shows that addressing these challenges requires coordinated efforts by libraries, policymakers, educators, and technology providers. By adopting inclusive, ethical, and sustainable approaches, societies can harness the full potential of digital resources while safeguarding the public interest.

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Digital Libraries in the Digital Age: Pros and Cons

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ABSTRACT

Information and Communication Technology has revolutionized the concept of libraries. Every library is slowly getting digitized. A digital Library comprises digital collections, services and infrastructure to support lifelong learning subjects for students, Research Scholars, Faculty member's communication, as well as preservation and conservation of our recorded knowledge. It is also a process of democratization of information. This paper will discuss the factors that will necessitate the traditional libraries to get digitized, as well as the definition, need, advantages and disadvantages of digital libraries.

KEY WORDS: Digital Age, Electronic Resources (E-resources), Information and Communication Technology (ICT), Online Information Access, E-books and E-journals, Academic Libraries, Knowledge Management, Advantages and Disadvantages

INTRODUCTION

We are in the age of a networked society where IT, in addition to its use in all spheres of human activity, has been used extensively to record, store, and disseminate information in a digital form. IT has almost converted the world into a global village. The revolution in the IT sector is influencing the. If we consider that the information is for use and for all, then why not libraries for all? Why not make libraries universally open for all those who seek information? By considering this view, several large organizations in USA and Europe have already more or less switched over to digital mode. They are making digital images of periodicals, which are not available in electronic form, and thereafter, no new procurement is being made on print media if a digital version is available. An example of such an organization is University Micrographic Inc. (UMI of USA), National Institute of Scientific and Technical Information (INIST of France), etc.

THE DIGITAL LEARNING CENTRE

1. Easy to understand:

The visuals or graphical information system of digital libraries is more popular than the text-based information system.

2. Shifting of the environment:

The new generation user becomes happy when they are able to read from a computer screen.

3. Multiple functions of the same information:

In the case of digital libraries, by using hypertext, it is possible to structure and organize the same digital information in a variety of WATS, which serve multiple functions.

4. Information explosion:

A digital library is expected to be able to handle the problem of information explosion. It will be able to handle and manage a large amount of digital content by simply providing a link, without actually procuring the document.

5. Information explosion:

By using a digital library, one will be able to retrieve information specifically for e.g. a particular image, photo, a definition, etc.

6. Distance learning:

Learning from home, office or other places, which are convenient to the user end.

7. **To procure online publication**:

More and more information is going to be published over internet, digital media is needed to procure the online publication and to provide a link to important sources of information.

Pros of Digital Libraries

S. No	Subject	Descriptions
1.	Anytime, Anywhere Access	Electrical modern libraries enable users to access information 24/7 from anywhere, eliminating the limitations of library working hours and physical presence.
2.	Vast and Updated Resources	They provide access to a worldwide range of current and authoritative resources, including international e-journals, e-books, video and audio lecture e-theses and open-access materials that may not be available in print form.
3.	3 Space and Cost Efficiency	Digital resources reduce the need for physical storage space and minimize costs related to printing, binding, and physical maintenance of materials.
4.	Advanced Search and Retrieval	Users can quickly locate relevant information using keyword searches, filters, hyperlinks, and citation tracking, saving time and effort.
5.	Guide for Digital and Lifelong Learning	Digital libraries promote self-directed learning, online education, and continuous knowledge enhancement, which are essential in the digital learning ecosystem

Cons of Digital Libraries

S. No	Subject	Descriptions
1.	Digital Divide	Not all learners have equal access to devices, internet connectivity, or digital skills, which can limit the benefits of digital libraries.
2.	Technical Issues	System failures, Virus problem, software compatibility problems, and cybersecurity threats can disrupt access to resources
3.	Copyright and Licensing Restrictions	Many digital resources have access limits, subscription costs, or usage restrictions, which may affect availability for learners.
4.	Eye Strain and Health Concerns	Extended screen time can cause eye strain, fatigue, and reduced concentration compared to reading printed materials
5.	Lack of Physical Interaction	Digital libraries may reduce face-to-face interaction, collaborative learning, and the traditional library experience valued by some learners.

Infrastructure Requirements for a Digital Library

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1. Audio-Visual Equipment

Audio-visual tools are essential for accessing, creating, and delivering multimedia content in a digital library. Devices such as **Colour Television, VCR, DVD players, sound systems, and telephones** support audio and video-based learning materials. These tools help users access recorded lectures, documentaries, educational videos, webinars, and training programs. Audio-visual equipment enhances interactive learning and supports inclusive education by catering to different learning styles.

2. Computer Systems

Computers form the backbone of a digital library. A **server** stores digital content and manages user access, while **personal computers (PCs)** with multimedia capabilities allow users to browse, search, and download resources. **Uninterruptible Power Supply (UPS)** systems ensure continuous operation during power failures and protect data from sudden shutdowns. High-performance computers are necessary for digitization, data processing, and smooth access to large digital collections.

3. Network Facilities

Networking enables resource sharing and remote access in digital libraries.

- **LAN (Local Area Network)** connects computers within the library or institution.
- **MAN (Metropolitan Area Network)** connects multiple institutions within a city.
- **WAN (Wide Area Network)** allows connectivity across regions or countries.
  The **Internet** is the most important network component, providing access to online databases, e-journals, open-access resources, and cloud services. Efficient networking ensures fast, secure, and uninterrupted information flow.

4. Printers

Printers support documentation and user requirements for physical copies of digital content.

- **Laser printers** are used for high-quality, fast printing.
- **Dot matrix printers** are suitable for continuous forms and low-cost printing.
- **Barcode printers** help in labelling and managing library materials.
- **Digital graphic printers** are used for printing images, charts, and posters.
  Printers bridge the gap between digital and print resources.

5. Scanners

Scanners are vital for the **digitization of printed materials**.

- **HP Scanjet and flatbed scanners** are commonly used for books and documents.
- **Sheet feeder scanners** are suitable for bulk document scanning.
- **Drum scanners** provide high-resolution scanning for archival purposes.
- **Slide scanners** are used for digitizing photographs and slides.
  Scanners help preserve rare and fragile documents by converting them into digital formats.

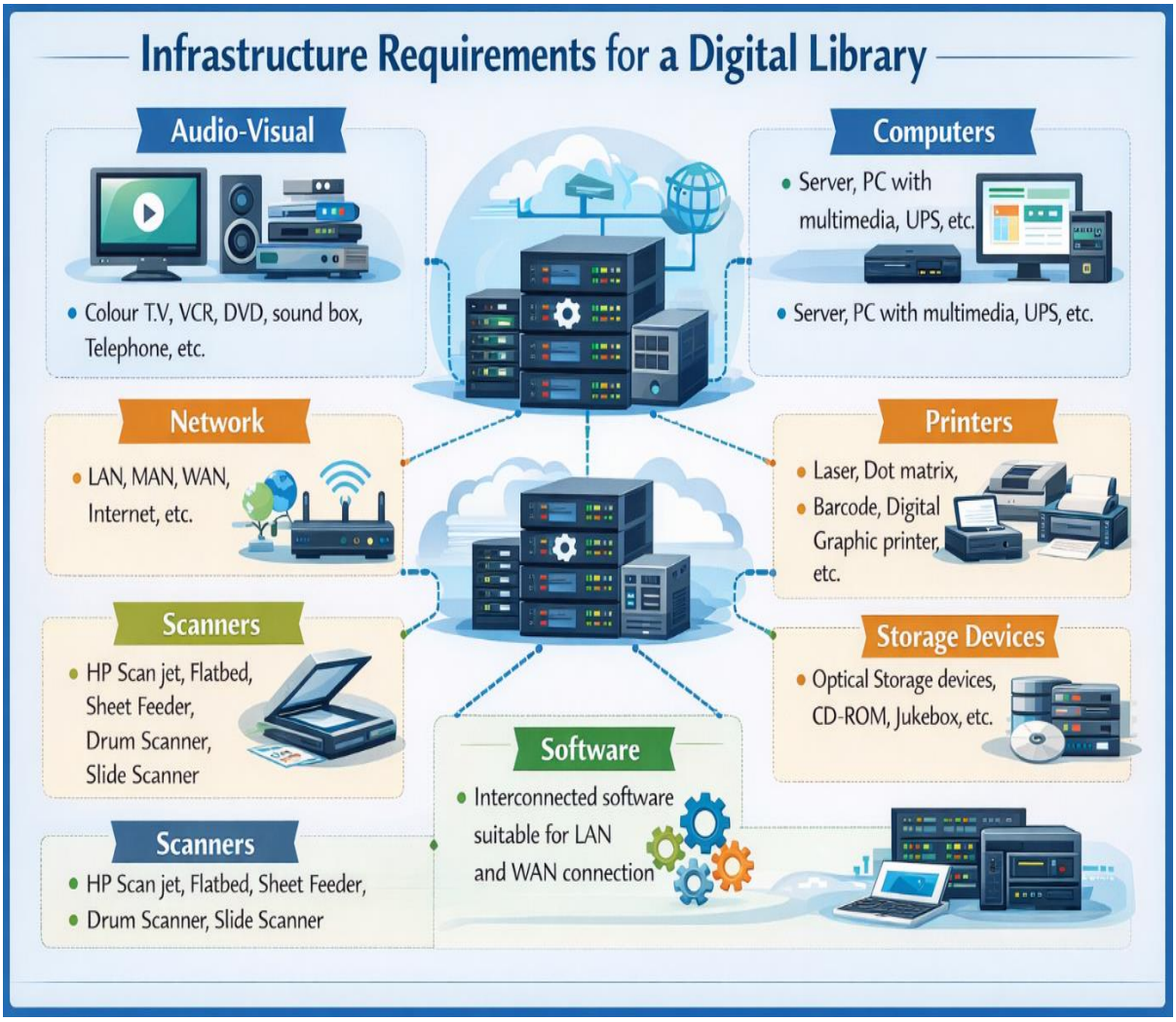
6. Storage Devices

Storage devices are required to store large volumes of digital data securely. **Optical storage devices**, **CD-ROMs**, and **jukebox systems** store e-books, journals, audio-visual files, and backup data. Modern digital libraries may also use network-attached storage (NAS) and cloud storage for

scalability, data security, and easy retrieval. Proper storage ensures long-term preservation and quick access to digital resources.

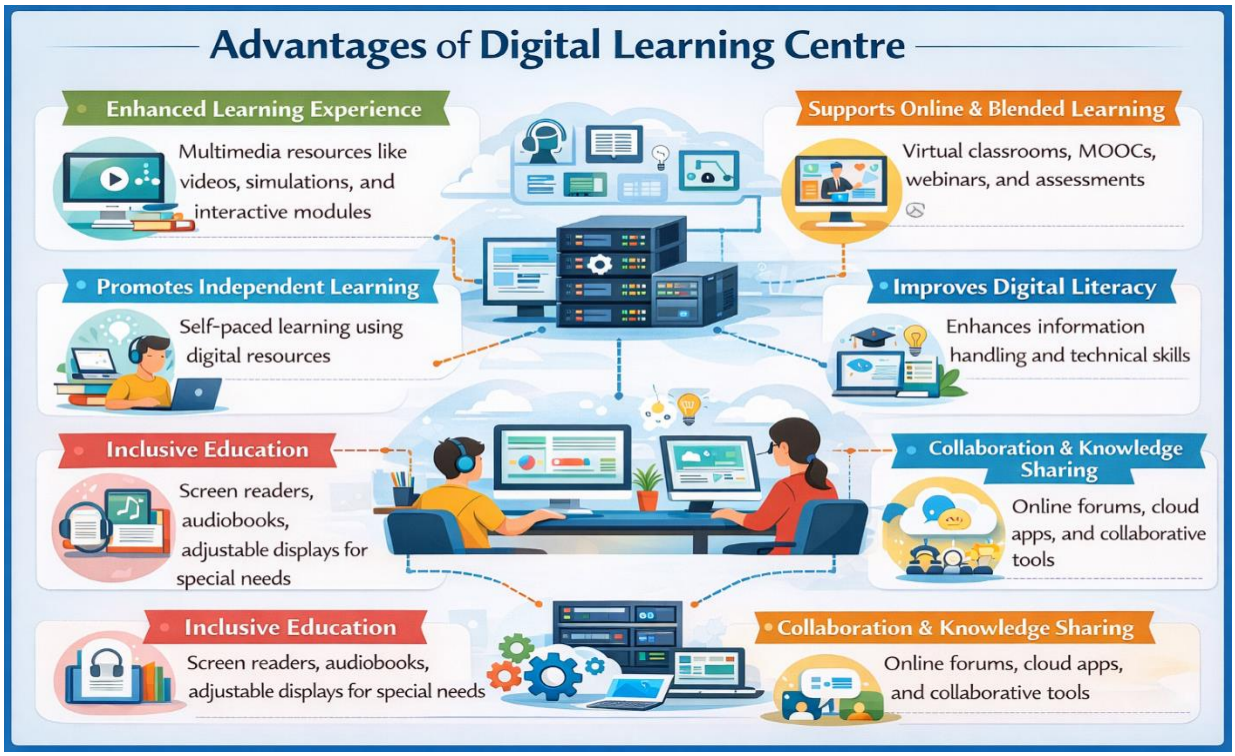
7. Software

Software acts as the operational framework of a digital library. Suitable library management software, database software, digitization tools, and content management systems are required. These software solutions must be **interconnected and compatible with LAN and WAN environments** to enable seamless data sharing, access control, indexing, and retrieval. User-friendly interfaces and secure authentication systems enhance efficiency and user satisfaction.



Advantages of the Digital Learning Centre

The **Digital Learning Centre** enhances learning by integrating **multimedia resources** such as videos, simulations, and interactive modules, which improve understanding and retention. It supports **blended and online learning** through virtual classrooms, MOOCs, webinars, and online assessments. The centre promotes **independent and self-paced learning** using digital resources and tools. Continuous use of technology improves **digital literacy and technical skills**. Access to **updated academic content** keeps learners informed about recent developments. It also supports **inclusive education** through assistive technologies like screen readers and audiobooks. Additionally, **collaborative tools and online forums** encourage teamwork, interaction, and knowledge sharing among learners.



Concept of Digital Library

1. Meaning of Digital Library

A **digital library** is an organized collection of information resources that are stored, managed, and accessed in **digital or electronic format**. It provides online access to e-books, e-journals, databases, multimedia content, theses, dissertations, and institutional repositories through computers and the internet.

2. Evolution of Digital Libraries

The concept of digital libraries emerged with the growth of **Information and Communication Technology (ICT)**, the internet, and digitization techniques. Traditional libraries have gradually transformed into hybrid and fully digital libraries to meet the growing demand for fast, remote, and updated information.

3. Digital Resources

Digital libraries include various types of resources such as **e-books, e-journals, online databases, audio-visual materials, images, research papers, and open-access resources**. These resources may be born-digital or converted from print formats through digitization.

4. Organization and Management

Digital libraries organize information using **metadata, indexing, classification, and database management systems**. Proper organization ensures easy storage, retrieval, and long-term preservation of digital content.

5. Access and Retrieval

Users can access digital library resources **anytime and anywhere** through networked systems. Advanced search tools, keyword searching, hyperlinks, and filtering options help users retrieve relevant information quickly and efficiently.

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6. Role in Education and Research

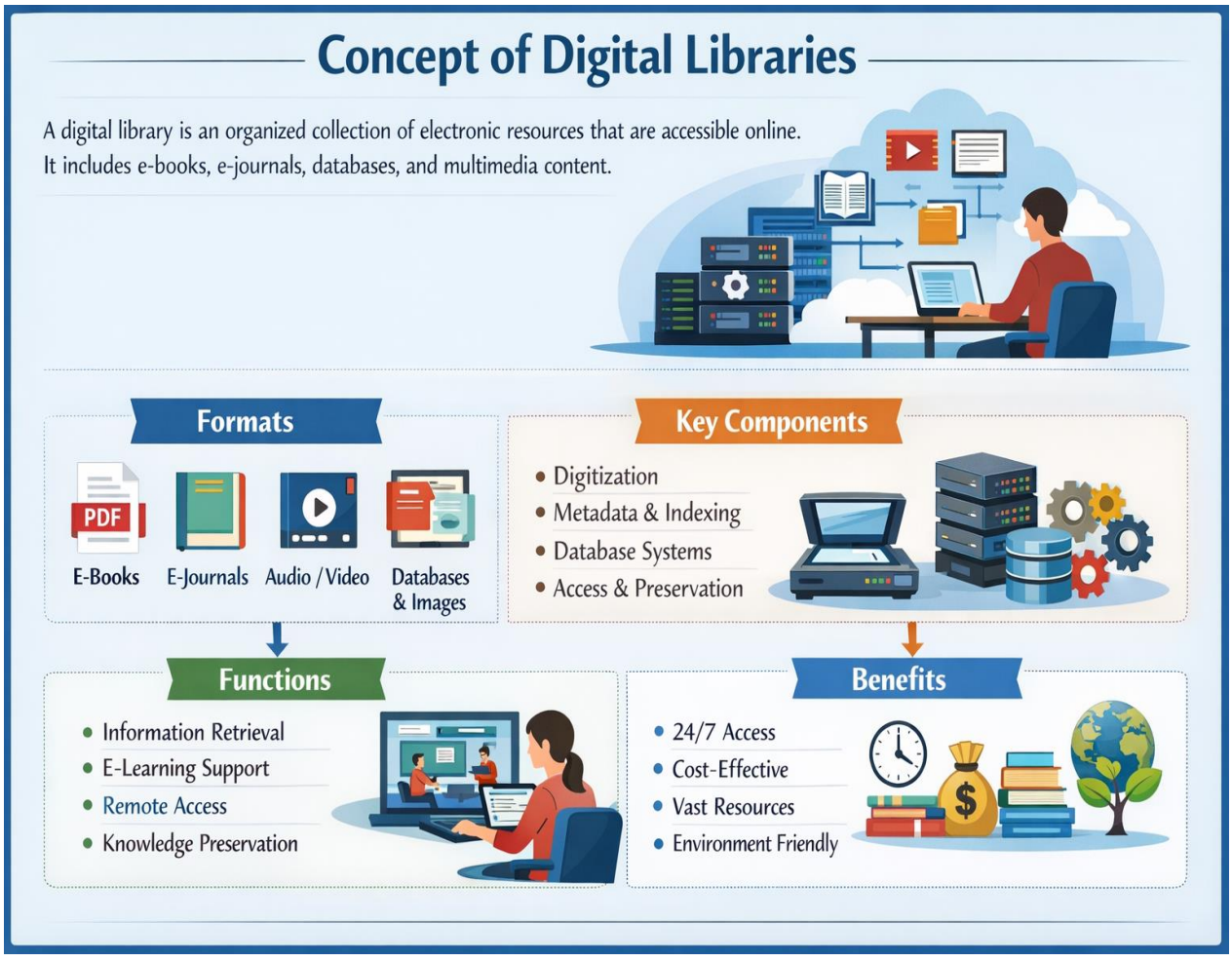
Digital libraries support **e-learning, distance education, blended learning, and academic research**. They provide updated scholarly information and research tools that enhance teaching, learning, and knowledge creation.

7. Preservation of Knowledge

One of the key concepts of digital libraries is the **preservation of rare, valuable, and fragile materials** in digital form. Digital preservation ensures long-term access and protects documents from physical deterioration.

8. User-Centered Services

Digital libraries focus on user needs by offering services such as **personalized access, remote login, assistive technologies, and collaborative tools**. These services improve user satisfaction and promote inclusive learning.



Methodology

Research Design

- Descriptive research method
- Quantitative and qualitative approach

Sources of Data

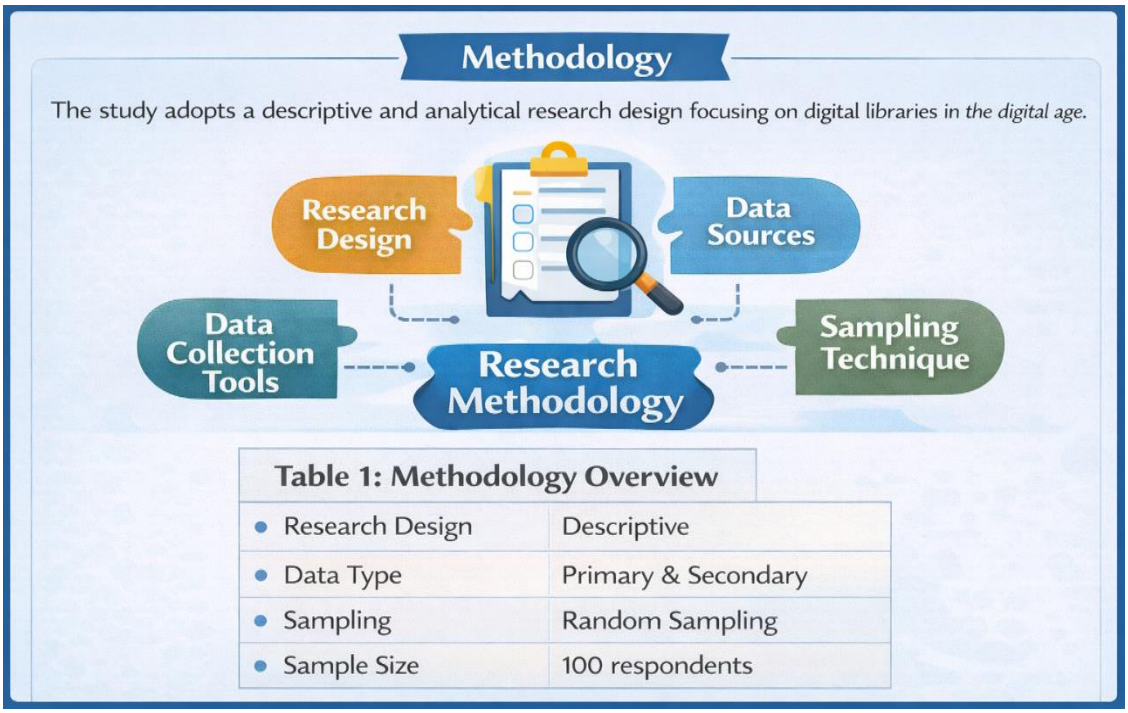
- **Primary Data**: Questionnaire and user feedback (students, faculty, librarians)
- **Secondary Data**: Books, journals, conference proceedings, reports, websites, and e-resources

Tools for Data Collection

- Structured questionnaire
- Observation method
- Review of published literature

Sampling Technique

- Random sampling
- Sample size: 100 respondents (students and faculty)



Methodology Overview

Aspect	Description
Research Design	Descriptive
Data Type	Primary ,Secondary and Tertiary
Sampling	Random Sampling
Sample Size	100 respondents
Tools Used	Questionnaire, Literature Review, research review

Findings of the Study

- Majority of users prefer **digital libraries for quick access** to information.
- **E-books and e-journals** are the most frequently used resources.
- Digital libraries support **self-learning and research activities**.
- Lack of awareness and technical skills is a major challenge.
- Reliable internet connectivity is essential for effective usage.

Review of Literature

Several studies have discussed the impact of digital libraries on education and research. **Borgman (2000)** highlighted that digital libraries provide global access to information and support collaborative learning. **Arms (2012)** emphasized that digital libraries improve information storage, organization, and retrieval through advanced technologies. **Singh and Kaur (2018)** found that students prefer digital libraries due to quick access to e-books and e-journals, especially for exam preparation and research work.

On the other hand, researchers have also pointed out certain limitations. **Sharma (2020)** identified challenges such as the digital divide, lack of technical skills, and copyright restrictions. **Ramesh (2021)** noted that dependence on internet connectivity and high initial setup costs can limit effective usage in some institutions. Overall, the literature reveals that while digital libraries offer significant advantages in accessibility, efficiency, and resource sharing, their successful implementation depends on proper infrastructure, training, and supportive policies.

Conclusion

Digital libraries have become an integral part of the modern education system. They provide easy access to vast and updated information resources, support online and blended learning, and promote independent learning. Despite challenges such as digital divide, technical issues, and copyright restrictions, digital libraries play a vital role in enhancing teaching, learning, and research. Proper infrastructure, user training, and supportive policies can ensure the effective utilization of digital libraries in the digital age.

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Digital Transformation's Impact on Library Innovation

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Abstract

Digital transformation has significantly transformed the library services as the libraries are now able to improve the service delivery, increase the accessibility of e-resources, and create more innovative information management systems. The paper explores the complex effects of digital transformation on academic and public libraries and the areas of innovation in service models, e-resource management, and information preservation strategies. The research reveals the major drivers of digital transformation, such as artificial intelligence, cloud computing, and integrated library management systems through the extensive literature review and analysis. The results show that libraries that have gone through the process of digital transformation are seen to be much more efficient in their operations, user experience, and they are also seen to achieve much more in preserving information. This study advances the knowledge of the digital technology transforming library functions in the information system and offers practical advice to librarians and institutional leaders going through digital transformation projects.

Keywords: Digital transformation, Library innovation, E-resource management, Information preservation, Library services, Artificial intelligence, Cloud computing, Integrated library systems, Digital libraries, Information technology

Introduction

Digital transformation signifies a significant change in how libraries perceive, design, and provide information services to various user groups. The emergence of digital technologies has fundamentally transformed the environment of library functions, compelling institutions to rethink conventional service frameworks and adopt creative strategies for knowledge management and dissemination. Libraries across the globe are under extraordinary pressure to upgrade their infrastructure, embrace new technologies, and develop value-added services that surpass physical limits. This transformation covers various aspects: operational effectiveness through automation, increased accessibility to digital resources, enhanced user experience via tailored services, and novel methods for information preservation and long-term accessibility. The convergence of artificial intelligence, cloud computing, big data analytics, and mobile technologies presents unparalleled opportunities for libraries to redefine their roles as guardians of knowledge and promoters of digital literacy. Grasping the ramifications of digital transformation on library innovation is essential for institutional strategizing, resource management, and development in modern information ecosystems. This article presents a thorough analysis of how digital transformation shapes library innovation, scrutinizing essential domains such as service innovation, e-resource administration, technological frameworks, and preservation strategies.

Literature Review

Luo (2018) discussed the impact of digital transformation on the services offered by libraries through the integration of new technologies like cloud computing and digital platforms. The research has indicated that technological innovation improves the efficiency and interaction of services. It has underlined the fact that libraries that are strategically pursuing the utilization of digital tools are in a better position to accommodate contemporary learning conditions. Another aspect that was observed by the author is the necessity to align innovation with institutional goals.

Khan and Rafiq (2019) ventured into the issue of digital transformation and its association with fostering innovation in academic libraries. They have found out that digital systems enhance access to e-resources and facilitate knowledge sharing. The research emphasized that effective digital innovation requires

organizational preparedness and digital competencies of its staff. It concluded that libraries should equally invest in technological and human capital.

Breeding (2021) emphasized the role played by digital technologies on the library infrastructure and innovation of the services. The researcher concluded that libraries can provide data-driven and user-focused services with the help of automation, artificial intelligence, and advanced analytics. It also brought forward such issues as privacy, data security, and ethical issues. The author pointed out that a balanced and responsible use of technologies cannot be ignored.

IFLA (2022) has addressed the views of the global community on digital transformation and innovation in libraries. The report revealed that digital transformation increases the ability of libraries to serve research, education, and cultural preservation. It has stressed the importance of collaboration, collective digital platforms, and policy designs to the sustainability of innovation. The research paper concluded that the digital transformation enhances the role of libraries in providing equal access to information.

Digital Transformation: Drivers and Technologies

Artificial Intelligence and Machine Learning Applications

The use of artificial intelligence technologies is transforming library processes with automatic cataloguing, a smart search template, and tailored suggestions to users. The use of machine learning applications can examine the behavior patterns of users, anticipate information requirements, and refine the decisions on resource allocation depending on usage data. The processing of natural language allows searching more by advancement in the facilities of library systems, as one can query the system with natural language and not with controlled vocabulary. AI-based chatbots also offer real-time customer support by answering popular queries and referring users to the relevant materials or librarians. The apps of predictive analytics aid libraries in predicting the need of resources, maximize the building of collections, and make evidence-based choices on the use of space and service provision.

Cloud Computing and Infrastructure Transformation

The library management systems, which are hosted on clouds, are scalable, accessible and cheaper in contrast to traditional on-premise systems. Cloud services allow libraries to deploy an integrated system of acquisition, cataloguing, circulation, analytics, and patron services on a common infrastructure. Cloud providers offer a strong infrastructure and service level agreements, which increase disaster recovery, business continuity, and data security. SaaS models also save time and technical expertise needed to implement them; hence, libraries are able to quickly implement complex solutions. The hybrid cloud architecture enables libraries to strike a balance between control and cost-related issues, keeping sensitive institutional data within their own datacenters and using cloud services to scale their applications.

Data Analytics and Evidence-Based Decision Making

The more sophisticated analytics can help libraries to turn raw operational data and usage data into actionable information to drive the strategic decision-making process. The data visualization tools enable an effective presentation of multifaceted information patterns to the stakeholders, making it easy to understand and support the conversations related to the allocation of resources. The comparison with peer institutions helps libraries to put their performance in perspective and find areas of improvement. Predictive analytics can facilitate scenario planning and strategic prognostication, and facilitate proactive, rather than reactive, decision-making. Privacy-saving analytics methods allow advanced analysis at the same time, guaranteeing the privacy and confidentiality of patients and institutional data.

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Impact on Library Innovation

Service Model Innovation

Digital transformation facilitates the library in creating innovative service models that can be used in meeting the current information requirements. Online research consultations, virtual reference services, and instructing digital literacy do not require a physical location. Libraries become innovation centers within their localities, through their makerspaces, digital media labs and collaborative learning environments. Embedded librarian programs, embedded within the academic curriculum and organization processes, make libraries more visible and relevant. Open educational resources programs tap into the experience of libraries to facilitate access to learning resources at low costs. The community engagement programs use digital platforms to engage and create content with communities, as well as raise awareness.

User Experience Enhancement

Digital technologies essentially change the interactions of users with library systems and collections. All discovery services allow access to different resources in one point and cut down on fragmented search results, enhancing the efficiency of the users. Mobile applications can develop services for smartphones and tablet devices, which are available anywhere and anytime with access to collections and services. The functions of personalization, which rely on the user profile, search history, and preference data, generate customized experiences that increase relevance and satisfaction. The accessibility is provided through such features as screen readers, high-contrast interfaces, and multilingual features to provide inclusive access to various user groups. Constant service improvement is performed by user-centered design processes with feedback of actual users.

Operational Efficiency and Cost Management

The routine processes will be automated to minimize the number of man-hours and number of mistakes in routine processes, and the staff can concentrate on the activities that are of high value. Integrated systems eliminate communication gaps and redundancies between departments in the optimization of workflow. Resource scheduling systems are the ones that maximize the use of physical and human resources. Evidence-based decisions minimize wastes and enhance efficiency in allocations. Sharing services and common platforms spreads costs among several institutions.

E-Resources and Digital Collection Management

Strategic E-Resource Acquisition and Assessment

Digital transformation facilitates the use of more advanced methods of e-resource choice, purchase, and assessment. Acquisition is determined by evidence-based selection criteria based on the usage data, peer recommendations, and how the acquisition aligns with the institutional priorities. The process of negotiation of licenses also includes the accessibility requirements, perpetual access and the open access efforts. Return-on-investment and cost-per-use measures are used to make decisions on retaining resources. Discovery and assessment tools can highlight the patterns of usage behavior within various groups of users and across different fields. A combination of institutional repositories and open access programs equalises commercial and open access resources.

Access and Interoperability Solutions

Federated search and unified discovery systems allow smooth access to heterogeneous collections of e-resources. Link resolvers and OpenURL resolvers give users access to full text by connecting citations to full text, increasing discoverability. Integrations based on API allow libraries to integrate resources in learning management systems and research processes. Resource discovery and interoperability are enabled by standards

compliance, such as MARC, Dublin Core and BIBFRAME metadata standards. The access is increased by cross-institutional resource sharing via library consortia and cooperative agreements.

Open Access and Open Educational Resources

Digital transformation enhances the library's support for open access and open educational resources movements. Institutional repositories offer a medium through which they capture, preserve, and disseminate scholarly works of researchers attached to the institutions. Open education programs help faculty to create and embrace the use of freely available learning materials. Licensing and copyright are used to negotiate complicated intellectual property cases. The call to open science and the reform of scholarly communication represent library functions in the wider transformation of the research ecosystem.

Information Preservation and Long-term Sustainability

Digital Preservation Infrastructure and Standards

Full-scale digital preservation necessitates a strong technical infrastructure and the need to follow the standards and best practices. Being a record of information regarding resource origin and history of transformation, and technical traits, preservation metadata allows interpretation and accessibility in the future. Format migration approaches ensure that the content is not lost when changing the technology to newer versions; the materials are converted to the new formats without loss of authenticity. Preservation planning and risk assessment systems identify vulnerable collections and set priorities on preservation activities. The concept of preservation at scale is carried out in distributed preservation networks and trusted digital repositories.

Digitization Initiatives and Born-Digital Materials

Unique and rare collections can be digitized to make them more accessible and preserve the fragile originals. Standards of digitization provide the quality and consistency of large-scale projects. The born-digital materials, such as electronic theses and digital scholarship and research data, must be planned to be preserved upon creation. Research data repositories are data provided to support curation, preservation and sharing of research outputs. More Bit preservation and fixity checking identify corruption and guarantee the integrity of data over time. Our collaborators and partners will collaboratively develop the preservation models with them as well

Collaborative Preservation Models

The process of long-term preservation of the collections in the individual libraries cannot be achieved in the case of the whole collection; collaboration techniques share the burden and resources. Resource pooling Library consortia share resources on infrastructure and expertise on preservation. Trusted Digital Repository (TDR) models provide guidelines to the preservation service providers. Redundancy ensures that dark archives and copies in different geographical locations will avoid loss. Collaboration with national libraries and preservation groups would utilize specialized knowledge.

Challenges and Considerations

Technical and Financial Barriers

Digital transformation infrastructure can be costly in terms of capital and can overstretch institutional budgets. Continued costs of operation of cloud services, renewals of licenses, and training of employees are also recurrent costs. Old systems might not be compatible with the new digital systems and can only be replaced (at high cost) or integrated through a custom solution. Infrastructure: The cybersecurity and adherence to data protection laws require regular investments. The access of libraries to the resources of digital transformation is especially problematic for small libraries and rural libraries.

Organizational and Workforce Considerations

The tendency of staff to resist the change due to fears of the impacts of automation on the employment conditions calls for the need to change the change process carefully and communicate effectively. Huge investments in training will be needed to achieve technological competencies among the library employees. It is not easy to retain old, experienced librarians when there is a change in the organization. Hiring of technologically advanced candidates is competitive and expensive. This is because professional values and user focus in a rapidly changing technological environment need to be managed through deliberate organizational culture management.

Privacy, Security, and Ethical Dimensions

Analytics and personalization associated with collecting user data at a detailed level provoke privacy concerns and need effective data governance systems. Cybersecurity threats as ransomware, phishing, and unauthorized access, demand significant expenditure on security infrastructure. The AI systems are prone to algorithmic bias, which can reinforce historical inequalities in accessing information. The problems of the digital divide imply that digital transformation efforts do not equally apply to all users. Organizational policies on ethical questions that need to be considered include information on data ownership, the transparency of the algorithms, and the autonomy of the users.

Findings and Recommendations

Findings

- Libraries implementing comprehensive digital transformation demonstrate significantly improved operational efficiency, reduction in manual processing time through workflow automation and integration of systems.
- User satisfaction with library services increases by following digital transformation implementation, particularly regarding accessibility and personalized services.
- E-resource utilization increases substantially when libraries implement unified discovery platforms and personalized recommendation systems.
- Staff engagement and innovation capacity increase when organizations invest substantially in training, provide clear change management communication, and create cultures supporting experimentation.
- Collaborative approaches to digital transformation and preservation enable smaller institutions to achieve outcomes comparable to larger, better-resourced libraries.

Recommendations for Library Leaders

- Develop comprehensive digital transformation strategies aligned with institutional missions and user needs. Establish governance structures with clear accountability, decision-making authority, and resource allocation mechanisms. Involve diverse stakeholders—including librarians, IT professionals, administrators, and users—in strategy development and implementation oversight.
- Implement digital transformation through phased approaches that balance ambitious long-term vision with achievable short-term wins, building momentum and demonstrating value. Prioritize high-impact initiatives with clear benefits and manageable complexity. Use early successes to build organizational support for subsequent phases.
- Invest substantially in staff training and professional development, providing opportunities for librarians to develop technological competencies while maintaining focus on professional values. Implement comprehensive change management programs, including clear communication, stakeholder engagement, and feedback mechanisms. Address staff concerns regarding automation impacts through transparent discussion and redeployment opportunities.
- Adopt user-centered design principles, systematically incorporating user feedback into service development. Establish mechanisms for ongoing assessment and improvement, utilizing analytics to

identify enhancement opportunities. Create feedback loops connecting user insights to product development and service refinement.

- Pursue collaborative partnerships with peer institutions, consortia, and service providers to distribute costs and leverage collective expertise. Investigate shared services and outsourcing opportunities that enable access to sophisticated solutions while managing costs. Participate in standards-setting and best practice communities
- Plan digital transformation as an ongoing evolution rather than a project with a defined endpoint. Allocate resources for continuous infrastructure updates, security patches, and staff development. Monitor technological developments and organizational capacity, adjusting strategies to maintain alignment.

Conclusion

The process of digital transformation has made it indispensable that libraries become relevant in the changing information environments. The implementation of digital technologies strategically improves efficiency of operations, users' experiences, and access to electronic resources, as well as information sustainability. Achieving change requires an organization to be ready, have skilled human resources, sufficient resources, and a strategic vision. The new technologies of artificial intelligence and cloud computing have enormous potential but need closer consideration of the ethical, privacy, and security issues. Sharing and dynamic strategies are essential to control the increasing complexity of the digital infrastructures. Finally, digital transformation reinforces the main purpose of libraries, namely, the provision of equal access to knowledge, learning, and the maintenance of cultural heritage.

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Digital Transformation in Academic Libraries: An Overview

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Abstract

Digital transformation has significantly reshaped academic libraries by redefining traditional services and integrating advanced technologies for effective information access, organization, and dissemination. The rapid growth of electronic resources, library automation, wireless communication technologies, and artificial intelligence has substantially influenced user behavior and expectations within higher education institutions. This study adopts a descriptive literature review methodology, analyzing relevant scholarly publications to identify major trends, technological advancements, challenges, and future directions of digital transformation in academic libraries. The review highlights the increasing emphasis on user-centered collection development, the expansion of digital and mobile-based library services, and the role of national-level digital initiatives in India, in strengthening academic library infrastructure. It also emphasizes the growing integration of artificial intelligence in information discovery and service delivery, indicating a shift toward personalized and intelligent library systems. Despite these developments, challenges such as inadequate ICT skills, financial constraints, copyright issues, resistance to change, and digital preservation concerns persist. The study concludes that sustainable digital transformation requires balanced strategies combining technology, professional development, institutional support, and continuous user engagement.

***Keywords**:* Digital transformation, Academic libraries, Library automation, E-resources, Artificial intelligence, Digitization, Digital initiatives in India.

Introduction

Academic libraries are integral to higher education institutions, supporting teaching, learning, and research activities. Traditionally, these libraries functioned primarily as repositories of printed books, journals, and on-site reference services. However, advances in information and communication technologies (ICT) have fundamentally altered the structure and functioning of academic libraries, enabling wider access to digital resources, online databases, automated systems, and networked information services.

Digital transformation in academic libraries extends beyond the digitization of collections or the automation of routine processes. It represents a comprehensive shift in library operations, service delivery models, collection development practices, and organizational culture. Contemporary users increasingly demand immediate access to information, intuitive digital platforms, and personalized services aligned with their academic requirements. In response, academic libraries are transitioning from collection-centered models to user-centered and service-oriented frameworks.

Recent developments in wireless communication technologies, mobile applications, institutional repositories, artificial intelligence, and large language models have further accelerated this transformation. While these technologies have enhanced information access and service efficiency, academic libraries—particularly in developing countries—continue to face challenges related to infrastructure, financial constraints, digital literacy, and sustainability. In this context, a systematic review of recent literature is necessary to examine current trends, technological developments, challenges, and future directions of digital transformation in academic libraries. This paper synthesizes recent studies published primarily between 2024 and 2025, along with selected foundational literature, to provide an overview of digital transformation in academic libraries.

Review of Literature

Shimray, Subaveerapandiyan, et al. (2025) examined digital transformation in academic libraries with particular reference to e-resources, OPACs, and artificial intelligence. Their study revealed a declining dependence on traditional OPAC-based discovery systems, as students increasingly prefer electronic resources and AI-enabled tools for information retrieval. The findings indicate that clarity, ease of access, and user convenience are key factors influencing user preference, suggesting a fundamental change in information-seeking behavior in academic environments.

Gunarathna (2024) investigated student satisfaction with physical and digital library facilities in higher education institutions. The study emphasized that users prioritize relevance, accessibility, and usability over the sheer volume of resources. Rather than indiscriminate expansion of collections, the research emphasized the importance of curated and need-based collection development. This study reinforces the argument that user requirements should guide digital transformation rather than technological abundance alone.

Ranavagol, Patil, and Nijaguna (2024) conducted a systematic review on wireless communication technologies and their applications in library services. The study discussed the implementation of technologies such as Radio Frequency Identification (RFID), Near Field Communication (NFC), mobile technologies, and personal digital assistants in academic libraries. While these technologies were found to enhance operational efficiency, circulation management, and user interaction, the authors identified significant challenges, including lack of ICT skills among library professionals, financial constraints, and resistance to technological change from both staff and users.

Mulani (2024) explored digitization in libraries by analyzing trends, challenges, and future perspectives. The study identified major trends such as digitization of collections, development of online catalogs and databases, establishment of institutional repositories, growth of the open access movement, and integration of multimedia content. The research also highlighted challenges related to technical infrastructure, cost, copyright issues, digital preservation, and inclusivity. Future directions emphasized the growing role of artificial intelligence, machine learning, blockchain technologies, and immersive tools such as virtual and augmented reality in library services.

Raja et al. (2024) examined digital transformation in academic libraries with a particular focus on developments in India. The study discussed digital transformation across multiple dimensions, including library automation, digital library services, digital reference services, and resource digitization. It further highlighted national-level digital initiatives such as INFLIBNET services, DELNET resource sharing, institutional repositories, and government-supported digital education platforms. The authors emphasized that coordinated national initiatives play a crucial role in strengthening academic library infrastructure and promoting equitable access to information.

Soni (2023) examined the challenges associated with digital transformation in libraries, including outdated infrastructure, access inequality, and organizational resistance. The study emphasized the importance of collaboration, agile management practices, and user-centered design as effective strategies for managing digital transformation in library and information science institutions. These more recent strategic perspectives have shifted attention from individual digital services to holistic digital transformation.

Alongside these recent studies, earlier research provides essential context for understanding the evolution of digital services in academic libraries.

Chowdhury and Margariti (2004) analyzed digital reference services in Scottish academic libraries and found email-based reference services to be the most widely used and effective mode of digital interaction.

In the Indian context, **Maharana and Panda (2005)** examined virtual reference services in institutions such as IITs and IIMs, noting that while adoption was still emerging, digital reference services showed significant potential for future growth. Such studies focused on the development of digital reference services in academic libraries across different regions.

Yasui (2006) reported the presence of online information assistance services in Japanese university libraries, while **Nicholas (2010)** examined trends and usage of digital reference services in Jamaican academic libraries. Studies conducted in developing countries emphasized the role of digital reference services in overcoming geographical and infrastructural limitations (Abu Bakar, 2011; Baro, Efe, & Oyeniran, 2014). These international studies further demonstrated the global adoption of digital reference services.

Objectives of the Study

The specific objectives of the study are

1. To examine the concept and scope of digital transformation in academic libraries.
2. To identify major trends and technological developments influencing digital transformation in academic libraries.
3. To analyze changes in user behavior and information-seeking patterns in academic libraries in the digital environment.
4. To examine the role of national-level digital initiatives in India in supporting academic library transformation.
5. To identify key challenges faced by academic libraries in the process of digital transformation.
6. To explore future directions and strategic approaches for achieving sustainable, inclusive, and user-centered digital transformation in academic libraries.

Methodology

This study adopts a descriptive literature review methodology based entirely on secondary sources. The review focuses on scholarly works addressing digital transformation in academic libraries, with particular attention to recent developments in technologies, services, challenges, and future directions.

Background and Significance of the Study

The concept of digital transformation has gained substantial importance in the field of library and information science due to rapid technological advancements and evolving user expectations in higher education. While earlier initiatives in libraries largely focused on digitization, i.e., the conversion of physical resources into digital formats, and digitalization, involving the use of digital tools to automate and enhance existing services, contemporary academic libraries are undergoing digital transformation, which represents a broader and more strategic shift. Digital transformation encompasses not only technological adoption but also organizational restructuring, service reorientation, policy integration, and a transition toward user-centered and data-driven library ecosystems.

Academic libraries are no longer perceived merely as custodians of printed collections; they have evolved into dynamic knowledge hubs that facilitate seamless access to digital information, support research and learning workflows, and promote information and digital literacy. The expansion of online and blended learning environments, particularly in the post-COVID-19 era, has further intensified the demand for robust digital library infrastructures, intelligent discovery systems, and flexible service delivery models.

The significance of the present study lies in its focus on recent scholarly literature published during 2024–2025, which captures contemporary developments in digital transformation within academic libraries. While earlier studies primarily addressed automation and basic digitization, recent research emphasizes advanced dimensions such as artificial intelligence, wireless communication technologies, integrated library platforms, user experience, and strategic digital governance. By synthesizing current research findings, this paper provides updated insights relevant to librarians, educators, policymakers, and researchers engaged in academic library planning and development.

In the Indian context, digital transformation of academic libraries has been strongly influenced by government-led digital initiatives and national knowledge infrastructures. Programs and platforms supporting digital libraries, open educational resources, institutional repositories, research visibility, and interlibrary cooperation have collectively contributed to strengthening academic library services across the country. Understanding these initiatives within a broader digital transformation framework is essential for developing sustainable, inclusive, and future-ready academic libraries that align with national educational and research priorities.

Trends and Technological Developments in Academic Libraries

Recent literature reveals that academic libraries are undergoing a multidimensional transformation shaped by technological innovation, evolving user expectations, and institutional demands for efficiency and accessibility. One of the most significant trends is the gradual shift from traditional print-dominated collections to digitally enriched and technology-driven information environments. The rapid growth of electronic resources, online databases, and institutional repositories has reduced reliance on physical collections and expanded access to scholarly content beyond the physical boundaries of libraries.

A prominent trend identified across recent studies is the movement toward **user-centered library services**. Academic libraries are increasingly prioritizing relevance, ease of access, and usability over the sheer volume of resources. This shift reflects changing information-seeking behavior among students and researchers, who expect seamless and intuitive digital interfaces. Studies indicate that well-curated digital collections aligned with academic needs enhance user satisfaction and engagement, reinforcing the importance of quality-focused collection development in digital environments.

Another major technological development is the integration of **wireless communication technologies** in library operations and services. Technologies such as Radio Frequency Identification (RFID), Near Field Communication (NFC), and mobile-based applications are widely adopted to improve circulation management, security, inventory control, and user interaction. These technologies enable faster service delivery, reduce manual workload, and support self-service models, thereby enhancing operational efficiency. Mobile access to catalogs, notifications, and digital resources has further extended library services beyond physical spaces, positioning academic libraries as flexible and responsive information centers.

The transformation of information discovery systems represents another key trend in academic libraries. Traditional **OPAC**-based search systems are gradually losing prominence as users increasingly rely on electronic resources and intelligent discovery tools. Artificial intelligence-driven systems, including recommendation engines and natural language-based search interfaces, are reshaping how users locate and evaluate information. Recent studies suggest that users prefer AI-assisted tools for their clarity, speed, and personalized search capabilities, indicating a shift toward more intuitive and user-friendly discovery platforms.

Digitization of library resources continues to be a basic component of digital transformation. To improve preservation and accessibility, academic libraries are actively engaged in digitizing rare collections, theses, dissertations, and institutional research outputs. The establishment of institutional repositories and support for

open access initiatives have enhanced research visibility and facilitated global knowledge sharing. Integration of multimedia and interactive content has further enriched learning experiences, particularly in digital and blended learning environments.

Artificial intelligence is emerging as a transformative force in academic libraries, extending beyond information retrieval to support reference services, user analytics, and personalized recommendations. AI-powered chatbots and virtual assistants are increasingly used to provide round-the-clock reference support, while machine learning techniques assist in content organization and usage analysis. These developments signal a transition from technology-assisted services to intelligence-driven library ecosystems.

Digital Initiatives in India

National-level digital initiatives and government-supported knowledge infrastructures significantly shape digital transformation in academic libraries in India. Unlike institution-driven transformation observed in some developed contexts, Indian academic libraries have benefited from centralized platforms aimed at improving access, resource sharing, and digital capacity across higher education institutions.

The **INFLIBNET** (Information and Library Network) Centre has played a pivotal role in advancing digital transformation by supporting library automation, facilitating access to electronic resources, and strengthening scholarly communication. Services such as the UGC-Infonet Digital Library Consortium, N-LIST, Shodhganga, and ShodhGangotri have enhanced access to scholarly journals, e-books, theses, and research outputs, thereby improving research visibility and academic productivity. Similarly, DELNET has contributed to interlibrary cooperation and resource sharing through networked services, reducing duplication of resources and promoting collaborative access.

National digital platforms such as the **NDLI** (National Digital Library of India), institutional repositories, and open educational resource initiatives have further expanded digital access to academic content. The adoption of library automation software such as SOUL and the growing integration of digital reference services reflect a broader shift toward technology-enabled service delivery. However, the extent of digital transformation varies across institutions due to differences in infrastructure, funding, and digital literacy. While leading institutions have adopted advanced digital systems, many colleges continue to face challenges in achieving full-scale digital transformation. Nevertheless, coordinated national initiatives have laid a strong foundation for sustainable and inclusive digital development of academic libraries in India.

Challenges in Digital Transformation of Academic Libraries

Despite the growing adoption of digital technologies and innovative service models, academic libraries face numerous challenges in the process of digital transformation. These challenges are multifaceted, encompassing technological, financial, organizational, legal, and user-related dimensions. The literature consistently indicates that digital transformation is not a linear or uniform process, particularly across institutions with varying levels of resources and preparedness.

One of the most significant challenges identified in recent studies is the **lack of adequate information and communication technology (ICT) skills among library professionals**. Effective implementation and management of advanced technologies such as wireless communication systems, digital repositories, and artificial intelligence require specialized technical competencies. However, many library professionals have limited exposure to ongoing training and professional development opportunities. This hinders their optimal use of digital systems. The skills gap becomes more pronounced as libraries adopt increasingly complex technologies, making capacity building a critical concern.

Financial constraints represent another major barrier to digital transformation in academic libraries. The cost of acquiring, implementing, and maintaining digital infrastructure, including hardware, software licenses, network systems, and cybersecurity measures, can be substantial. Institutions with limited funding often struggle to sustain digital initiatives, resulting in uneven levels of technological advancement across academic libraries. Inadequate financial support also affects staff training, system upgrades, and long-term digital preservation efforts.

Technological and infrastructural challenges further complicate digital transformation efforts. Many academic libraries face issues related to outdated hardware, limited network bandwidth, system incompatibility, and unreliable power supply. Ensuring seamless integration of new technologies with existing library systems remains a persistent difficulty. Additionally, rapid technological obsolescence requires continuous system upgrades, placing further strain on institutional resources.

Legal and copyright-related issues pose significant challenges in the digital environment. The digitization of resources, provision of electronic access, and use of digital content are governed by complex copyright laws and licensing agreements. Academic libraries must balance the need for wider access to information with legal compliance. Legal compliance often restricts the extent of resource sharing and digitization. Managing intellectual property rights and ensuring ethical use of digital content remain ongoing concerns in digital library operations.

Digital preservation is another critical challenge highlighted in the literature. Ensuring long-term access to digital resources requires systematic preservation strategies, reliable storage solutions, and regular migration of data to new formats. Without adequate preservation policies and infrastructure, digital resources are at risk of loss due to technological obsolescence, system failures, or data corruption. Preservation challenges are particularly acute for institutional repositories and digitized heritage collections.

Resistance to change among library staff and users also affects the success of digital transformation initiatives. Organizational culture, fear of job displacement, and lack of confidence in new technologies can lead to reluctance in adopting digital systems. Similarly, users accustomed to traditional library services may initially resist digital interfaces, especially when services are not aligned with their actual needs or are perceived as complex. Effective change management and user engagement are therefore essential components of successful digital transformation.

Finally, issues of access and inclusivity remain significant challenges, especially in institutions serving diverse user communities. Digital divides arising from socioeconomic disparities, limited digital literacy, and unequal access to devices and internet connectivity can restrict the benefits of digital library services. Ensuring equitable access to digital resources and services is crucial to prevent the exclusion of marginalized user groups.

Strategies for Managing Digital Transformation in Academic Libraries

Effective digital transformation in academic libraries requires carefully planned strategies that address technological, organizational, and user-related challenges in an integrated manner. Rather than focusing solely on the adoption of new technologies, libraries must implement holistic approaches that ensure sustainability, adaptability, and meaningful user engagement. The literature emphasizes that successful digital transformation depends on strategic planning, institutional support, and continuous evaluation.

Collaboration and institutional partnerships are among the most effective strategies for managing digital transformation. Academic libraries can benefit significantly from cooperation with other libraries, academic institutions, technology providers, and library networks. Such partnerships enable resource sharing, joint digitization initiatives, and access to advanced digital tools that may otherwise be financially or technically

unattainable. Participation in library consortia and national networks strengthens collective capacity and reduces duplication of efforts, thereby enhancing the efficiency and reach of digital library services.

Capacity building and continuous professional development of library staff constitute another critical strategy. As digital technologies evolve rapidly, librarians must acquire new skills related to information technology, digital resource management, data analytics, and artificial intelligence applications. Regular training programs, workshops, and skill enhancement initiatives help bridge the ICT skill gap identified in the literature. Empowering library professionals with relevant competencies ensures effective implementation, maintenance, and innovation in digital services.

Adoption of agile and adaptive management practices is increasingly recognized as essential for navigating the dynamic digital environment. Agile management approaches allow libraries to respond quickly to technological changes and shifting user needs. This involves flexible planning, iterative service development, and cross-functional collaboration among library staff. By fostering an organizational culture that embraces experimentation and continuous improvement, academic libraries can remain resilient and responsive in the face of ongoing digital change.

User-centered design and service planning are fundamental to the success of digital transformation initiatives. Libraries must actively engage users in the design, evaluation, and refinement of digital services. Incorporating user feedback through surveys, usability testing, and interaction analysis helps ensure that digital platforms are intuitive, accessible, and aligned with user expectations. A focus on user experience enhances satisfaction, increases service adoption, and minimizes resistance to technological change.

Strategic investment in sustainable digital infrastructure is also essential. Academic libraries should prioritize scalable and interoperable systems that support long-term growth and integration. Open-source software solutions, cloud-based platforms, and shared infrastructure models can reduce costs while enhancing flexibility. Establishing clear policies for digital preservation, data security, and copyright compliance further strengthen the sustainability of digital initiatives.

Change management and communication strategies play a vital role in **addressing resistance among staff and users**. Transparent communication about the objectives, benefits, and impact of digital transformation helps build trust and acceptance. Providing adequate support during transitions, recognizing staff contributions, and fostering a collaborative work environment contribute to smoother implementation of digital systems.

Overall, managing digital transformation in academic libraries requires a balanced combination of technological innovation, human resource development, collaborative partnerships, and user-focused planning. Strategic and adaptive approaches enable libraries to overcome challenges and position themselves as effective, inclusive, and future-ready knowledge centers within the academic ecosystem.

Future Directions of Digital Transformation in Academic Libraries

The future of academic libraries is closely tied to the ongoing development of digital technologies and the changing ways in which scholars communicate. As higher education institutions increasingly adopt digital-first approaches, academic libraries are expected to move beyond supportive roles and actively shape knowledge creation, access, and dissemination. The literature shows that future digital transformation will involve deeper technological integration, improved user engagement, and a stronger connection to institutional academic goals.

One of the most significant future directions is the expanded use of **artificial intelligence and machine learning technologies**. AI-driven systems are expected to transform information discovery through intelligent search engines, personalized recommendation systems, automated metadata generation, and virtual reference assistants. These technologies will enable libraries to offer more precise, context-aware, and user-specific

services while reducing manual workloads. Ethical use of AI, transparency in algorithms, and data privacy will become important areas of policy development.

Another key direction is the transition from traditional integrated library systems to **advanced library service platforms (LSPs)**. LSPs are designed to manage both print and electronic resources within unified, cloud-based environments. These platforms support interoperability, real-time analytics, and seamless integration with institutional learning management systems and research platforms. Their adoption will enable libraries to manage complex digital collections more efficiently and support emerging forms of scholarly output.

Open access and open science initiatives are also expected to play a central role in the future of academic libraries. Libraries will increasingly support institutional repositories, open educational resources, research data management, and open publishing platforms. By facilitating open access to scholarly content, academic libraries contribute to knowledge democratization and global academic collaboration. Librarians are likely to assume advisory roles in research data curation, copyright management, and scholarly impact assessment.

Digital preservation and long-term access to scholarly content will gain increased attention in the coming years. As digital materials continue to grow in volume and complexity, libraries must develop robust preservation strategies to ensure authenticity, integrity, and accessibility over time. This includes adopting **standardized preservation frameworks**, migration strategies, and trusted digital repositories capable of supporting diverse digital formats.

User engagement will remain a defining factor in future digital library services. Academic libraries are expected to adopt more immersive and interactive technologies, such as **augmented reality, virtual learning spaces, and data visualization tools**, to enhance learning and research experiences. Mobile-first service design and inclusive accessibility features are essential for meeting the needs of diverse user communities and learning styles.

Finally, future digital transformation efforts will increasingly emphasize **sustainability, inclusivity, and policy alignment.** Libraries will need to balance technological innovation with environmental considerations, financial sustainability, and social responsibility. Strategic planning, continuous assessment, and evidence-based decision-making will guide libraries in navigating future challenges while maximizing the impact of digital transformation.

Conclusion

Digital transformation has fundamentally reshaped the role and function of academic libraries by expanding services beyond physical spaces and redefining user interaction with information. This paper reviewed recent literature to examine key technological developments, emerging digital services, and the challenges associated with transforming academic libraries in contemporary higher education environments. The findings indicate that digital transformation goes beyond automation and digitization, encompassing user-centered service models, integrated digital platforms, and the growing application of artificial intelligence in information access and management.The review also highlights persistent challenges such as limited infrastructure, skill gaps among library professionals, financial constraints, and issues related to copyright and digital preservation. Addressing these challenges requires strategic planning, continuous professional development, institutional support, and alignment with national and global digital initiatives.

Overall, the study concludes that sustainable and inclusive digital strategies are crucial for keeping academic libraries relevant. By adopting adaptive technologies and needs-based approaches, academic libraries can effectively support teaching, learning, and research in the evolving digital knowledge ecosystem.

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Digital Era Innovations in Library Services and Resource Management

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Abstract

The digital era has transformed library services and resource management through the integration of information and communication technologies. Innovations such as cloud-based library management systems, digital repositories, discovery services, mobile library apps, and AI-enabled search tools have enhanced accessibility, personalization, and efficiency. Libraries increasingly provide e-resources, open educational resources, remote reference services, and virtual learning support, expanding their role beyond traditional spaces. Digital preservation initiatives and institutional repositories support scholarly communication and long-term access to knowledge. Data analytics is being applied for informed decision-making, user behavior analysis, and service improvement. At the same time, libraries face challenges including digital divide, data privacy, copyright issues, and the need for continuous capacity building among professionals. Overall, digital innovations are reshaping libraries into dynamic knowledge hubs that support lifelong learning, research, and community engagement while redefining the roles of librarians in a rapidly evolving information ecosystem.

Keywords: Digital era; Library services, Resource management, E-resources, Digital libraries, Innovation, ICT, Discovery tools, Institutional repositories, Knowledge management

Introduction

The digital era has profoundly reshaped the landscape of library services and resource management, ushering in a paradigm shift from traditional print-based systems to technology-enabled, user-centered environments. Libraries are no longer confined to physical collections and onsite services; instead, they have evolved into hybrid or fully digital knowledge centers that provide seamless access to information anytime and anywhere. The integration of information and communication technologies (ICT), artificial intelligence, cloud computing, mobile technologies, and big data analytics has enabled libraries to innovate in the way resources are acquired, organized, delivered, and preserved.

Digital collections, including e-books, e-journals, databases, and institutional repositories, have expanded the scope and reach of library resources. Modern discovery tools and federated search systems allow users to retrieve information from multiple platforms through a single interface, improving search efficiency and user satisfaction. Innovative services such as virtual reference, online user education, current awareness services, personalized alerts, and learning support through learning management systems further enhance user engagement.

In terms of resource management, automation and integrated library management systems facilitate cataloguing, circulation, acquisitions, and serials control with greater accuracy and speed. Libraries are also adopting data-driven decision-making to understand user needs, evaluate resource usage, and optimize budgets. Digital preservation strategies ensure long-term access to scholarly output and cultural heritage.

However, these innovations also bring challenges, including issues of digital literacy, copyright, licensing, data privacy, and the digital divide. Overall, innovations in the digital era are redefining the role of libraries as proactive, interactive, and inclusive hubs of information, supporting education, research, and lifelong learning in an increasingly networked world.

Definition of the Digital Age

The **digital age**, also called the **information age**, refers to the contemporary period characterized by the widespread creation, storage, processing, and exchange of information using digital technologies. It began with the advent of computers, the internet, and communication technologies that transformed how people communicate, learn, work, and access knowledge. In the digital age, information exists primarily in electronic formats and can be transmitted instantly across the world. This era emphasizes connectivity, automation, data-driven decision-making, and the integration of technology into everyday life, including education, business, governance, and library services.

Characteristics of the Digital Age

- **Digitization of information** – Conversion of print and analog content into electronic formats.
- **Instant communication** – Widespread use of email, social media, and messaging platforms for real-time interaction.
- **Global connectivity** – The internet links people, institutions, and resources across the world.
- **Ubiquitous technology use** – Smartphones, computers, cloud services, and smart devices are part of daily activities.
- **Information explosion** – Massive growth of data and information available online.
- **Automation and AI** – Increased use of algorithms, machine learning, and automated systems in services and industries.
- **User-centered services** – Personalization and on-demand information access.
- **Virtual learning and remote work** – Expansion of online education, e-resources, and telecommunication-based work.
- **E-commerce and e-governance** – Digital platforms dominate business transactions and government services.
- **New ethical and security issues** – Data privacy, cybersecurity, digital divide, and intellectual property concerns.

Development of Libraries in the Digital Age

Libraries in the digital age have undergone rapid transformation from traditional print-centered institutions to hybrid and digital knowledge centers. The adoption of Information and Communication Technologies (ICT) has enabled automation of housekeeping operations through Integrated Library Management Systems (ILMS), improving cataloguing, circulation, and acquisitions. Digital libraries, institutional repositories, and open access archives have broadened global access to scholarly content. E-resources such as e-books, e-journals, databases, MOOCs, and multimedia collections support diverse learning needs.

User services have become more interactive and user-centered. Virtual reference services, online information literacy training, mobile apps, cloud services, discovery tools, and AI-enabled search systems enhance accessibility and personalization. Remote access facilities allow users to consult library resources anytime and anywhere. Libraries now function as learning commons and digital knowledge hubs, supporting e-learning, research, and collaboration through makerspaces, Wi-Fi environments, and digital labs.

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Challenges of Libraries in the Digital Age

Despite significant progress, libraries face multiple challenges. The **digital divide** limits equitable access for users lacking devices or internet connectivity. Issues of **copyright, licensing restrictions, and digital rights management (DRM)** create barriers to resource sharing. **Data privacy and cybersecurity risks** arise from increased online services and user data collection.

Constant technological change demands **continuous training and skill upgradation** among library professionals. Financial constraints affect subscription to costly databases and upgrading infrastructure. **Digital preservation** of electronic information poses technical and organizational challenges due to format obsolescence and long-term storage requirements. Additionally, ensuring **information literacy** is crucial to help users evaluate misinformation in an overloaded digital environment.

Impact of Digitization on Library Resource Management

Digitization has significantly transformed library resource management by shifting the focus from print-centered processes to digital, networked environments. One of the major impacts is the **transition from physical collections to hybrid and digital collections**, including e-books, e-journals, databases, and digitized heritage materials. This has expanded access beyond geographic and time barriers, enabling users to retrieve information remotely through library websites, discovery layers, and mobile platforms.

Digitization has improved **acquisition and organization** of resources. Integrated Library Management Systems (ILMS) and Electronic Resource Management Systems (ERMS) streamline cataloguing, classification, subscription tracking, license management, and usage analytics. Metadata standards such as MARC, Dublin Core, and OAI-PMH enhance interoperability and resource discovery across platforms and consortia.

Resource sharing has become easier through **library networks and consortia**, reducing costs via shared subscriptions and interlibrary digital document delivery. Institutional repositories support open access to theses, dissertations, and research outputs, strengthening scholarly communication. Digitization also promotes **long-term preservation** of rare and fragile materials through digital archiving and backup systems.

At the same time, digitization introduces new responsibilities. Libraries must handle **digital rights management, copyright licenses, data privacy, and cybersecurity.** Financial challenges arise due to recurring subscription costs and technology upgrades. Staff require continuous training in digital tools, metadata creation, and digital preservation techniques.

Digital Innovation in Library Resource Management

Digital innovation has revolutionized library resource management by introducing smart, automated, and user-centric systems. The integration of **Integrated Library Management Systems (ILMS) and Library Services Platforms (LSPs)** enables seamless handling of acquisitions, cataloguing, circulation, serials control, and reporting in a unified environment. Cloud-based systems further reduce infrastructure costs and support remote access and real-time updates.

The emergence of **Electronic Resource Management Systems (ERMS)** has transformed the management of e-journals, databases, licenses, and usage statistics. Libraries can now monitor subscriptions, track renewals, and analyze cost-effectiveness using data analytics and dashboards. **Discovery services** and **federated search tools** provide single-window search across multiple resources, greatly enhancing user experience.

Digital repositories and institutional repositories facilitate the management, preservation, and dissemination of theses, dissertations, research articles, and learning materials, promoting open access and scholarly communication. **Digitization projects** preserve rare manuscripts and heritage collections while expanding global accessibility.

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Artificial intelligence and machine learning support **smart recommendations, chatbots, plagiarism detection, and automated metadata generation.** Radio Frequency Identification (RFID) and self-check systems streamline circulation, inventory management, and security.

Mobile applications, QR codes, virtual reference services, and learning management system (LMS) integration make resources available **anytime, anywhere**. Data-driven decision making helps libraries optimize collection development and user services.

Management and Integration Strategy of Digital Resources

Effective management and integration of digital resources in libraries require systematic planning, technology adoption, and user-centered approaches. A well-designed strategy ensures seamless access, long-term preservation, and optimal utilization of digital collections.

1. Strategic Planning and Policy Framework

Libraries should formulate clear **digital collection development policies** covering selection, licensing, access rights, preservation, and evaluation. Alignment with institutional goals and user needs is essential.

2. Resource Selection and Acquisition

Digital resources—including e-books, e-journals, databases, multimedia, and open educational resources—should be acquired through **evidence-based selection**, usage statistics, curriculum mapping, and cost–benefit analysis.

3. Integration through Technology Platforms

Use of **Integrated Library Management Systems (ILMS), Library Services Platforms (LSPs),** and **Electronic Resource Management Systems (ERMS)** enables unified management of print and electronic resources. Link resolvers, discovery services, and federated search tools support **single-window access.**

4. Metadata Standards and Interoperability

Implement metadata standards such as **MARC21, Dublin Core, METS, MODS, and OAI-PMH** to ensure discoverability and interoperability across repositories and consortia.

5. Access and Authentication

Remote access can be facilitated using **proxy servers, SSO, and Shibboleth** while ensuring copyright compliance and fair-use practices.

6. Digital Preservation Strategy

Adopt **LOCKSS/CLOCKSS, institutional repositories, backups, and format migration** to ensure long-term preservation and integrity of digital assets.

7. User Training and Information Literacy

Conduct regular **orientation, workshops, and digital literacy programs** to maximize resource use and avoid misuse.

8. Evaluation and Analytics

Use **usage analytics, altmetrics, and feedback systems** to measure impact, renew subscriptions wisely, and redesign services.

9. Collaboration and Consortia Participation

Participation in **national and international consortia** reduces costs and expands access.

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10. Security and Ethics

Ensure **data privacy, cybersecurity measures, and copyright compliance** in all digital operations.

Construction and Optimization of Library Digital Platform

The construction of a library digital platform involves designing an integrated, user-centered system that provides seamless access to e-books, e-journals, databases, and institutional repositories. It requires robust infrastructure, including cloud services, secure servers, and a scalable Library Services Platform with discovery tools and single sign-on authentication. Metadata standards and interoperable protocols ensure unified search and resource integration. Optimization focuses on improving usability, mobile compatibility, fast retrieval, personalization, and accessibility features. Continuous data analytics, user feedback, and interface refinement enhance performance. Regular content updates, cybersecurity measures, staff training, and digital preservation strategies ensure sustainability and effective service delivery in the digital environment.

Digital Copyright Management and Information Security

Digital copyright management and information security are critical components of modern library services. **Digital copyright management** involves regulating the creation, distribution, and use of digital resources in accordance with intellectual property laws and licensing agreements. It includes understanding **fair use, Creative Commons licenses, DRM (Digital Rights Management) systems, e-resource licensing, plagiarism detection, and rights clearance** for digitization projects. Libraries must balance copyright compliance with users' academic freedoms and equitable access to information.

Information security focuses on protecting digital collections, user data, and library systems from unauthorized access, loss, or misuse. Key practices include **authentication and authorization controls, encryption, firewalls, anti-malware systems, secure backup, and cybersecurity policies.** Secure remote access tools (such as VPN or SSO) safeguard online service delivery. Staff training and user awareness help prevent phishing, identity theft, and data breaches.

Library Service Innovation in the Digital Age

Library service innovation in the digital age focuses on leveraging digital technologies to deliver flexible, user-centered, and value-added services. Traditional services such as lending, reference, and information literacy have been transformed through online platforms, mobile applications, and cloud-based systems. **Virtual reference services**, chatbots, and AI-powered recommendation systems provide real-time assistance beyond physical library hours**. Discovery services and single-search interfaces** simplify access to diverse digital collections including e-books, e-journals, databases, and multimedia.

Libraries now support **remote learning and research** through institutional repositories, digital libraries, MOOCs integration, and virtual learning environments. **Makerspaces, digital labs, and collaborative learning commons** encourage creativity and innovation. Personalized services such as **current awareness, alert services, and user profiling** enhance engagement. Social media outreach, webinars, and digital exhibitions expand community interaction.

Inclusive practices—such as **assistive technologies, multilingual interfaces, and mobile-friendly design**—broaden access. Data analytics helps libraries understand user behavior and improve service design. Overall, service innovation in the digital age transforms libraries into dynamic, interactive knowledge hubs that support lifelong learning, research, and societal development.

Conclusion

Digital era innovations have fundamentally transformed library services and resource management, shifting libraries from custodians of print collections to dynamic digital knowledge hubs. The integration of ICT, cloud platforms, artificial intelligence, mobile technologies, and data analytics has enhanced accessibility,

efficiency, and personalization in information delivery. Libraries now support remote learning, digital research workflows, and 24/7 access to diverse e-resources through institutional repositories, discovery tools, and virtual services. Resource management has become more strategic and data-driven, with ERM systems, automation, and digital preservation ensuring sustainable access and informed decision-making. At the same time, libraries must address challenges such as digital divide, copyright restrictions, cybersecurity, skill gaps, and financial constraints. Continuous professional development, strong policy frameworks, and user-centered design are essential to maximize the benefits of digital transformation. Overall, innovations in the digital age position libraries as inclusive, innovative, and collaborative institutions supporting lifelong learning, research advancement, and societal development.

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A Study on the Usage of Digital Library Services among Higher Education Students

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Abstract

This paper deals with a study on the usage of digital library services among higher education students. Digital libraries have transformed the academic environment by providing students with easy access to digital information such as e-books, e-journals, e-theses, and databases. Simple random sampling was used for the study. Primary data were collected through a structured questionnaire. The study contributes to the improvement and development of student learning. Digital libraries assist students in acquiring essential academic and professional competencies. Digital libraries have transformed access to information in the educational world. This paper includes the definition, objectives, methodology, results and discussion finding and conclusion.

Keywords: Digital library, Services and Higher Education Students

Definition of Digital Libraries

A digital library defined as a collection of digital resources such as books, magazines, journals, theses, dissertations audio, videos and other multimedia materials that are accessible electronically

Objectives of the study

The following objectives are framed for the present study

- To study the sex-wise distribution of respondents using digital library services among higher education students.
- To determine the amount of time spent by students using digital library services.
- To identify the types of digital library services utilized by students.

Methodology

The study was conducted using the questionnaire method. The respondents comprised students from higher education institutions in Tamilnadu. A total of 380 questionnaires were distributed, of which 315 were collected from the students. The response rate was 82.89 percent.

Results and Discussion

Table -1 Sex-wise distribution of questionnaire

S .No	Sex	Respondents	Percentage
1	Male	208	66
2	Female	107	34
Total		315	100

From the above Table: 1 indicates sex wise distribution of questionnaire. 66% of the respondents belong to male category and 34% belong to the female category. Majority of the respondents belong to the male category.

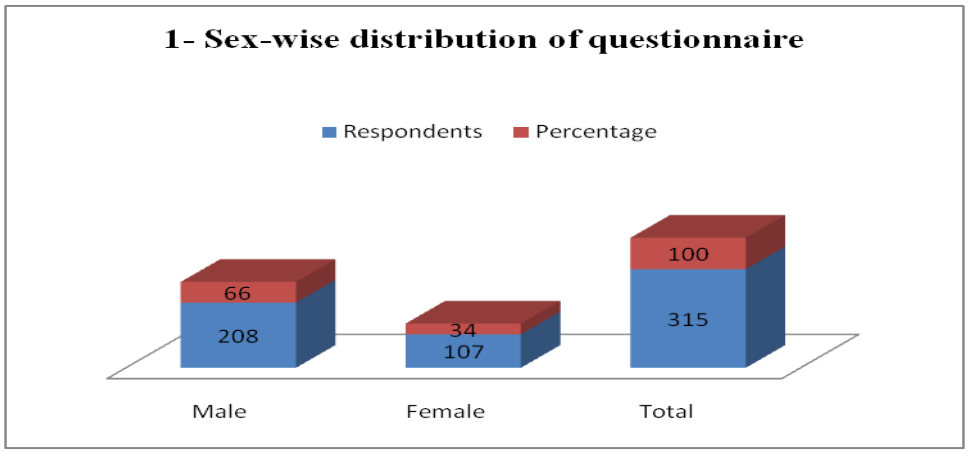


Table- 2 Time spent on accessing digital library

S .No	Time Spent	Respondents	Percentage
1	1 hour	170	54
2	2 hours	110	35
3	3 hours	35	11
Total		315	100

The above Table-2 indicates the Time Spent on accessing digital library. It could be noted that out of 315 respondents 170 of them spent time 1 hour to access digital library, 110 of them spent time 2 hours to access digital library and 35 of them time spent 3 hours to access digital library.

Table- 3 digital library services

S .No	Digital library services	Respondents	Percentage
1	Multimedia services	41	13
2	E-reosources	126	40
3	OPAC	85	27
4	Digital reference services	63	20
Total		315	100

Table 3 indicates the digital library services. Out of 315 respondents 126 (40%) of the respondents are using e-resources, 85 (27%) of the respondent are using OPAC, 63(20%) of the respondents are using digital reference services and 41(13%) of the respondents are using multimedia services.

Findings

- The majority of the respondents are male
- It is found that more than 54 % of the respondents spend time one hour used digital library.
- Most of the respondents have concentrated on accessing e-resources 40%

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Conclusion

The study examines the usage of digital library services among higher education students**.** The findings reveals that the majority of the respondents are male, most respondents prefer Spending one hour using digital library services and they primarily concentrate on accessing e-resources .

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Digital Transformation of College Libraries in the 21st Century

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ABSTRACT

The importance of clientele in the library is stressed. The need for good relation between the library staff and the users is highlighted. Representation for the clientele on some of the policy making bodies of the library like the library Advisory Committee is suggested. The importance of library service through mass media is suggested for the benefit of illiterates. Concludes that the librarian should be conversant with the different aspects of information technology and library operations and services should be modernized with on line information retrieval facilities and internet. Enumerates the steps to be followed in the planning of library automation. Examines the key issues of information resources Management. States that document sharing networks. Explain that services and products that can be generated with the design and development of databases.

KEYWORDS: 21st Century, Digital information centre, Library Automation, Bar-coding, Information Technology, Library Planning

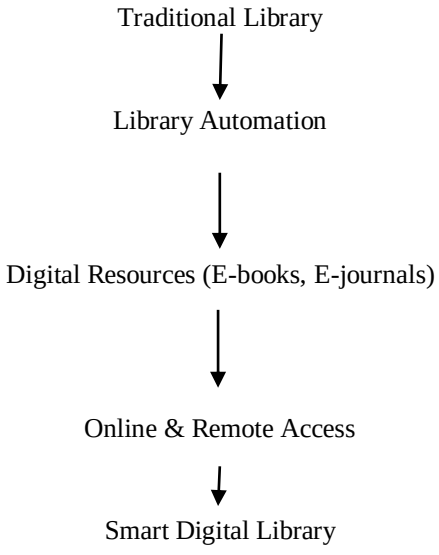
INTRODUCTION

Management Science has advanced very much branching out into different specializations like Production Management. Financial Management, Workforce, Marketing Management and so on. It is obvious that it not possible to convert an information professional into a good manager by merely introducing more management theory in the existing curriculum of library schools. It needs a multi-pronged strategy to tide over the problem. Two such strategies are discussed here.

Concept of Digital Transformation in College Libraries

Digital transformation refers to the adoption of digital technologies to modify traditional library services and operations. It includes:

a) Automation of library functions
b) Access to electronic resources
c) Online user services
d) Digital preservation of knowledge



Traditional Library

Print books, manual Catalogues, physical Access only

Library Automation

Computerized catalogue, OPAC, bar-coding, Circulation systems

Digital Resources

E-books, E-journals, online databases, Institutional repositories

Online & Remote Access

24/7 access, cloud systems, Mobile access, virtual Reference services

Smart Digital Library

AI-based services, data analytics, personalized user experience, smart learning environment

Importance of Digital Transformation in College Libraries

Digital transformation has become essential for college libraries to remain relevant in the rapidly evolving academic environment. Students and faculty increasingly depend on digital platforms for teaching, learning, and research. Traditional library systems alone are no longer sufficient to meet user expectations for instant access, remote availability, and multimedia information.

Digitally transformed libraries enhance academic productivity by offering seamless access to global information resources. They also support outcome-based education, research innovation, and lifelong learning. By adopting digital tools, college libraries can improve service efficiency, user satisfaction, and institutional visibility.

Objectives of Digital Transformation in College Libraries

The major objectives of digital transformation include:

- To improve access to information resources anytime and anywhere
- To enhance the quality and efficiency of library services
- To support e-learning, online education, and research activities
- To preserve knowledge digitally for future generations
- To promote information literacy and digital skills among users

Components of Digital Transformation

Library Automation

Automation uses software such as KOHA, SOUL, or Libby's to manage:

1. Acquisition
2. Cataloguing
3. Circulation
4. Serials control

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Electronic Resources

E-resources include:

1. E-books
2. E-journals
3. Online databases
4. Institutional repositories

Digital Infrastructure

a) Computers and servers
b) High-speed internet
c) Wi-Fi facilities
d) Cloud-based storage

Digital Services

a) Online Public Access Catalogue (OPAC)
b) Remote access services
c) Virtual reference services
d) Digital lending

Digital transformation enhances academic activities by

a) Providing 24/7 access to resources
b) Supporting online and blended learning
c) Enabling collaborative research
d) Improving information literacy skills

Digital Learning Environment

A picture showing students using laptops and tablets in a modern digital library with online databases displayed on screens.



Fig: I Digital Learning Environment:

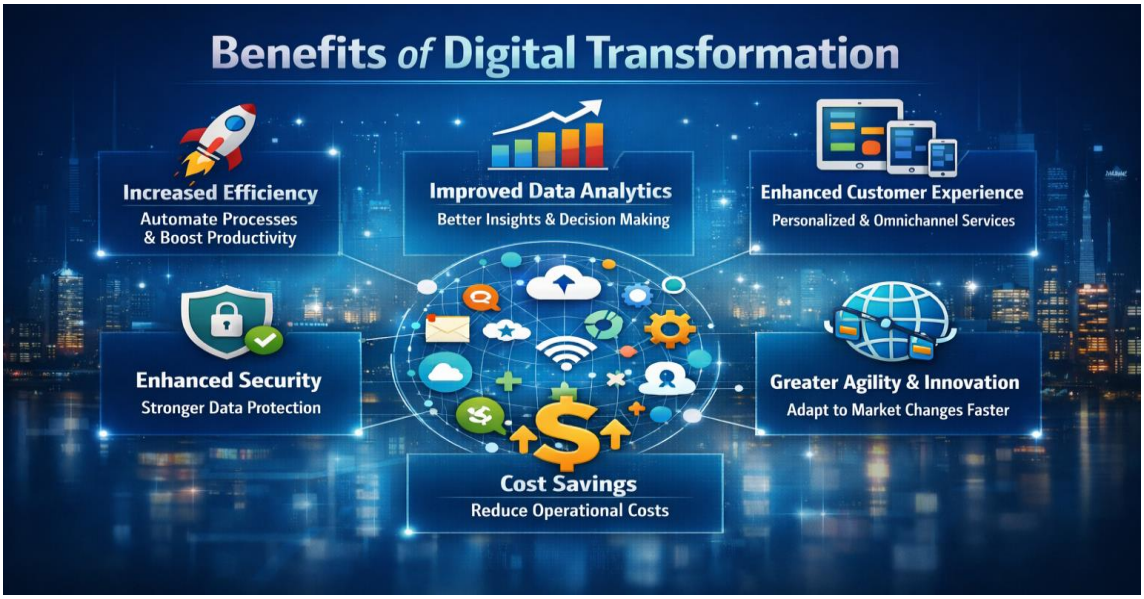


Fig: II Benefits of Digital Transformation:

Challenges in Digital Transformation

Despite its advantages, digital transformation faces several challenges:

a) High cost of digital resources

b) Licensing and copyright issues

c) Lack of technical skills among staff

d) Digital divide among users

e) Long-term digital preservation issues

Challenges of Digital Libraries:

High Cost

↓

Technical Issues

↓

Digital Divide

↓

Copyright & Licensing

Role of Librarians in the Digital Era:

Librarians are transforming into:

a) Information managers

b) Digital content curators

c) Research support professionals

d) Trainers in digital literacy

Impact of Digital Transformation on Users

Digital transformation significantly changes user behaviour and learning patterns. Students benefit from faster information retrieval, remote access to resources, and interactive digital platforms. Faculty members gain improved research support through access to e-journals, citation tools, and institutional repositories.

Digitally enabled services reduce dependency on physical visits and promote self-learning. Personalized services such as alerts, recommendations, and online assistance enhance user engagement and satisfaction.

Modern Librarian Role:

A librarian assisting students with online databases and digital research tools using a computer system.



Future Trends in Digital College Libraries:

a) Artificial Intelligence (AI) based search tools

b) Big data analytics

c) Virtual and augmented reality learning spaces

d) Mobile library services

e) Open Educational Resources (OERs)

Digital Preservation and Institutional Repositories

Digital preservation is a crucial aspect of digital transformation. College libraries are increasingly responsible for preserving institutional knowledge such as these, dissertations, faculty publications, question papers, and research outputs.

Institutional repositories ensure long-term access to academic content and increase the visibility of institutional research at national and international levels. Open-access repositories also promote knowledge sharing and reduce publication barriers.

ELECTRONIC ERA:

The **Electronic Era** refers to the period in which electronic technologies are widely used to create, store, process, and communicate information. This era began in the mid-20th century with the invention of electronic devices such as computers, transistors, and communication systems. In the Electronic Era, information handling

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shifted from manual and mechanical methods to electronic systems, resulting in faster processing, greater accuracy, and large-scale data storage.

In the field of **libraries and information science**, the Electronic Era is marked by the introduction of computers, library automation, electronic databases, OPAC, e-resources such as e-books and e-journals, and online information services. It has improved access to information, enabled remote usage, reduced physical storage limitations, and enhanced user services. Overall, the Electronic Era has transformed traditional systems into efficient, technology-driven information environments.

STRATEGIES FOR THE 21ST CENTURY

In the 21st century, strategies focus on adapting to rapid technological changes, globalization, and knowledge-based economies. Organizations and institutions adopt digital transformation, innovation, and continuous learning as key strategies to remain competitive and relevant. The use of information and communication technology (ICT), data-driven decision making, automation, and online platforms has become essential. Emphasis is placed on skill development, creativity, sustainability, customer-centric approaches, and effective knowledge management. In education and libraries, 21st-century strategies include e-learning, digital resources, collaboration, and lifelong learning to meet the evolving needs of society.

Digital Information Centre

A Digital Information Centre is a modern library setup that provides access to information in electronic formats such as e-books, e-journals, online databases, and institutional repositories. It uses computers, internet connectivity, and digital tools to support learning, teaching, and research. Users can access information anytime and anywhere, improving knowledge sharing and academic productivity**.**

Library Automation

Library automation refers to the use of computer technology to perform routine library operations such as acquisition, cataloguing, circulation, serials control, and OPAC. Automation reduces manual work, improves accuracy, saves time, and enhances user services. Library management software like KOHA helps in effective organization and quick retrieval of information.

Bar-coding

Bar-coding is a technology used in libraries to identify and manage library materials efficiently. Each book or document is assigned a unique barcode that helps in fast circulation, stock verification, and theft control. Bar-coding improves accuracy in issue and return processes and supports automated library systems.

Information Technology

Information Technology (IT) plays a vital role in modern libraries by enabling storage, processing, and dissemination of information in digital form. IT supports online catalogues, digital libraries, networking, database management, and remote access to resources. The use of IT has transformed libraries into knowledge-based service centres.

Library Planning

Library planning involves systematic decision-making to develop library resources, services, staff, and infrastructure to meet user needs. It includes planning for collections, budgeting, technology adoption, space management, and future growth. Effective library planning ensures efficient use of resources and continuous improvement **of library services.**

PLANNING FOR LIBRARY AUTOMATION

Planning for library automation is the process of carefully designing and implementing computer-based systems to manage library operations efficiently. It involves analyzing user needs, selecting functions to

automate such as cataloguing, circulation, and OPAC, choosing appropriate library management software, and ensuring adequate infrastructure and trained staff. Proper budgeting, data migration, and phased implementation are also important parts of the planning process.

Example

A college library plans to automate its services by adopting **KOHA** library management software. The library first assesses its collection and user requirements, installs computers and networking facilities, trains library staff, and then automates cataloguing and circulation. Later, it introduces OPAC and e-resources for users. This planned approach improves service speed, accuracy, and user satisfaction.

Security and Ethical Issues in Digital Libraries

With increased digitization, libraries face challenges related to data security, copyright, and ethical use of information. Unauthorized access, data breaches, plagiarism, and misuse of digital content are major concerns.

College libraries must implement secure authentication systems, copyright compliance mechanisms, and awareness programs on ethical information use. Librarians play a key role in guiding users on responsible digital practices.

Role of College Management in Digital Transformation

Institutional support is vital for successful digital transformation. College management must allocate sufficient budget, support staff training, and encourage technology adoption. Strategic planning and policy formulation ensure sustainable digital library development.

Collaboration between administrators, librarians, IT staff, and faculty members is essential to integrate library services with academic objectives.

Suggestions for Effective Digital Transformation

- Provide continuous ICT training for library professionals
- Allocate adequate funds for digital resources and infrastructure
- Promote user awareness and digital literacy programs
- Adopt open-source library software to reduce costs
- Regularly evaluate and upgrade digital services

Conclusion

In conclusion, digital transformation has reshaped college libraries into dynamic knowledge centres capable of supporting modern education and research. By integrating automation, digital resources, online services, and emerging technologies, college libraries enhance access, efficiency, and user engagement. Despite challenges such as financial constraints and skill gaps, strategic planning and institutional support can ensure successful transformation. In the 21st century, digitally empowered college libraries are essential for academic excellence, innovation, and lifelong learning.

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Digital Transformation and Innovation: A Study of Digital Libraries, Electronic Resources and Digital Preservation

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ABSTRACT

Digital transformation has introduced a lot of changes in the creation, storage, access, and preservation of information. Libraries, which are very important for knowledge sharing, have shifted from conventional systems to digital platforms through technological innovation. This paper proposes to examine the concept of digital transformation with special reference to digital libraries, electronic resources, and digital preservation. The paper will be based on the secondary data collected from books, journals, research articles, and web materials. Digital libraries have introduced easy and remote access to information resources in digital form. Electronic resources like e-books, e-journals, online databases, and institutional repositories facilitate teaching, learning, and research work. Digital preservation has ensured the long-term storage and protection of digital information for future use. The results of the study have shown that digital transformation has improved the accessibility, efficiency, and sustainability of library services. However, issues like technological obsolescence, copyright problems, and lack of technical expertise also exist. The paper has concluded that the effective application of digital technologies and innovation are very important for the efficient management of digital libraries and information resources in the modern knowledge society.

***KEYWORDS**:* Digital Transformation, Digital Libraries, Electronic Resources, Digital Preservation, Innovation.

INTRODUCTION

Digital transformation can be defined as the integration of digital technologies into different activities with the aim of improving efficiency, accessibility, and service delivery. In the library and information field, digital transformation has resulted in the transformation of traditional library services into innovative digital platforms. The rise in the use of the internet, information and communication technology, and digital technologies has resulted in the rise of digital libraries and electronic resources. Users have also shown a preference for fast and distant access to information as opposed to visiting libraries physically. Digital preservation has also become a significant aspect in ensuring the long-term availability of digital information.

OBJECTIVES OF THE STUDY

1. To describe the role of digital libraries in facilitating access to information.
2. To describe how digital libraries support and enhance access to information resources.

DIGITAL LIBRARY

- A digital library is an organized collection of digital resources like e-books, e-journals, images, audio, and video materials that can be accessed using computers and the internet.
- Digital libraries offer round-the-clock access to information, conserve space, and enable remote access.
- They improve knowledge sharing and facilitate digital learning and research.
- Institutional repositories, national digital libraries, and academic digital libraries are examples of digital libraries.

ELECTRONIC RESOURCES (E-SOURCES)

- Electronic resources can be defined as information materials that are in electronic form.
- E-sources include e-books, e-journals, online databases, open access materials, and multimedia resources. E-sources facilitate the rapid retrieval of information and are commonly used in learning institutions.

- They enhance the efficiency of learning, minimize reliance on print materials, and facilitate sustainable information management.

DIGITAL PRESERVATION

- Digital preservation is the process of preserving digital information for a long period of time.
- Digital preservation ensures that digital information is accessible even after technological advancements.
- Data backup, migration, emulation, and use of standard formats are some of the techniques used in digital preservation.
- Digital preservation is an important process that helps in preserving cultural heritage and institutional knowledge.

FEATURES OF DIGITAL LIBRARY

- 24/7 access to information
- Remote accessibility
- Easy search and retrieval
- Space-saving storage
- Support for multiple formats
- Techniques of Digital Preservation
- Data backup and replication
- Migration to new formats
- Emulation of old systems
- Use of standardized file formats

CHALLENGES IN DIGITAL TRANSFORMATION

- High cost of digital infrastructure
- Rapid technological changes
- Copyright and licensing issues
- Lack of trained professionals
- Data security and privacy risks

PROPOSED DIGITAL TRANSFORMATION AND INNOVATION IDEAS FOR LIBRARY IMPLEMENTATION

- Implementation of AI-Based Digital Preservation Systems in Libraries
  - ❖ Libraries can implement Artificial Intelligence tools to strengthen digital preservation practices.
  - ❖ Machine learning techniques can be used for automatic format migration, metadata creation, early detection of data loss, and predictive preservation planning.
  - ❖ These systems will reduce manual workload and ensure continuous long-term access to digital resources.
- Adoption of Blockchain Technology for Secure and Authentic Digital Collections
  - ❖ Libraries can adopt blockchain technology to ensure the authenticity and integrity of digital collections.
  - ❖ Blockchain-based systems can record provenance details, prevent unauthorized modification of digitized materials, and manage digital rights securely.
  - ❖ This approach will improve trust, transparency, and secure sharing of e-resources among libraries.
- Use of Cloud Computing for Scalable E-Resources Management
  - ❖ Libraries can migrate digital collections and e-resources management systems to cloud platforms to achieve scalability and cost efficiency.

- ❖ Cloud-based infrastructure can support secure storage, backup, disaster recovery, and remote access to digital resources.
- ❖ Proper policies can be implemented to address data security, vendor dependency, and data sovereignty concerns.

- Implementation of AI-Enhanced User-Centric Discovery Services
  - ❖ Libraries can introduce AI-powered discovery tools such as intelligent search engines, recommendation systems, and personalized user interfaces.
  - ❖ These services can improve user engagement, support faster information retrieval, and enhance user satisfaction.
  - ❖ Designing user-friendly and sustainable interfaces will ensure long-term usability of digital library systems.
- Development of Advanced Preservation Strategies for Born-Digital and Digitized Resources
  - ❖ Libraries can implement updated digital preservation strategies to manage born-digital and digitized materials effectively.
  - ❖ Approaches such as migration, emulation, and enhanced archival frameworks can be adopted to address format obsolescence and technological change.
  - ❖ Clear policies can also be developed to handle legal and ethical issues related to digital content.
- Integration of Green IT Practices in Digital Library Preservation Systems
  - ❖ Libraries can integrate Green IT practices into digital preservation and e-resource management systems.
  - ❖ Energy-efficient servers, optimized cloud usage, and AI-based resource management can reduce environmental impact.
  - ❖ Sustainable digital practices will support eco-friendly library operations while ensuring long-term preservation of digital assets.
- Strengthening Preservation Strategies for Open Access Scholarly E-Resources
  - ❖ Libraries can enhance preservation strategies for Open Access resources by developing institutional repositories and participating in collaborative preservation networks.
  - ❖ Shared platforms and policies can ensure long-term access to scholarly content.
  - ❖ Special attention can be given to addressing funding limitations and access challenges in developing regions.
- Implementation of Immersive Technologies for Innovative Digital Library Services
  - ❖ Libraries can implement immersive technologies such as Augmented Reality and Virtual Reality to provide innovative access to digital collections.
  - ❖ Virtual exhibitions, 3D heritage displays, and interactive learning environments can improve user engagement.
  - ❖ Preservation frameworks must be developed to manage challenges related to software, hardware, and file format obsolescence.

FUTURE TRENDS IN DIGITAL TRANSFORMATION AND INNOVATION IN LIBRARIES

- ❖ Artificial Intelligence (AI) and Machine Learning (ML): AI and ML will help libraries automate cataloguing, provide personalized recommendations, and offer intelligent support to users.
- ❖ Virtual Reality (VR) and Augmented Reality (AR): VR/AR will create immersive learning experiences, allowing users to explore virtual archives and interact with 3D digital resources.
- ❖ Cloud-based Services: Cloud computing will enable scalable, secure, and remote access to library resources anytime, improving efficiency and flexibility.
- ❖ Mobile Library Access: Libraries will provide mobile apps for accessing e-books, journals, and databases on smartphones and tablets.

- ❖ Smart Libraries with IoT: IoT devices will manage check-ins, track resource usage, and monitor environmental conditions for preservation.
- ❖ Big Data and Data Analytics: Libraries will use data analytics to study user behavior, optimize services, and make evidence-based decisions.
- ❖ Open Access Resources: Greater adoption of open-access journals and repositories will enhance global sharing of knowledge and research.
- ❖ Digital Preservation Standards: Advanced digital preservation techniques will ensure long-term accessibility of digital content.
- ❖ Collaborative Platforms: Libraries will collaborate digitally with institutions worldwide for resource sharing and joint projects.
- ❖ Automation and Robotics: Future libraries may use robotic systems for book handling, sorting, and assisting users in physical or hybrid spaces.

CONCLUSION

Digital transformation helps libraries improve access, preservation, and management of digital resources. Technologies like AI, cloud computing, and blockchain make library services faster and more efficient. At the same time, libraries face challenges such as cost, technical skills, and data security. Proper planning and training can help libraries use these technologies effectively. Overall, digital transformation supports sustainable and user-friendly library services.

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Digital Preservation in Libraries: Concepts, Strategies, and Challenges

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Abstract

Digital preservation has emerged as a critical function of modern libraries due to the rapid growth of digital information and the vulnerability of digital formats to technological obsolescence. Libraries are increasingly responsible for ensuring long-term access to digital resources such as e-books, e-journals, institutional repositories, databases, and digitized heritage materials. This paper examines the concept of digital preservation in libraries, focusing on its importance, methods, tools, and challenges. It discusses various digital preservation strategies including migration, emulation, and replication, along with the role of metadata standards and digital repositories. The study also highlights the role of librarians in managing and sustaining digital preservation initiatives. By analyzing best practices and existing models, the paper aims to provide a comprehensive understanding of how libraries can effectively preserve digital resources for future generations.

Keywords: Digital Preservation, Libraries, Digital Resources, Metadata, Institutional Repositories

Introduction

The rapid advancement of information and communication technologies has transformed the nature of library collections from predominantly print-based resources to a hybrid and increasingly digital environment. Digital resources offer significant advantages in terms of accessibility, storage efficiency, and information sharing. However, these resources are inherently fragile due to factors such as hardware failure, software dependency, format obsolescence, and lack of long-term preservation planning. As a result, digital preservation has become a central concern for libraries worldwide.

Digital preservation refers to a series of managed activities necessary to ensure continued access to digital materials for as long as necessary. Unlike traditional preservation, which focuses on the physical protection of materials, digital preservation involves maintaining both the content and the means to render it usable. Libraries play a vital role in preserving digital knowledge as trusted custodians of information.

Objectives of the Study

The objectives of this study are:

- To explain the concept of digital preservation in libraries
- To identify types of digital resources preserved by libraries
- To examine digital preservation strategies and tools
- To analyze challenges faced by libraries in digital preservation
- To highlight the role of librarians in digital preservation initiatives

Methodology

This paper is based on a descriptive and analytical approach. Data has been collected from secondary sources such as books, scholarly journals, conference proceedings, library association reports, and reputable online resources related to digital preservation. The study synthesizes existing literature to present a structured overview of digital preservation practices in libraries.

Review of Literature

Several researchers have emphasized the importance of digital preservation in libraries. Previous studies highlight that without proper preservation strategies, valuable digital content may become inaccessible within a short period. Researchers have discussed frameworks such as the Open Archival Information System (OAIS) model as a foundation for digital preservation systems. Other studies focus on the need for institutional policies, trained manpower, and sustainable funding to support long-term preservation activities.

Concept of Digital Preservation

Digital preservation involves maintaining digital materials over time so that they remain accessible and usable despite technological changes. It includes processes such as selection, storage, maintenance, and periodic review of digital objects. Preservation is not a one-time activity but a continuous process that requires planning and institutional commitment.

Types of Digital Resources in Libraries

Libraries preserve a wide range of digital resources including e-books, e-journals, online databases, institutional repository content, digitized manuscripts, theses and dissertations, multimedia files, and web-based resources.

Digital Preservation Strategies

Common digital preservation strategies include migration, which involves converting files into newer formats; emulation, which recreates old software environments; and replication, which ensures multiple copies of digital objects are stored in different locations.

Challenges in Digital Preservation

Libraries face several challenges in digital preservation such as technological obsolescence, high costs, and lack of skilled staff, copyright issues, and inadequate infrastructure. Addressing these challenges requires institutional support and collaborative efforts.

Role of Librarians

Librarians play a crucial role in digital preservation by developing policies, selecting appropriate tools, managing metadata, ensuring legal compliance, and raising awareness about preservation practices.

Conclusion

Digital preservation is an essential responsibility of modern libraries. Through effective strategies, proper planning, and skilled professionals, libraries can ensure long-term access to digital knowledge. Continued research, training, and collaboration are necessary to strengthen digital preservation efforts.

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Electronic Resources Management in Academic Libraries

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ABSTRACT

The rapid growth of information and communication technologies (ICT) has significantly transformed the creation, storage, organization, access, and dissemination of scholarly information. Academic libraries, which traditionally relied on print collections, are increasingly shifting toward electronic resources to meet the evolving information needs of users. Electronic resources, commonly referred to as e-resources, include electronic journals, electronic books, online databases, institutional repositories, digital theses and dissertations, and multimedia resources. These resources support teaching, learning, and research by providing instant, remote, and multi-user access to information.

Managing electronic resources has emerged as a complex and challenging task for academic libraries. Issues related to acquisition models, licensing agreements, access management, usage evaluation, technological infrastructure, staff competencies, and long-term preservation require systematic and strategic management. Electronic Resources Management (ERM) involves a coordinated set of activities aimed at ensuring effective selection, acquisition, organization, access provision, evaluation, and maintenance of electronic information resources.

This paper presents an in-depth study of electronic resources management in academic libraries. It discusses the concept, evolution, types, lifecycle, tools, and technologies associated with e-resources. The study also highlights the challenges faced by libraries and suggests strategies and best practices for effective management. Furthermore, it examines emerging trends that are likely to shape the future of electronic resources management. The paper aims to provide a comprehensive understanding of ERM for library professionals, researchers, and students of library and information science.

Keywords: Electronic Resources, Electronic Resources Management, Academic Libraries, Digital Libraries, Information Technology, Library Automation

INTRODUCTION

Academic libraries have long been recognized as vital support systems for higher education and research. Traditionally, libraries focused on acquiring, organizing, and preserving print-based resources such as books, journals, reports, and reference materials. However, the advent of digital technologies and the widespread use of the internet have dramatically changed the information environment. Users now expect instant, convenient, and remote access to information, leading to a paradigm shift from print-based collections to electronic resources.

Electronic resources offer several advantages over print resources, including round-the-clock availability, simultaneous access by multiple users, advanced search functionalities, and rapid dissemination of information. Consequently, academic libraries allocate a significant portion of their budgets to electronic journals, databases, and e-books. While these resources enhance access and usability, they also introduce new management challenges that require specialized knowledge and skills.

Electronic Resources Management (ERM) has therefore become a critical area within library and information science. ERM encompasses a wide range of activities such as resource evaluation, vendor negotiation, license management, access configuration, troubleshooting, user training, and usage analysis. Effective ERM ensures that libraries provide reliable access to digital resources while maintaining cost-effectiveness, legal compliance, and user satisfaction.

OBJECTIVES OF THE STUDY

The main objectives of this study are:

- To explain the concept and scope of electronic resources management in academic libraries
- To examine the various types of electronic resources used in academic environments
- To analyze the lifecycle of electronic resources from selection to evaluation
- To identify the challenges faced by academic libraries in managing electronic resources
- To discuss tools, technologies, and standards used in ERM
- To suggest strategies and best practices for effective electronic resources management
- To highlight emerging trends and future directions in electronic resources management

SCOPE AND METHODOLOGY OF THE STUDY

The scope of this study is confined to electronic resources management practices in academic libraries, including universities, colleges, and research institutions. The paper focuses on conceptual, managerial, and practical aspects of ERM rather than detailed technical system design.

The methodology adopted for the study is descriptive and analytical in nature. It is based on an extensive review of secondary sources such as books, scholarly journals, conference proceedings, reports, and online publications related to electronic resources management. The study synthesizes existing literature to present a comprehensive overview of ERM practices.

CONCEPT OF ELECTRONIC RESOURCES

Electronic resources are information materials that are created, stored, accessed, and used in digital form through electronic devices such as computers, tablets, and smartphones. These resources are accessed via the internet or local networks and require appropriate hardware, software, and authentication mechanisms.

Electronic resources may be born-digital or digitized versions of print materials. They play a crucial role in supporting academic activities by providing timely and comprehensive access to scholarly content.

Definition of Electronic Resources

Electronic resources can be defined as information sources that are available in electronic format and accessed through computer-based systems. They include a wide range of digital content used for educational and research purposes.

TYPES OF ELECTRONIC RESOURCES IN ACADEMIC LIBRARIES

Academic libraries provide access to various types of electronic resources to support diverse user needs.

Electronic Journals

Electronic journals are digital versions of scholarly journals that provide access to current and archived research articles. They are widely used by faculty and researchers for academic work and are usually available through subscription-based models or open access platforms.

Electronic Books

Electronic books, or e-books, are digital versions of printed books. Academic libraries acquire e-books through different acquisition models such as perpetual access, subscription-based access, and demand-driven acquisition. E-books support flexible and remote learning environments.

Online Databases

Online databases provide access to bibliographic records, abstracts, and full-text documents across various disciplines. These databases include indexing and abstracting services, citation databases, and subject-specific resources.

Institutional Repositories

Institutional repositories are digital platforms designed to collect, preserve, and disseminate the intellectual output of an institution. They include research articles, theses, dissertations, conference papers, and other scholarly materials produced by faculty and students.

Multimedia and Other Digital Resources

In addition to text-based resources, academic libraries provide access to multimedia resources such as audio, video, images, datasets, and learning objects. These resources enhance teaching and learning experiences.

ELECTRONIC RESOURCES MANAGEMENT IN ACADEMIC LIBRARIES

Electronic Resources Management refers to the systematic management of electronic information resources throughout their lifecycle. ERM integrates administrative, technical, and user-focused activities to ensure seamless access and optimal utilization of digital resources.

ERM includes tasks such as selection, acquisition, licensing, access management, maintenance, evaluation, renewal, and cancellation of electronic resources. Effective ERM requires coordination among librarians, IT staff, vendors, and users.

LIFECYCLE OF ELECTRONIC RESOURCES

The lifecycle of electronic resources in academic libraries consists of several interconnected stages.

Selection

Selection of electronic resources is based on factors such as curriculum relevance, research needs, user demand, content quality, pricing, and compatibility with existing systems. Trial access and user feedback play an important role in selection decisions.

Acquisition and Licensing

Acquisition involves negotiating subscription terms and pricing models with vendors or publishers. Licensing agreements define access rights, usage restrictions, archival rights, and copyright compliance.

Access and Authentication

Libraries provide access to electronic resources through authentication methods such as IP-based access, proxy servers, and federated identity systems. Ensuring uninterrupted remote access is a key responsibility of libraries.

Maintenance and Troubleshooting

Maintenance involves monitoring resource availability, updating links, resolving access issues, and maintaining accurate metadata. Regular communication with vendors is essential for resolving technical problems.

Usage Evaluation

Usage evaluation involves analyzing statistics to assess the value and effectiveness of electronic resources. Usage data helps libraries make informed decisions regarding renewals and cancellations.

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Renewal or Cancellation

Based on usage data, cost-effectiveness, and user feedback, libraries decide whether to renew, renegotiate, or cancel electronic resource subscriptions.

TOOLS AND TECHNOLOGIES FOR ELECTRONIC RESOURCES MANAGEMENT

Several tools and technologies support ERM in academic libraries. These include Electronic Resource Management Systems (ERMS), Integrated Library Management Systems (ILMS), discovery tools, link resolvers, and usage statistics standards such as COUNTER. These tools help streamline workflows and improve access management.

CHALLENGES IN MANAGING ELECTRONIC RESOURCES

Despite their benefits, electronic resources present several challenges. These include high subscription costs, complex licensing terms, technical and access issues, dependence on vendors, preservation concerns, and the need for continuous staff training. Addressing these challenges requires strategic planning and collaboration.

STRATEGIES AND BEST PRACTICES FOR EFFECTIVE ERM

Academic libraries can adopt various strategies to improve ERM practices. These include developing clear collection development policies, participating in library consortia, regularly evaluating usage data, training library staff and users, promoting open access resources, and strengthening institutional repositories.

EMERGING TRENDS IN ELECTRONIC RESOURCES MANAGEMENT

Emerging trends in ERM include the growth of open access publishing, increased use of cloud-based library systems, application of artificial intelligence and data analytics, expansion of digital preservation initiatives, and a stronger focus on user-centered services.

CONCLUSION

Electronic resources have become indispensable components of academic libraries in the digital era. Effective electronic resources management is essential to ensure optimal utilization, cost-efficiency, legal compliance, and user satisfaction. By adopting systematic ERM practices, leveraging appropriate technologies, and embracing emerging trends, academic libraries can enhance their services and remain relevant in a rapidly changing information environment. A strategic and proactive approach to electronic resources management will continue to play a crucial role in supporting education, research, and knowledge dissemination.

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Digital Transformation & Innovation

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ABSTRACT

Digital transformation and innovation have greatly impacted how we produce, store, retrieve, and preserve information in today's knowledge society. The rapid growth of information and communication technology has led to the rise of digital libraries, e-resources, and digital preservation, which play a vital role in improving access to information and supporting lifelong learning. Digital transformation in libraries involves using current technologies like automation, cloud computing, artificial intelligence, and data management systems to boost efficiency and enhance the user experience. Innovation in library services allows libraries to move beyond their physical collections and develop dynamic, user-focused digital platforms.

Digital libraries are organized collections of digital resources, including e-books, e-journals, databases, multimedia, and institutional repositories, accessible at any time and from any location. E-resources are essential for education and research, offering up-to-date, accessible, and searchable information to users. They support remote learning, research, and the sharing of knowledge, thereby expanding the reach and effectiveness of library services.

Digital preservation is another important aspect of digital transformation that ensures the long-term accessibility, authenticity, and usability of digital resources. By employing systematic methods like data backup, format migration, and metadata management, digital preservation safeguards valuable information.

INTRODUCTION

The rise of digital transformation and innovation has changed the way we create, manage, and share information in today's knowledge economy. The fast growth of information and communication technology (ICT) has pushed libraries and information centers to rethink their traditional roles and shift to new models that are driven by ICT, focusing on accessibility, efficiency, and user engagement. As a result, libraries are increasingly seen as technology-supported knowledge centers that promote scholarly communication, teaching, learning, and research.

In this fast-changing environment, digital libraries, e-resources, and digital preservation serve as the four main pillars of digital transformation in the library and information sector. Digital libraries offer organized access to various electronic materials, including e-books, e-journals, databases, and institutional repositories, breaking the barriers of time and space. E-resources have become vital for the academic and research community by providing timely, searchable, and affordable information across different fields. Meanwhile, digital preservation ensures the long-term sustainability, integrity, and accessibility of digital resources through clear standards, policies, and technological methods.

Digital Transformation: Conceptual Framework and Importance

Digital transformation means integrating digital technology into all areas of a business. It fundamentally changes how an organization operates and delivers value to its stakeholders. Digital transformation goes beyond just using new technology. It involves changing organizational processes, culture, leadership, and business models. In today’s globalized world, with rapid technological advancements, digital transformation has become a key driver of sustainability, innovation, and growth.

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Conceptual Framework of Digital Transformation

The conceptual framework of digital transformation outlines the main aspects, forces, processes, and outcomes that contribute to an organization's transformation through digital technology. This framework helps us understand how value is created through digital initiatives.

1. *Technological Aspect*

This aspect focuses on adopting and using new digital technologies, including:

- Artificial Intelligence (AI)
- Big Data Analytics
- Cloud Computing
- Internet of Things (IoT)
- Blockchain and Automation

These technologies support real-time decision-making, improve efficiency, enable scalability, and drive innovation.

2. *Organizational Aspect*

Digital transformation requires significant changes in organizational structure, culture, and leadership. This includes:

- Digital leadership and vision
- Employee digital skills and training
- Agile organizational structures
- Change management processes

Organizations must foster a culture of innovation, collaboration, and learning.

3. *Process Dimension*

This dimension involves redesigning business processes to improve efficiency and customer value. The key factors are:

- Automation of processes
- Data-driven processes
- Integration of digital platforms
- Elimination of redundant manual processes

Digital enabled processes improve speed, accuracy, and customer service.

Importance of Digital Transformation

Digital transformation is crucial for today's organizations and economies. Its importance can be seen from different angles:

1. *Increased Operational Efficiency*

Automation and digital processes lower operational costs, reduce errors, and boost productivity. This helps organizations achieve greater efficiency with fewer resources.

2. *Better Customer Experience*

Digital transformation allows organizations to offer customers personalized, seamless, and responsive experiences. This leads to higher customer satisfaction and loyalty.

3. *Innovation and Business Model Evolution*

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Organizations can develop new products, services, and business models through digital platforms. This encourages innovation and adaptability in a fast-changing market.

Digital Libraries: Structure

Digital libraries are a complex type of information system that acquires, organizes, preserves, and offers access to digital information electronically. Unlike traditional libraries, digital libraries are not confined by geographic boundaries. They allow users to easily access information resources anytime and anywhere. With the growth of information and communication technology, digital libraries have become essential for modern education, research, and knowledge sharing.

Structure of Digital Libraries

The structure of a digital library consists of interconnected technology, organizational, and content-based components that work together to ensure effective access and management of information.

1. *Digital Content Layer*

This layer includes digital information such as:

- E-books and e-journals
- Theses and dissertations
- Multimedia resources (audio, video, images)
- Databases and datasets

The content can be created digitally or converted from physical resources.

2. *Metadata and Organization Layer*

Metadata describes digital information and supports effective search and retrieval. Some common metadata standards include:

- Dublin Core
- MARC 21
- MODS
- METS

This layer ensures consistency, interoperability, and effective information discovery.

Electronic Resources: Access Models and Use

Electronic resources, or e-resources, are vital to modern information systems, particularly in academic, research, and special libraries. These resources include electronic journals, e-books, online databases, digital repositories, and multimedia content. The fast growth of information and communication technology has changed access models and significantly impacted how information resources are used. Understanding access models and the use of electronic resources is crucial for effective resource management and user satisfaction.

Access Models of Electronic Resources

Access models define how users can reach electronic resources. Libraries adopt various models based on costs, licensing, user needs, and organizational goals.

1. *Subscription-Based Access Model*

In this model, libraries pay for subscriptions to electronic journals, databases, or e-book collections through regular fees. Access is limited to the duration of the subscription. This model is common in academic and research libraries. It provides access to current and peer-reviewed literature.

2. *Open Access Model*

Open access resources are available to users at no cost, without restrictions or technical barriers. This model promotes global knowledge sharing. It includes institutional repositories and open access journals. It boosts the visibility and citation rates of research.

Digital Preservation: Standards, and Policies

Digital preservation involves the processes and activities that keep digital information accessible, usable, authentic, and intact over the long term. The growing number of digital and digitized materials presents a significant challenge for libraries, archives, museums, and research institutions when it comes to maintaining these materials over time. Issues like outdated technology, media decay, and shifting user needs make digital preservation crucial for modern information management. It requires clear methods, international standards, and institutional policies.

Standards for Digital Preservation

Standards provide a systematic and compatible way to apply digital preservation techniques.

1. *OAIS (Open Archival Information System) Reference Model*

The OAIS (ISO 14721) Reference Model is a widely accepted conceptual model that outlines roles, responsibilities, and processes for digital preservation. It influences system design and policy creation. It focuses on long-term access and authenticity.

2. *PREMIS (Preservation Metadata: Implementation Strategies)*

PREMIS is a set of metadata standards for preservation. It captures technical, rights, and provenance metadata. It is essential for managing preserved digital objects.

3. *METS (Metadata Encoding and Transmission Standard)*

METS is used for the packaging and management of metadata for digital objects. It ensures interoperability. It enables interaction between digital repositories.

Digital Preservation Policies

Digital preservation policies provide guidance and support for digital preservation.

1. *Content Selection Policy*

This policy outlines the criteria for selecting digital content for preservation based on value, relevance, and legal issues.

2. *Access and Rights Management Policy*

This policy addresses copyright, licensing, and access rights for the preserved content.

3. *Preservation Strategy Policy*

This policy describes the preservation approach, storage, and technology update strategies.

4. *Security and Risk Management Policy*

This policy focuses on data security, backups, and disaster recovery strategies.

5. *Roles and Responsibilities Policy*

This policy defines staff roles and responsibilities for preservation tasks.

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Conclusion

Digital knowledge systems have become essential for education, research, and sharing information in the digital age. While these systems offer great opportunities for accessing information and promoting innovation and collaboration, they face increasing challenges. These include technological obsolescence, security risks related to data, interoperability issues, copyright concerns, and digital inequality. It is crucial to tackle these challenges to maintain the reliability, authenticity, and accessibility of digital knowledge.

For digital knowledge systems to last, we need to take a unified approach that emphasizes building strong technological infrastructure, developing financially sustainable models, investing in human skills, and creating effective policy frameworks. Using open standards, focusing on digital preservation, building capacity, and designing user-friendly systems are vital for ensuring the sustainability of these digital platforms. By proactively addressing new issues and integrating sustainability into planning and governance, we can keep digital knowledge systems as strong and inclusive platforms for knowledge creation and sharing in the future.

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Electronic Resources in the Digital Era: Trends and Challenges

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Abstract

The digital era has fundamentally transformed information access and delivery in academic institutions. Electronic resources (e-resources) have become an integral component of modern academic libraries, supporting teaching, learning, and research activities. These resources include electronic journals, electronic books, online databases, institutional repositories, and open access platforms. This paper presents a theoretical and analytical overview of electronic resources in the digital environment, with particular emphasis on emerging trends and challenges faced by academic libraries. Major developments such as the growth of open access publishing, consortia-based subscriptions, institutional repositories, integration of e-resources with learning management systems, and enhanced mobile and remote access are discussed. Simultaneously, libraries encounter challenges including escalating subscription costs, licensing and copyright restrictions, digital divide, inadequate ICT infrastructure, limited user awareness, information literacy gaps, and issues of digital preservation. The study emphasizes the need for strategic planning, user education, sustainable funding models, and collaborative initiatives to ensure the effective utilization of electronic resources. It concludes that despite existing challenges, electronic resources continue to play a transformative role in strengthening higher education and research in the digital era.

Keywords: Electronic Resources, Digital Era, Academic Libraries, Open Access, Information Literacy

Introduction

The rapid advancement of information and communication technologies (ICT) has significantly altered the production, storage, dissemination, and use of information. Academic libraries have evolved from traditional print-based repositories into hybrid or fully digital information centres. In this changing information landscape, electronic resources have emerged as a core component of library collections and services. Electronic resources offer instant and remote access to a vast array of scholarly information, thereby overcoming geographical and temporal limitations. Faculty members, research scholars, and students increasingly rely on e-resources for literature review, research output, and academic communication. The convenience, speed, and flexibility associated with electronic resources have resulted in their preference over traditional print materials. However, the transition from print to digital formats has also introduced several challenges. Issues related to high subscription costs, licensing restrictions, technological infrastructure, digital literacy, and long-term preservation continue to concern library professionals and policymakers. Understanding both the trends and challenges associated with electronic resources is therefore essential for effective academic library management. This paper provides a comprehensive theoretical overview of electronic resources in the digital era, focusing on their major trends and challenges.

Concept and Types of Electronic Resources

Electronic resources refer to information materials that are stored in digital format and accessed through electronic devices such as computers, tablets, and smartphones. These resources may be available online or offline and can be accessed locally within the library or remotely via the internet.

Types of Electronic Resources

Electronic resources commonly used in academic libraries include:

- **Electronic Journals (E-journals):** Scholarly journals available in digital format providing access to current and archival research articles.

- **Electronic Books (E-books):** Digital versions of books offering features such as full-text search, bookmarking, and annotation.
- **Online Databases:** Bibliographic, abstracting, indexing, and full-text databases covering various academic disciplines.
- **Open Access Resources:** Scholarly publications freely available without subscription or access barriers.
- **Institutional Repositories:** Digital platforms that preserve and disseminate the intellectual output of academic institutions.
- **Electronic Theses and Dissertations (ETDs):** Digitized postgraduate research works submitted by scholars.

Objectives of the Study

The objectives of the study are:

i To examine the concept and importance of electronic resources in the digital era.
ii To identify major trends in the development and use of electronic resources.
iii To analyze the challenges faced by academic libraries in managing e-resources.
iv To suggest strategies for effective utilization of electronic resources.

Trends in Electronic Resources in the Digital Era

Growth of Open Access Publishing

One of the most significant trends in the digital era is the expansion of open access (OA) publishing. Open access resources allow free and unrestricted access to scholarly literature, thereby increasing research visibility and impact. Governments, funding agencies, and academic institutions increasingly encourage open access initiatives to promote knowledge sharing.

Consortia based E-Resource Subscription

Due to rising subscription costs of commercial publishers, academic libraries have adopted consortia-based subscription models. Library consortia enable institutions to collectively negotiate licenses, reduce costs, and expand access to electronic resources. This collaborative approach has become a sustainable solution for resource sharing.

Institutional Repositories and Digital Archives

Institutional repositories have gained prominence as tools for preserving and disseminating institutional research output. They support open access, enhance institutional visibility, and ensure long-term access to scholarly content.

Integration with Teaching and Learning Platforms

Electronic resources are increasingly integrated with learning management systems (LMS) and virtual learning environments. This integration supports blended and online learning, enabling seamless access to digital content for academic communities.

Mobile and Remote Access

The widespread use of mobile devices has transformed access to electronic resources. Libraries now provide remote access facilities, allowing users to access e-resources anytime and anywhere, thus increasing usage and user satisfaction.

Challenges in the Use of Electronic Resources

High Subscription Costs

The escalating cost of electronic resource subscriptions poses a major challenge for academic libraries, especially in developing countries. Budget constraints limit access to essential scholarly content.

Licensing and Copyright Issues

Electronic resources are governed by complex licensing agreements that restrict usage, sharing, and archiving. Copyright and digital rights management issues often limit fair use and long-term access.

Digital Divide and Infrastructure Constraints

Inadequate ICT infrastructure, limited internet connectivity, and lack of access to digital devices contribute to the digital divide, affecting equitable access to electronic resources.

Lack of Awareness and Information Literacy

Many users lack adequate skills to effectively search, evaluate, and use electronic resources. Insufficient information literacy programmes reduce the optimal utilization of available resources.

Preservation and Long-Term Access

Digital preservation remains a significant challenge. Technological obsolescence and dependency on publishers raise concerns regarding the permanent availability of electronic content.

Strategies for Effective Utilization of Electronic Resources

To overcome the challenges associated with electronic resources, academic libraries should adopt the following strategies:

- Strengthening ICT infrastructure and ensuring reliable internet connectivity.
- Conducting regular orientation and information literacy programmes.
- Promoting open access initiatives and institutional repositories.
- Participating actively in library consortia.
- Developing clear licensing and digital preservation policies.

Conclusion

Electronic resources have become the backbone of academic library services in the digital era. They have transformed the way information is accessed and used, contributing significantly to teaching, learning, and research. While several trends indicate the growing importance of electronic resources, numerous challenges continue to hinder their effective utilization. Addressing these challenges requires coordinated efforts from librarians, institutions, policymakers, and publishers. With strategic planning, user-centric services, and sustainable practices, electronic resources can play a crucial role in strengthening higher education and research ecosystems.

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Content Management Analysis of Library Websites in Engineering Colleges in Coimbatore: An Evaluative Study

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ABSTRACT

Library websites have become essential digital gateways for accessing academic resources and services in engineering institutions. Effective content management plays a crucial role in ensuring usability, accessibility, accuracy, and user satisfaction. This study examines the content management practices of selected engineering college library websites in Coimbatore, using content analysis as a systematic research method. A descriptive and evaluative research design was adopted, and data were collected through direct observation using a structured evaluation checklist based on standard website assessment criteria. The analysis focuses on key components such as content coverage, organization, navigation, usability, accessibility, updating frequency, availability of e-resources, and interactive features. Descriptive statistical techniques were employed to identify strengths, weaknesses, and gaps across the selected websites. The findings reveal notable variations in content organization, maintenance, and user-oriented features, with several websites exhibiting issues related to outdated information, limited usability, and inadequate feedback mechanisms. The study highlights the importance of structured content management and user-centered design in enhancing the effectiveness of library websites. The paper concludes with practical recommendations to improve resource discoverability, usability, and overall performance of library websites, thereby supporting the academic and research needs of engineering students.

Keywords: Content Analysis, Library Websites, Content Management, Engineering College Libraries, Website Evaluation, Digital Library Services.

INTRODUCTION

Many research scholars undertake historical and conceptual studies in economics and related social sciences to understand the evolution of different schools of thought, such as institutional, neo-classical, and behavioural economics. These studies frequently examine paradigm shifts and changing research efforts using qualitative sources like interviews, letters, journals, and newspapers. Within such research, content analysis serves as a key data analysis technique. Given that much of social science and research involves verbal and non-verbal communication, content analysis has been widely applied in areas like consumer studies, media economics, and cultural economics to examine patterns in communication, market dynamics, and cultural representation, often in conjunction with statistical methods.

Historically, the foundations of quantitative content analysis were established by Learfield and Lasswell in the 1920s and 1930s, with early applications being time-consuming and limited to manual word counts. By the 1950s, more advanced approaches emerged, focusing on concepts and semantic relationships, a period marked by Berenson publishing the first major textbook in 1952. Throughout the latter half of the twentieth century, both quantitative and qualitative methodologies evolved to incorporate communication models and non-verbal analysis. Today, modern computing has rendered content analysis a more efficient, reliable, and methodologically robust tool.

CONTENT ANALYSIS

According to Berelson, content analysis is a research technique for the objective, systematic, and quantitative description of the manifest content of communication. The term content analysis is used here to mean the scientific analysis of communication messages. The method being “scientific” catholic in nature, requires that the analysis be rigorous and systematic. According to Paisley, content analysis is a phase of

information processing in which communication content is transformed through objective and systematic application of categorization rules into data that can be summarized and compared.

Content analysis, while certainly a method of analysis, is more than that, it is a method of observation. Instead of observing people's behaviour directly, or asking them to respond to scales or interviewing them, the investigator takes the communications that people have produced and asks questions of the communication **(Kerlinger, 1968)**

Content analysis refers to any procedure for answering the relative extent to which specified references, attitudes or themes permeate a given message or document **(Stone, 1964)**

LITERATURE REVIEW

Charles, Prasad and Mary (2024) examined the library web pages of India's top-ranked engineering institutions using content analysis based on earlier checklists. Their research focused on how these websites deliver quality services to support teaching, learning, and research in alignment with their institutions' vision and mission. Using a checklist categorized into basic library information, resources and services, website content, and adopted technologies, the authors collected data. Through percentage analysis, the study measured content quality and found significant variation in the quality of services and resources across institutions. This result underscores the need for greater standardization and improvement in library website content.

Devi and Verma (2018) conducted an evaluative study of engineering institution library websites by developing a comprehensive framework of 172 parameters and a five-point rating scale. The evaluation criteria utilized binary variables ("Yes" and "No"), with supplementary conditional parameters applied as necessary. Their analysis focused on the library websites of 19 Indian Institutes of Technology (IITs) and 29 National Institutes of Technology (NITs). The findings indicated that the IIT Kanpur library website achieved the highest rank, while the NIT Agartala website ranked the lowest among those evaluated. The authors emphasized that periodic website evaluation is crucial to ensure a proper structure, updated content, and effective information dissemination.

Gupta and Walia (2022) evaluated the library websites of selected state and deemed universities in Delhi to assess the effectiveness of their web-based information dissemination. Employing a comprehensive checklist of six major aspects and sixty-six elements, the study analyzed the availability of library information, resources, and services. The findings revealed that while general library information, collections, e-resources, and services were present, they were not provided comprehensively across all websites. The study also noted a minimal adoption of Web 2.0 tools, with very few libraries maintaining a social media presence or blogs. In the evaluation, the Delhi Technological University (DTU) website ranked highest, while the Indira Gandhi Delhi Technical University for Women (IGDTUW) website ranked lowest. The authors emphasized the necessity for dedicated, content-rich library websites, highlighting their potential to guide librarians in enhancing the quality and effectiveness of web services.

Hugar (2019) examined the impact of ICT-led developments on engineering college libraries, emphasizing the associated opportunities and challenges in creating, disseminating, promoting, and storing digital information. The study conducted a content analysis of the library websites of engineering colleges affiliated with Goa University, using a structured checklist. Its primary objective was to assess the effectiveness of these websites and to guide librarians in improving their web-based information services. The findings underscored the need to develop unique, well-structured library websites that effectively showcase individual library resources and services while also providing links to other reputable engineering and IIT library resources. The study concluded by offering practical suggestions for the design and management of effective library websites.

Indira (2022) examined the library websites of 68-degree colleges affiliated with Mahatma Gandhi University in Kerala, focusing on their role as gateways to academic and scholarly information. The study

assessed the availability of e-resources, Web OPAC, digital repositories, and value-added services. The findings revealed that only 50% of the colleges maintained active library websites offering Web OPAC and access to online resources. Consequently, the study recommended implementing features such as remote access to e-resources, Web OPAC, and other utility-based services to enhance the functionality and user-friendliness of these websites.

OBJECTIVE OF THE STUDY

- To analyze key features such as general information, resources, services, multimedia, search functionality and user interface on selected engineering college library websites.
- To assess the usability of these websites from an engineering student perspective, examining navigation, accessibility, content accuracy, and Web 2.0 features.
- To benchmark the websites against established standards to identify strengths, weaknesses, and gaps in content organization, maintenance, and feedback mechanisms.
- To formulate strategic recommendations for improving website efficiency, user-centered design, and resource discoverability for engineering college libraries in the Coimbatore region.

METHODOLOGY

The study adopts a **descriptive and evaluative research design** to assess the content management practices of library websites in selected engineering colleges in Coimbatore district. Engineering colleges with functional library websites are chosen using a **purposive sampling technique**. Collection of data of the library websites of selected institutes are done through Google search engine.

The following institutes with library websites are selected:

S.No	Name of the Engineering College Library	Abbreviations of college	Established year	URL
1	Karunya Institute of Technology and Sciences	KITS	1986	https://www.karunya.edu/library/question/banks
2	Amrita Vishwa Vidyapeetham Coimbatore	AMBE	1994	https://www.amrita.edu/school/engineering/coimbatore/resources/library/
3	Sri Krishna College of Engineering and Technology	SKCET	1998	https://skcet.ac.in/academics/library/

DATA ANALYSIS AND INTERPRETATION

This study, titled **"Content Management Analysis of Library Websites in Engineering Colleges in Coimbatore: An Evaluative Study,"** evaluates the content management practices of library websites at selected engineering colleges. Data were collected using a structured checklist to assess aspects such as general information, library services, digital resources, website design, content organization, accessibility, and interactive features. The data were analyzed using descriptive statistical techniques which including frequencies and percentages with results presented in tables and figures for clarity.

The analysis identifies strengths and weaknesses in current content management and highlights the state of website usability and efficiency in supporting academic and research needs. This chapter aims to provide insights into the effectiveness of these websites, establishing a foundation for discussion and offering recommendations to improve user engagement and information dissemination.

Table-1: General Information of Engineering College Libraries website/web page

General Information of Engineering College Libraries website																	
S. No	Name of the colleges	About the library	Mission/Statement/ Objective/ Aims	Library news and events	Library Hours	Library Rules	Membership Details	Library Advisory Committee	Library Brochure	Academic Calendar	Holidays	Achievements	Location of the library	Floor plan/Location Guide	Photo Gallery	Score	Percentage
1	KITS	1	1	0	1	1	1	0	1	0	1	0	1	0	1	9	64%
2	AMBE	1	0	1	1	1	0	0	1	0	1	1	1	0	1	9	64%
3	SKCET	1	1	0	1	1	1	0	1	1	1	0	1	0	0	9	64%

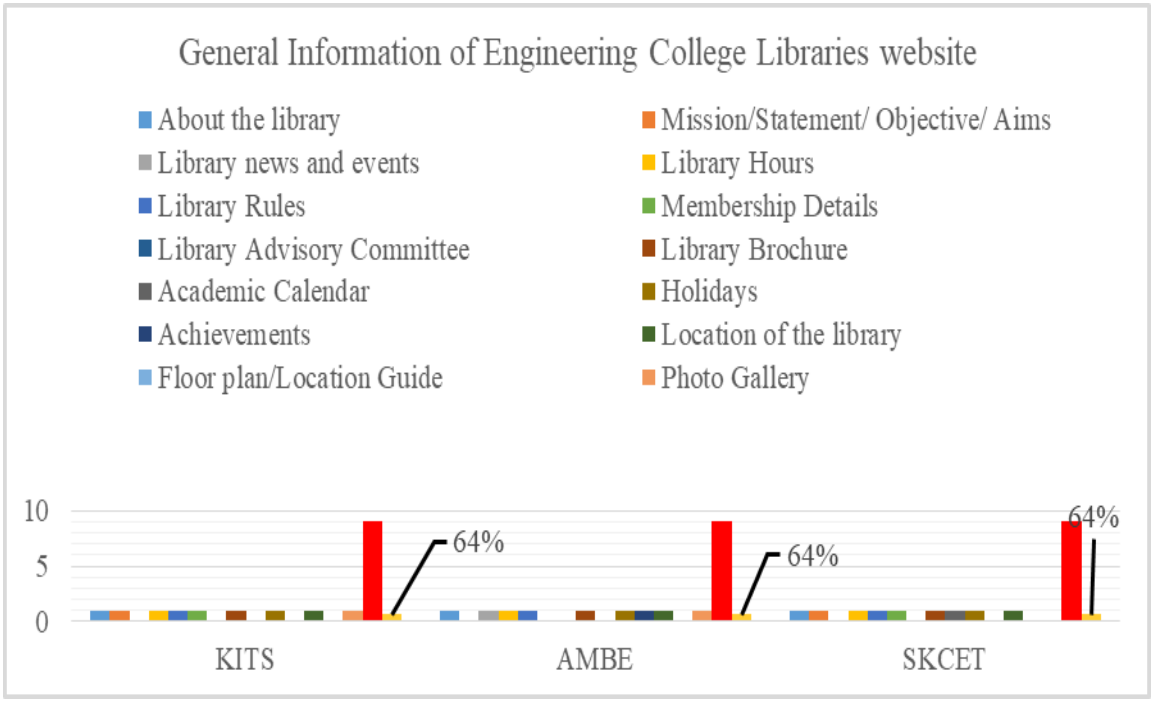


Figure-1: General Information of Engineering College Libraries website/web page

Interpretation

The table 1 shows all three library websites (KITS, AMBE, and SKCET) obtained an identical score of 64%, indicating a moderate level of availability of general library information. Basic elements such as about the library, library hours, rules, brochure, and location are consistently provided. However, the absence of information on library advisory committees and floor plans across all colleges reflects gaps in administrative and infrastructural transparency. Overall, the findings suggest that while essential information is present, library websites require further enrichment to achieve comprehensive coverage.

Table-2: Information about Library Services offered by Engineering colleges in the library

Information about Library Services																	
S. No	Name of the colleges	Circulation Service	Research & Reference Service	Referral Service	User education/orientation/awareness	Inter-library loan	Document Delivery Service	Bibliographic Service	Book Bank	Video viewing facility	Bulletin Board Service	Extension Service	Courseware	List of course reading materials	Online address book	Latest publication information (Faculty/students)	Score	Percentage
1	KITS	1	0	0	1	0	0	0	1	0	1	1	1	1	1	0	8	53%
2	AMBE	0	1	0	1	0	0	0	1	0	1	1	1	1	1	0	8	53%
3	SKCET	0	1	0	1	0	0	0	1	0	1	0	1	1	1	0	7	47%

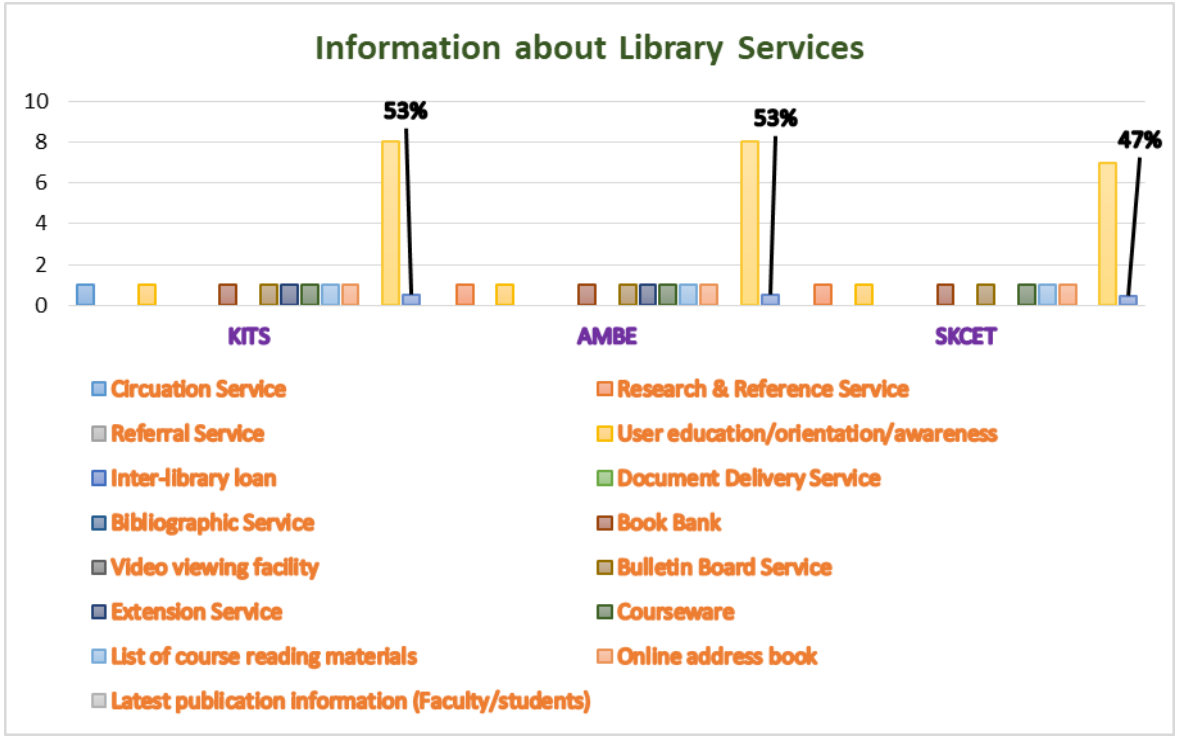


Figure-2: Information about Library Services offered by Engineering colleges in the library

Interpretation

The table 2 shows that KITS and AMBE recorded equal scores of 53%, whereas SKCET scored 47%, showing moderate visibility of library services. Services related to user education, book bank, bulletin board, courseware, and reading lists are commonly displayed, while inter-library loan, document delivery, and bibliographic services are completely absent. This indicates that traditional services are emphasized, but advanced support services remain underrepresented.

Table-3: Information about e-resources offered by Engineering colleges in the library

Information about e-resources													
S.No	Name of the colleges	E-Journal	E-Books	E-Databases	E-theses & dissertations	Institutional Repository	E-Question Paper	NPTEL Video Lecture	MOOC	Links to Library Networks	Library Consortium	Score	Percentage
1	KITS	1	1	1	1	1	1	1	0	1	0	8	80%
2	AMBE	1	1	1	0	1	0	1	1	1	0	7	70%
3	SKCET	1	1	1	0	1	1	1	1	1	0	8	80%

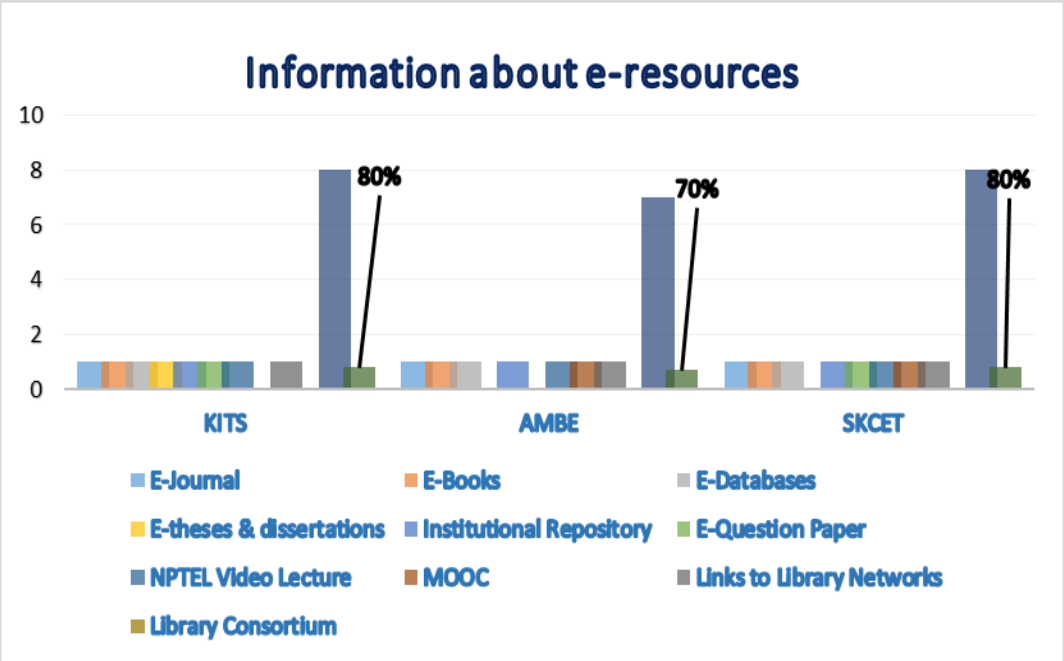


Figure-3: Information about e-resources offered by Engineering colleges in the library

Interpretation

The table 3 shows that KITS and SKCET achieved high scores of 80%, followed by AMBE with 70%, demonstrating strong representation of electronic resources. E-journals, e-books, databases, and institutional repositories are widely available. However, information on library consortia is absent in all cases. The results highlight good digital resource integration, with scope for strengthening collaborative resource sharing.

Table-4: Searching Features of Engineering college libraries' website/web page

Searching Features									
S.No	Name of the colleges	Site Search/ Search Engine	Keyword/ Field Search	Federated Search	Boolean Operators	Browse Option	History of Search Results	Score	Percentage
1	KITS	1	1	1	0	0	0	3	50%
2	AMBE	1	1	1	1	1	0	5	83%
3	SKCET	1	0	0	0	1	0	2	33%

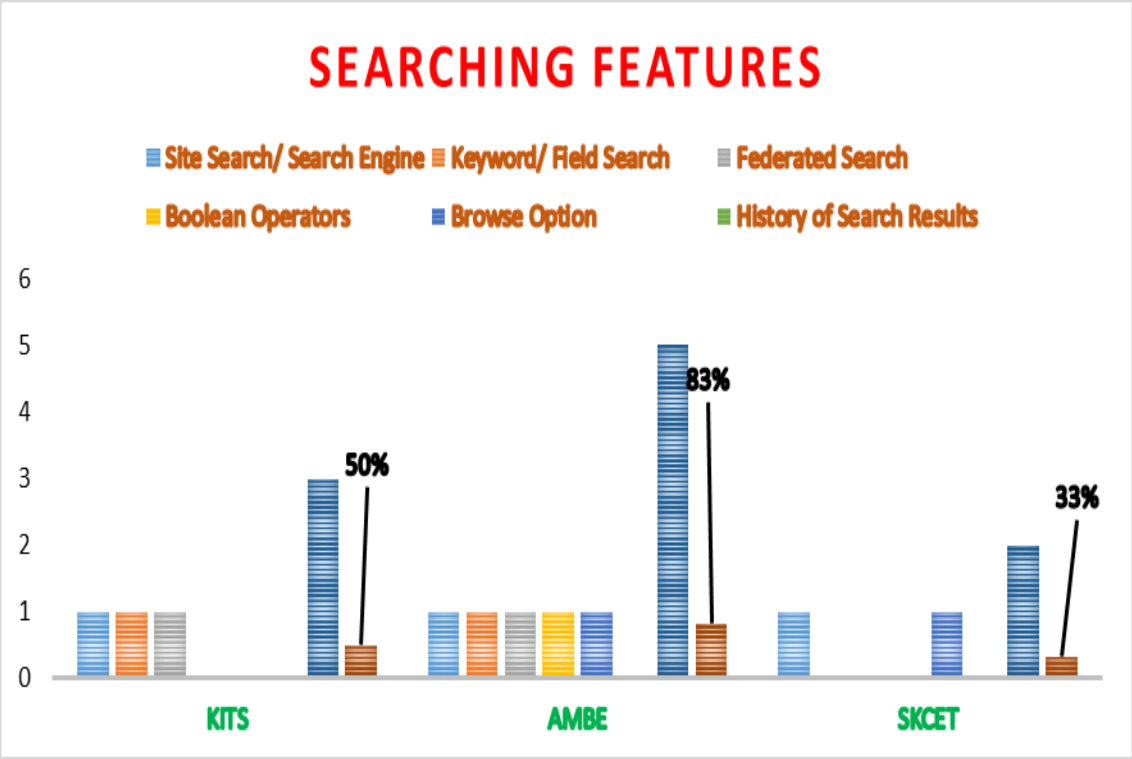


Figure-4: Searching Features of Engineering college libraries' website/web page

Interpretation

The table 4 shows that AMBE shows better provision of searching features (83%) compared to KITS (50%) and SKCET (33%). Although basic site search is available across all websites, advanced search functionalities such as Boolean operators and federated search are limited. This reflects a need to enhance search capabilities for improved information retrieval.

Table-5: Organization and Structure of Engineering colleges Library Websites

Organization and Structure											
S.No	Name of the colleges	Easy site accessible from different Web browsers	Site having font re-size/ colour options	Menu bar arranged in Dropdown Architecture (Integrated Homepage)	The organization scheme of a resource is appropriate	No password for accessing the Website	No language jargon for visitors	Using scroll left and right when reading content on the website	The title of the webpage appears on the top of the window bar	Score	Percentage
1	KITS	1	0	0	1	1	1	1	1	6	75%
2	AMBE	1	0	1	1	1	1	1	1	7	88%
3	SKCET	1	0	1	1	1	1	1	1	7	87%

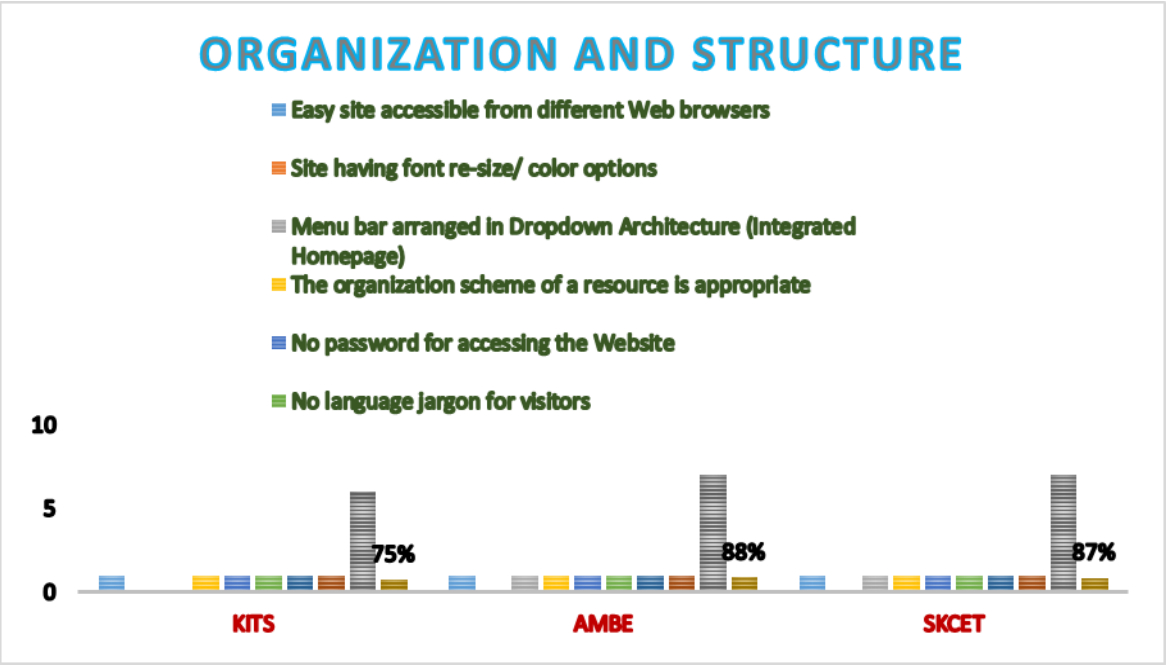


Figure-5: Organization and Structure of Engineering colleges Library Websites

Interpretation

The table 5 shows that AMBE (88%) and SKCET (87%) demonstrate better website organization than KITS (75%). All websites show satisfactory structural design and navigation. However, none provide font resizing or colour adjustment options, indicating limited accessibility support.

FINDINGS AND SUGGESTIONS

The study finds that library websites at engineering colleges in Coimbatore offer a moderate level of general and service-related information, with electronic resources more prominently featured than traditional or advanced library services. While resources such as e-journals, e-books, databases, and institutional repositories are widely accessible, essential services including inter-library loans, document delivery, bibliographic support, and referral services are notably underrepresented. Search functionality varies across institutions, with limited availability of advanced search options. Although the overall website organization and structure are satisfactory, basic accessibility features such as font resizing and color adjustment tools—are largely absent.

To address these gaps, it is recommended that engineering college libraries adopt a standardized and comprehensive content management framework. This should include clear documentation of all services, enhanced advanced search capabilities, integration of accessibility features, and regular content updates and evaluations. Greater emphasis on user-centered design and improved visibility of digital resources will further enhance the effectiveness of these websites in supporting academic and research activities.

CONCLUSION

The present study employs a structured content analysis approach to assess the content management practices of selected engineering college library websites in Coimbatore. Findings indicate that while most sites offer basic information and maintain a satisfactory organizational structure, they reveal significant gaps in advanced services, search functionalities, and accessibility features. The strong presence of electronic resources highlights positive strides toward digital library development; however, limited user-centered design and inconsistent content presentation diminish overall effectiveness. This study underscores the necessity of adopting standardized content management practices, implementing regular updates, and incorporating usability-oriented design to improve resource discoverability and user satisfaction. Strengthening these areas will allow engineering college library websites to serve as more effective portals for academic and research support.

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Design and Management of Digital Libraries in Academic and Research Institutions

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Abstract

Digital libraries have become an essential component of academic and research institutions, supporting teaching, learning, and scholarly communication in the digital age. The rapid growth of digital information, advances in information and communication technologies, and the increasing demand for remote access to knowledge resources have transformed traditional library systems into complex digital environments. This paper examines the design and management of digital libraries in academic and research institutions, focusing on their conceptual foundations, system architecture, resource organization, management practices, and challenges. The study highlights the role of digital libraries in enhancing access to information, supporting research activities, and ensuring long-term preservation of digital content. The paper is written in original academic language and aims to provide a comprehensive understanding of digital library design and management practices suitable for conference presentation.

Keywords: Digital Libraries, Academic Libraries, Research Institutions, Digital Library Design, Library Management

Introduction

The information landscape of the twenty-first century is characterized by rapid technological advancement and an unprecedented growth of digital content. Academic and research institutions increasingly rely on digital libraries to provide seamless access to scholarly resources, including e-books, e-journals, theses, research datasets, and multimedia materials. Unlike traditional libraries, digital libraries operate in a networked environment, enabling users to access information anytime and from anywhere.

The design and management of digital libraries require careful planning, technical expertise, and strategic decision-making. Issues such as system architecture, metadata standards, resource selection, copyright management, and user services play a critical role in determining the effectiveness of a digital library. This paper explores these aspects in detail, emphasizing the importance of well-structured design and efficient management for the sustainability of digital libraries in academic and research settings.

Concept of Digital Libraries

A digital library can be defined as an organized collection of digital resources supported by technological infrastructure and professional management to facilitate access, retrieval, and preservation of information. Digital libraries are not merely digitized versions of traditional libraries; they represent an integrated system that combines content, technology, and services.

In academic and research institutions, digital libraries support scholarly communication by providing access to peer-reviewed literature, institutional publications, and open access resources. They also play a vital role in preserving institutional knowledge, such as dissertations, project reports, and faculty publications, through institutional repositories.

Objectives of Digital Libraries in Academic and Research Institutions

The primary objectives of digital libraries in academic and research environments include:

- Providing timely and remote access to scholarly information

- Supporting teaching, learning, and research activities
- Preserving digital and digitized resources for long-term use
- Enhancing visibility of institutional research output
- Facilitating resource sharing and collaboration
- Improving efficiency in information storage and retrieval

These objectives guide the design and management strategies adopted by academic and research libraries.

Design of Digital Libraries

Planning and Requirement Analysis

The design of a digital library begins with systematic planning and requirement analysis. This involves identifying user needs, institutional goals, types of resources to be included, and technological capabilities. User studies, surveys, and consultations with faculty and researchers help in understanding information requirements.

Digital Library Architecture

Digital library architecture refers to the structural framework that supports content storage, access, and services. A typical digital library architecture includes:

- User interface layer
- Application and service layer
- Repository and database layer
- Network and hardware infrastructure

A well-designed architecture ensures scalability, interoperability, and system reliability.

Collection Development and Content Creation

Digital collection development involves selecting, acquiring, and creating digital resources. Content may be acquired through subscriptions, open access platforms, or digitization of print materials. Selection policies ensure relevance, quality, and alignment with institutional academic programs.

Metadata and Standards

Metadata plays a crucial role in resource discovery and retrieval. Standardized metadata schemes such as descriptive, administrative, and structural metadata support interoperability and efficient access. The use of consistent standards improves information organization and long-term usability.

Management of Digital Libraries

Organizational Structure and Staffing

Effective management of digital libraries requires skilled professionals with expertise in library science, information technology, and digital content management. Librarians play multiple roles as information managers, system administrators, and user educators.

Policy Framework

Clear policies are essential for managing digital libraries. Policies related to collection development, copyright, access control, preservation, and data security provide guidance for consistent decision-making and ethical practices.

Digital Rights Management

Managing intellectual property rights is a major responsibility of digital library management. Copyright compliance, licensing agreements, and fair use considerations must be carefully addressed to avoid legal issues.

User Services and Information Literacy

Digital libraries offer a range of user services, including reference support, document delivery, and training programs. Information literacy initiatives help users develop skills to effectively search, evaluate, and use digital resources.

Technologies Used in Digital Libraries

Digital libraries rely on various technologies such as:

- Digital repository software
- Database management systems
- Search and retrieval tools
- Networking technologies
- Cloud-based storage solutions

The selection of appropriate technologies influences system performance, usability, and sustainability.

Challenges in Design and Management

Despite their benefits, digital libraries face several challenges:

- High cost of digital resources and infrastructure
- Rapid technological obsolescence
- Long-term digital preservation issues
- Copyright and licensing restrictions
- Need for continuous staff training
- Ensuring data security and privacy

Addressing these challenges requires strategic planning, institutional support, and continuous evaluation.

Role of Digital Libraries in Research Advancement

Digital libraries significantly contribute to research advancement by providing access to current and high-quality scholarly information. They support interdisciplinary research, promote open access publishing, and enhance the global visibility of institutional research output.

Future Trends in Digital Libraries

The future of digital libraries is shaped by emerging technologies such as artificial intelligence, big data analytics, and semantic web applications. Personalized services, advanced search capabilities, and integration with research management systems are expected to enhance user experience and research efficiency.

Conclusion

The design and management of digital libraries are critical to the academic and research mission of modern institutions. A well-designed digital library, supported by effective management practices, enhances access to information, supports scholarly communication, and ensures the preservation of digital knowledge. As technology continues to evolve, academic and research libraries must adopt innovative approaches to remain relevant and sustainable in the digital era.

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Development of Modern Libraries in a Paperless Environment

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Abstract

The rapid growth of information and communication technologies has significantly transformed library operations, leading to the emergence of paperless library models. This paper explores the evolution of documentation from conventional manuscript and print formats to modern digital media. It analyses the impact of digitization and virtual libraries on contemporary information systems. The study highlights the growing importance of digital libraries, virtual platforms, microform technologies, and the Internet in improving the organization, storage, and accessibility of information. It concludes that the future development of libraries depends on the effective integration of advanced technologies to manage information resources efficiently, handles physical limitations, and meet the increasing demand for instant access to knowledge.

Keywords: Virtual Libraries, Information Technology, Knowledge Access, Library Automation.

Introduction

The present era is recognized as the information age, where information plays a vital role in social and educational development. Libraries have conventionally served as key institutions for collecting, organizing, and providing access to information. As society's information needs continue to grow, libraries are undergoing significant transformation.

Advancements in information and communication technologies have reshaped library operations, supporting the shift toward paperless environments. The concept of the library as a growing institution highlights the need for efficient management of expanding information resources. In this context, digital technologies and paperless practices help modern libraries overcome space limitations, improve access, and deliver timely information services

Evolution of writing materials

In the early stages of human civilization, information was recorded on limited and durable materials such as clay tablets, palm leaves, parchment, silk, and metal plates. The production of documents was minimal, and access to recorded knowledge was restricted to a small, privileged group. Libraries during this period functioned mainly as repositories for preserving rare and valuable documents.

The invention of paper and the introduction of printing technology revolutionized information creation and dissemination. The mass production of books and other printed materials led to a significant expansion of libraries and improved access to information. Educational and research institutions contributed greatly to the rapid growth of published knowledge across various disciplines.

In recent decades, the rate of information production has increased dramatically, especially in the fields of science and technology. This rapid expansion has placed considerable pressure on libraries in terms of storage, organization, and resource management. Traditional methods of handling information have become increasingly inadequate.

To address these challenges, modern libraries have embraced information and communication technologies. The transition from physical writing materials to digital formats, supported by computer technology, electronic storage, and online networks, has enabled libraries to manage information more efficiently. This evolution has laid the foundation for paperless library environments that offer improved access, reduced physical constraints, and enhanced information services.

Changes in the Physical Appearance of Documents

The physical form of documents in libraries has undergone significant changes due to advancements in information technology. Micrographic techniques have played an important role in reducing the size of traditional documents by converting them into compact formats such as microfilm, microfiche, magnetic tapes, optical disks, and digital storage media. These formats allow libraries to store large volumes of information in limited physical space.

The adoption of micrographic and electronic formats has helped libraries address challenges related to space, preservation, and efficient information management. As a result of these developments, scholars like F. W. Lancaster predicted the emergence of a paperless society, where information would primarily exist in electronic form.

However, it is widely acknowledged that both print and electronic documents are likely to coexist. While electronic publishing continues to grow rapidly, printed materials remain relevant for certain users and purposes. Despite this coexistence, the transformation in the physical appearance of documents represents a crucial step in the evolution of modern libraries toward a paperless environment.

Digitization of Records

Modern libraries are moving beyond traditional physical collections by adopting digital and electronic systems. In these digital libraries, documents are stored in electronic formats, making information more accessible and complementing traditional resources.

Global initiatives have greatly contributed to the development of digital libraries. For example, the TULIP project in 1992 brought together scholars from multiple universities to design digital libraries for scientific publications. Similarly, the U.S. National Library launched a project in 1994 to convert millions of records into digital form.

Digital libraries enable users to access information anytime through networked systems. They use multimedia, hypertext, hypermedia, and expert systems to make searching and retrieving information more efficient. Essentially, a digital library acts as a virtual repository of computer-readable publications and data, providing users with seamless access to vast knowledge. By linking libraries electronically, digital libraries represent a crucial step toward modern, paperless library environments.

Virtual Libraries

Technological advancements have enabled libraries to evolve beyond physical constraints, giving rise to virtual libraries collections that exist entirely in digital form without physical books or buildings. Frequently referred to as 'libraries without walls' or 'libraries without physical collections', virtual libraries allow users to access information anytime and from anywhere via the Internet.

Virtual libraries allow individuals to create personalized collections by gathering digital resources from multiple sources. They use multimedia and virtual reality technologies to provide users with an immersive experience similar to navigating a physical library. Users can browse, read, and even print digital books, simulating physical interaction with resources.

One of the earliest examples of a virtual library was developed by Hooks using hypermedia technology. This system enabled users to explore the Florida University Library's data bank through a graphical interface, selecting and reading digital books as if moving through the library physically. While fully digitizing all library resources remains challenging due to cost and complexity, virtual libraries have become a major component of modern, paperless library systems.

By reducing reliance on physical collections and expanding global access to knowledge, virtual libraries are a key milestone in the development of paperless library systems.

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Internet: The Data Superhighway of Information

The Internet is a global digital network that allows rapid exchange and access to vast amounts of information. Information can be stored on any computer connected to the Internet in the form of web pages, which can then be accessed from anywhere at any time. Because of its speed, accessibility, and virtually unlimited resources, the Internet is often referred to as the "Information Superhighway."

The Internet is open, decentralized, and accessible globally through appropriate hardware and software. It enables users to read books, journals, articles, and other resources online, making information widely available beyond the limitations of physical libraries. Today, the Internet serves as a vast repository of knowledge across all subjects, allowing users to search, store, transmit, and print information whenever needed.

The development of the World Wide Web (WWW) has further enhanced the Internet's capabilities, enabling not only text but also images, audio, and multimedia content to be accessed seamlessly. For modern libraries, the Internet has become a critical tool in supporting paperless library systems, digital collections, virtual libraries, and remote access to knowledge. By integrating online resources and digital tools, libraries can meet the growing demand for instant, global, and efficient access to information in the paperless era.

Conclusion

The rapid advancement of technology is transforming libraries toward a fully paperless future. Modern libraries can no longer serve only as repositories for physical collections; they must efficiently manage digital resources and provide users with seamless access to information across multiple platforms.

Libraries are evolving from large, space-intensive institutions into compact, digitally empowered centres of knowledge. Digital libraries, virtual libraries, and wall-free libraries have greatly enhanced information accessibility, allowing users to retrieve, store, and interact with information in real time from anywhere.

To remain relevant, libraries must adopt technological innovations, modernize operations, and integrate digital tools into their services. Paperless libraries enable global knowledge sharing, support interactive learning, and ensure that libraries continue to serve as vital centres of learning and information in an increasingly digital world.

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Awareness of Digital Transformation and Innovation in Electronic Information Access among Agricultural College Students in Tamil Nadu

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Abstract

The advancement of information and communication technology (ICT) has transformed information access in higher education, particularly in agricultural education. This study examines electronic information access patterns among agriculture students in selected regions of Tamil Nadu, focusing on awareness, usage behavior, digital literacy, and access barriers. A mixed-methods approach was adopted, involving a survey of 400 undergraduate and postgraduate students from agriculture colleges in Coimbatore, Tiruchirappalli, and Namakkal districts, complemented by interviews and focus group discussions. The findings reveal high reliance on general electronic resources such as Google Scholar and video-based platforms, while specialized agricultural databases remain underutilized. Notable gaps were identified in digital literacy skills, especially in database searching and critical evaluation of sources. Infrastructure constraints, including limited internet connectivity and off-campus access, further affect effective resource utilization. The study highlights the need for targeted digital literacy training, improved infrastructure, and curriculum-integrated information literacy initiatives to enhance effective use of electronic information resources in agricultural higher education.

Keywords: Electronic Information Resources, Agriculture Students, Information Access Behavior, Digital Literacy, Higher Education in Agriculture, Tamil Nadu

Introduction

The advancement of information and communication technology (ICT) has fundamentally transformed the way student's access, retrieve, and utilize information resources in academic institutions. In the context of higher education, particularly in specialized domains such as agriculture, the transition from traditional print-based information sources to digital platforms has become inevitable. Agriculture colleges, which play a crucial role in imparting practical and theoretical knowledge to the next generation of agricultural professionals, have witnessed a paradigm shift in their information service delivery mechanisms. The integration of electronic information resources—including online journals, e-books, databases, and institutional repositories—has created new opportunities and challenges for both educators and learners. Understanding the electronic information access patterns among agriculture students is essential to optimize library services, enhance learning outcomes, and bridge the digital divide that may exist across different regions. This study examines the electronic information access patterns among students in selected agriculture colleges across different regions of Tamil Nadu, a state that is a significant contributor to India's agricultural sector and home to several premier agricultural institutions.

Background and Context

Agriculture is a discipline that requires continuous learning and engagement with both traditional knowledge and contemporary innovations. Agriculture students must access a wide range of information sources to understand soil management, crop production, pest management, agricultural economics, and emerging sustainable farming practices. Traditionally, agriculture libraries served as the primary source of information, with students relying on textbooks, journals, and expert consultations. However, the digital revolution has introduced multiple electronic platforms and databases that provide access to cutting-edge research, global best practices, and real-time agricultural data. Tamil Nadu, with its diverse agro-climatic zones and significant agricultural output, hosts several reputable agriculture colleges that have invested in digital infrastructure and electronic resources. However, the effectiveness of these resources depends significantly on students' awareness,

skills, and actual usage patterns. This background necessitates a systematic examination of how agriculture students in Tamil Nadu are currently utilizing electronic information resources and what factors influence their access patterns.

Significance of the Study

The significance of this study lies in multiple dimensions. First, it addresses a research gap in understanding information seeking behavior specific to agriculture students, a domain that has received relatively less attention compared to general higher education studies. Second, the study focuses on a regional context (Tamil Nadu), which allows for an examination of local educational infrastructure, resource availability, and student demographics. Understanding these patterns will help agriculture colleges in Tamil Nadu optimize their information resource allocation and develop targeted digital literacy programs. Third, the findings can inform policy-making at institutional and state levels regarding investment in electronic resources and training initiatives. Furthermore, as agriculture faces challenges related to climate change, resource sustainability, and food security, equipping students with effective information access skills becomes critical for developing innovative solutions. The study also contributes to the broader discourse on digital equity in higher education, particularly in professional disciplines.

Objectives of the Study

The study aims to achieve the following objectives:

- To examine the level of awareness use of electronic information resources among agriculture students
- To examine the level of frequency of use of electronic information resources among agriculture students

Literature Review

The rapid expansion of electronic information systems has significantly transformed the way higher education students access, evaluate, and utilize academic resources, particularly in professional disciplines such as agricultural education. Studies on hybrid and technology-mediated learning environments reveal that personalized digital platforms enhance student engagement and academic performance by adapting content delivery to individual learning behaviors (Khadidos et al., 2025) The integration of advanced digital technologies has also raised concerns regarding information credibility and security, with research emphasizing the role of artificial intelligence–based mechanisms in safeguarding evolving information systems (Selvarajan et al., 2025) Digital transformation frameworks, including virtual reality and immersive systems, further influence how students interact with electronic learning materials and institutional information services (Shitharth et al., 2023)

Methodology

The study adopted a **descriptive survey research design** to assess the awareness and frequency of electronic information resource usage among agriculture students. A sample of **400 students** was selected using **stratified random sampling** to ensure proper representation. Data were collected through a **structured questionnaire** covering awareness, types of resources, frequency of use, and related issues. The questionnaire was administered online and in print. Collected data were analyzed using **descriptive statistical tools** such as frequency and percentage, and ethical standards were strictly followed throughout the study.

Data Analysis Methods

Table 1: Key Methodological Features Summary

Component	Details
Design	Mixed-methods (Quantitative + Qualitative)

Population	Agriculture students in Coimbatore, Tiruchirappalli, Namakkal districts, Tamil Nadu
Sample Size	400 students (surveys), 40 students (interviews), 5 FGDs (40-50 participants)
Sampling Method	Stratified random sampling (by college, level, year)
Instruments	Structured questionnaire (45 items), Semi-structured interviews, Focus group discussions
Quantitative Analysis	Descriptive statistics, Chi-square, t-tests, ANOVA, Pearson correlation (SPSS v26)
Qualitative Analysis	Thematic analysis (Braun & Clarke six-phase approach)
Validity & Reliability	Pilot testing, Cronbach's alpha ($\alpha = 0.82$), Member checking, Triangulation
Data Collection Period	January – June 2024
Ethical Considerations	Informed consent, Confidentiality, Anonymity, Audio recording with consent

Table 1 shows the mixed-methods design enabled a comprehensive analysis of electronic information access by integrating quantitative usage data with qualitative insights. Stratified random sampling ensured representative coverage across regions, academic levels, and institutions. The sample size was sufficient for statistical validity and in-depth exploration. Reliable instruments ($\alpha = 0.82$) and rigorous analytical techniques strengthened the credibility of findings. Ethical procedures, pilot testing, and triangulation ensured data accuracy and research integrity.

Table 2: Awareness and Frequency of Electronic Information Resource Usage Among Agriculture Students (N=400)

Electronic Information Resources	Aware of Resource (%)	Never Use (%)	Occasionally Use (%)	Frequently Use (%)	Very Frequently Use (%)
Online Scholarly Journals (e.g., JSTOR, ProQuest)	87.5	8.2	24.3	38.5	28.9
E-books and Digital Repositories	84.3	12.1	31.6	35.8	20.5
Agricultural Databases (e.g., AGRICOLA, CAB Abstracts)	72.8	18.4	29.6	32.2	19.8
Open Access Resources (e.g., Directory of Open Access Journals – DOAJ)	68.5	21.3	35.2	28.4	15.1
Institutional Repository/Library Catalogue (Online)	91.2	6.5	18.9	42.1	32.5
Google Scholar and Search Engines	98.2	1.2	8.4	28.3	62.1

Social Media for Academic Content (ResearchGate, Academia.edu)	79.6	14.7	33.8	35.2	16.3
Government Agricultural Websites (ICAR, State Department)	81.4	11.2	26.5	39.8	22.5
Video Tutorials and Webinars (YouTube, MOOCs)	94.1	5.3	15.6	41.2	38.0
Mobile Applications for Agriculture Information	65.2	24.8	38.1	27.3	9.8

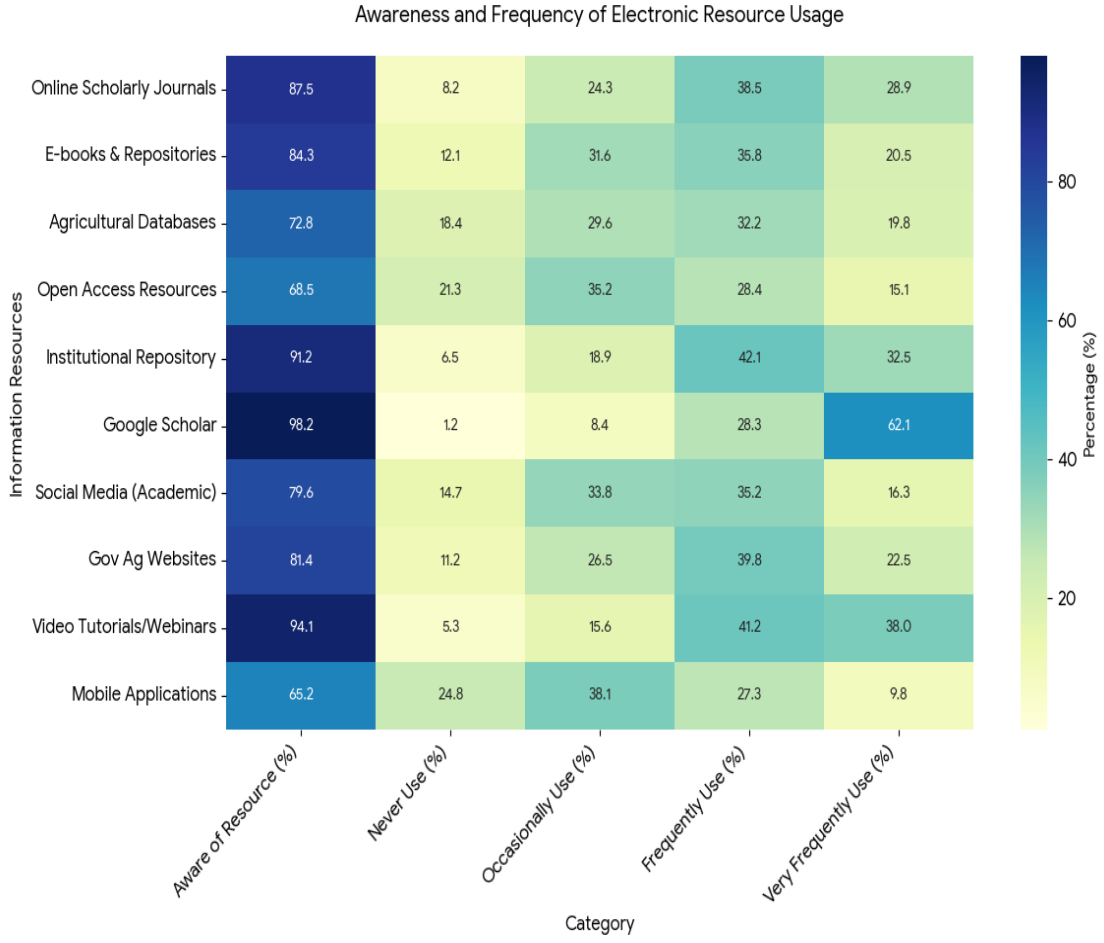


Figure 2: Awareness and Frequency of Electronic Information Resource Usage among Agriculture Students

Table.2 Shows the data indicate a high level of awareness and usage of general electronic information resources among agriculture students. Google Scholar and search engines show the highest awareness (98.2%) and very frequent usage (62.1%), highlighting students' strong preference for easily accessible and familiar platforms. Similarly, video tutorials and webinars demonstrate high awareness (94.1%) and frequent to very frequent usage (79.2% combined), reflecting the growing reliance on visual and self-paced learning tools.

Institutional repositories and online library catalogues also record high awareness (91.2%) and substantial frequent usage (74.6%), suggesting effective integration of library-provided digital services. Online

scholarly journals and e-books show moderate to high usage, indicating their importance for academic purposes, though a segment of students still access them only occasionally.

In contrast, specialized agricultural databases and open-access resources exhibit lower awareness and higher non-usage rates, with over 18% of students never using agricultural databases and 21.3% not using open-access platforms. Mobile applications for agricultural information record the lowest awareness (65.2%) and the highest non-usage rate (24.8%), indicating limited adoption for academic use.

Overall, the findings reveal a preference for general-purpose and multimedia resources over specialized scholarly databases, emphasizing the need for increased awareness, training, and promotion of discipline-specific electronic information resources among agriculture students.

Conclusion

This study examined electronic information access patterns among agriculture students in selected regions of Tamil Nadu, focusing on awareness, usage behavior, digital literacy, and access-related challenges. The findings indicate that while agriculture students demonstrate high awareness and frequent use of general electronic information tools such as Google Scholar, video tutorials, and institutional repositories, there is comparatively lower utilization of specialized agricultural databases and open-access scholarly platforms that are critical for discipline-specific learning and research. This imbalance suggests a reliance on easily accessible general resources rather than authoritative subject-focused databases.

The study also revealed notable gaps in students' digital literacy skills, particularly in advanced database searching, critical evaluation of information sources, and reference management. These skill deficiencies limit students' ability to effectively exploit available electronic resources for academic and research purposes. Infrastructure-related constraints, including inadequate internet connectivity and limited off-campus access, further impede effective electronic information usage, especially for students in certain regions.

Regional variations in electronic information access patterns highlight disparities in institutional infrastructure, training support, and resource availability across agriculture colleges in Tamil Nadu. These differences underscore the importance of context-specific interventions rather than uniform solutions.

Overall, the findings emphasize that the mere provision of electronic information resources is insufficient to ensure effective utilization. There is a pressing need for integrated digital literacy training, improved technological infrastructure, enhanced awareness of specialized agricultural databases, and curriculum-embedded information literacy programs. Strengthening these areas will enable agriculture students to engage more effectively with contemporary research, support evidence-based agricultural practices, and contribute meaningfully to sustainable agricultural development in Tamil Nadu.

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From Print to Platform: Digital Transformation of Libraries through E-Resources and Digital Preservation

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ABSTRACT

The transformation of libraries from print-oriented institutions to digitally driven knowledge platforms represents one of the most profound shifts in the history of information management. Rapid advancements in information and communication technologies have reshaped the way knowledge is created, stored, accessed, and shared. In response to these changes, libraries across the world are redefining their roles to meet the evolving expectations of users who increasingly depend on electronic access to information. This paper examines the digital transformation of libraries with a special focus on the expansion of e-resources and the growing importance of digital preservation. It discusses how libraries are moving beyond physical collections to become integrated digital platforms that support education, research, innovation, and lifelong learning. The paper also highlights the benefits, challenges, and future directions of this transformation, emphasizing the need for strategic planning, innovation, inclusivity, and sustainability in modern library practices.

Keywords: Digital Transformation, Libraries, E-Resources, Digital Preservation, Knowledge Platforms, Innovation

INTRODUCTION

Libraries have historically served as custodians of recorded knowledge and as essential support systems for education, research, and cultural development. For centuries, their primary focus was on the acquisition, organization, preservation, and circulation of printed materials such as books, journals, manuscripts, and newspapers. Access to information was largely dependent on physical presence within library spaces, and services were constrained by time, location, and availability of materials.The rapid growth of digital technologies, particularly the internet, mobile devices, and cloud-based systems, has fundamentally altered the information environment. In today's digital society, users expect information to be available instantly, remotely, and in formats that are easy to search, share, and reuse. These changing expectations have compelled libraries to transform their traditional service models and adopt new approaches to information management. The shift from print to platform reflects a broader transformation in which libraries are no longer confined to physical collections but function as dynamic digital ecosystems.

Digital transformation has enabled libraries to expand access to knowledge, improve service efficiency, and remain relevant in a competitive information landscape dominated by commercial search engines and digital content providers. The integration of e-resources and the implementation of digital preservation strategies have emerged as central components of this transformation. This paper explores the digital transformation of libraries by examining the role of e-resources and digital preservation in reshaping library services and ensuring long-term access to knowledge.

DIGITAL TRANSFORMATION IN THE LIBRARY CONTEXT

Digital transformation in libraries refers to a comprehensive and ongoing process in which digital technologies are embedded into all areas of library operations and services. Unlike automation, which focuses primarily on improving efficiency through the use of technology, digital transformation involves rethinking traditional library goals, workflows, and service models. It emphasizes adaptability, innovation, and a strong

focus on user needs. In the library context, digital transformation includes the digitization of print collections, the adoption of electronic resources, the development of online discovery tools, and the establishment of digital repositories and archives. It also involves redefining the roles of library professionals, who increasingly act as digital curators, information literacy trainers, data managers, and technology partners within academic and research communities.

Innovation plays a vital role in enabling digital transformation. Libraries are experimenting with emerging technologies such as artificial intelligence–based search tools, cloud computing, big data analytics, and mobile applications to enhance service delivery. At the same time, digital transformation requires organizational and cultural change, including continuous professional development and a willingness to embrace new ways of working.

EVOLUTION FROM PRINT LIBRARIES TO DIGITAL PLATFORMS

Traditional print libraries were largely space-bound institutions where access to information required physical visits and manual searching of catalogs and shelves. While print collections continue to hold scholarly, cultural, and historical value, their limitations in terms of accessibility, storage, and scalability have become increasingly evident in the digital age. The emergence of digital platforms has addressed many of these limitations by enabling remote access, efficient information retrieval, and personalized services. Digital platforms in libraries integrate multiple services such as online public access catalogs, e-resource portals, institutional repositories, digital archives, and virtual reference services. These platforms allow libraries to provide uninterrupted access to information and support users across geographical boundaries. The shift from print to platform has also expanded the role of libraries from being passive storehouses of information to becoming active participants in knowledge creation, dissemination, and preservation. Users now interact with libraries through websites, mobile applications, and digital interfaces, making usability, accessibility, and inclusivity critical considerations in service design.

E-RESOURCES AS THE CORE OF DIGITAL LIBRARY SERVICES

Electronic resources have become the backbone of digitally transformed libraries. E-resources are information materials that are created, stored, and accessed in digital formats, offering flexibility, convenience, and immediacy to users.

Types of E-Resources

Libraries provide access to a wide range of e-resources, including e-books, e-journals, online bibliographic and full-text databases, electronic newspapers and magazines, open educational resources, and institutional repositories. In addition, multimedia resources such as video lectures, podcasts, webinars, and research datasets are increasingly incorporated into digital collections. The diversity of e-resources enables libraries to meet the varied academic, professional, and personal information needs of users.

Role of E-Resources in Teaching and Learning

E-resources play a crucial role in supporting teaching and learning processes in educational institutions. They complement traditional classroom instruction by providing access to up-to-date learning materials and reference sources. E-resources support innovative pedagogical approaches such as blended learning, flipped classrooms, and online education by ensuring continuous access to course-related content.

For students, e-resources promote independent learning and critical thinking by enabling them to explore multiple sources of information. For educators, they provide opportunities to integrate diverse and current materials into the curriculum.

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Role of E-Resources in Research and Scholarly Communication

In the research context, e-resources are indispensable tools for accessing current literature, research data, and scholarly communication channels. E-journals and online databases enable researchers to stay informed about recent developments in their fields. Institutional repositories support the dissemination of research outputs and enhance the visibility and impact of scholarly work.

Advantages of E-Resources

The advantages of e-resources include round-the-clock availability, simultaneous multi-user access, and efficient search and retrieval capabilities. E-resources reduce the need for physical storage space and facilitate quick updates, ensuring access to the most recent information. Advanced features such as hyperlinks, cross-referencing, and multimedia integration significantly enhance the user experience.

Challenges in Managing E-Resources

Despite their benefits, e-resources present several challenges for libraries. High subscription costs, complex licensing agreements, and dependence on reliable internet connectivity can limit access. Digital rights management restrictions may affect fair use and long-term access. Additionally, digital literacy gaps among users and staff can hinder effective utilization. Libraries must adopt systematic e-resource management practices, including user training, license negotiation, usage analysis, and consortia-based purchasing, to address these challenges.

DIGITAL PRESERVATION: ENSURING LONG-TERM ACCESS TO KNOWLEDGE

AS libraries increasingly rely on digital content, digital preservation has become a critical responsibility. Digital preservation refers to the policies, strategies, and actions undertaken to ensure that digital information remains accessible, authentic, and usable over time.

Importance of Digital Preservation

Digital resources are vulnerable to technological obsolescence, data corruption, cyber threats, and accidental loss. Without proper preservation measures, valuable digital content may become inaccessible or unusable. Digital preservation ensures the longevity and reliability of digital collections, safeguarding scholarly, cultural, and institutional heritage.

Digital Preservation Strategies and Techniques

Libraries employ a variety of strategies to preserve digital content effectively. These include regular data backup, format migration, emulation, and the use of standardized, non-proprietary file formats. Metadata creation and management play a crucial role in documenting preserved resources and ensuring their discoverability. Digital repositories, trusted digital archives, and preservation frameworks further support systematic preservation efforts.

Role of Libraries in Digital Preservation

Libraries act as trusted custodians of digital knowledge and play a central role in preserving academic and cultural heritage. By developing preservation policies, adhering to international standards, and collaborating with national and international agencies, libraries can ensure the sustainability of digital resources. Digital preservation also strengthens institutional memory and supports future research and learning.

BENEFITS OF THE PRINT-TO-PLATFORM TRANSFORMATION

The digital transformation of libraries offers numerous benefits to institutions and users alike. It enhances access to information, improves service efficiency, and supports personalized user experiences. Digital platforms enable libraries to reach wider and more diverse audiences, including remote and underserved communities. Furthermore, digital transformation increases the visibility of institutional research output and

supports open access initiatives. From an environmental perspective, reduced reliance on paper-based processes contributes to sustainability.

CHALLENGES IN THE TRANSITION FROM PRINT TO PLATFORM

Despite its advantages, the transition from print to platform presents several challenges. Limited funding, inadequate technological infrastructure, and resistance to organizational change can hinder digital initiatives. Legal and ethical issues related to copyright, intellectual property rights, data privacy, and information security also require careful consideration. The digital divide among users remains a significant concern, necessitating inclusive policies, digital literacy programs, and user support services.

FUTURE DIRECTIONS OF DIGITALLY TRANSFORMED LIBRARIES

The future of libraries lies in their ability to adapt continuously to technological and societal changes. Emerging technologies such as artificial intelligence, machine learning, blockchain, and virtual and augmented reality are expected to further enhance library services and user engagement. Libraries are likely to focus on personalized information delivery, collaborative digital platforms, research data management, and evidence-based decision-making. As knowledge platforms, libraries will continue to support lifelong learning, research, innovation, and community engagement in the digital era.

CONCLUSION

The journey from print to platform represents a fundamental transformation in the way libraries manage, disseminate, and preserve knowledge. The integration of e-resources and the adoption of digital preservation practices have significantly enhanced access to information and ensured the long-term sustainability of digital content. Although challenges related to technology, funding, skills, and policy persist, the benefits of digital transformation far outweigh the limitations. Libraries that embrace innovation, strategic planning, inclusivity, and user-centered approaches will remain vital knowledge platforms in the evolving digital information landscape.

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Tamil Development, Learning and Teaching on Computers

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Abstract

Human languages are the astonishing creations of the human brain. Human society has continuously strived to develop the unique linguistic ability of the human brain. The result of this effort is the written forms of languages. The written form of language is the first language technology created by humankind. Languages that have progressed through various stages of development are being further modernized. Among them, Tamil is a notable language. After English, Tamil is the most widely used language in computers. Learning and teaching continue with us throughout our lives. It changes according to the times and circumstances. We can see many changes between the computers of the time they were invented and the computers we have today. We consider these changes as the development of computers. The computer has become an indispensable tool for learning and teaching today. The computer is used in many ways in the field of education compared to other fields.

The use of the Tamil language in computers has increased. We are using the computer as a tool to learn and teach the Tamil language. The computer easily facilitates teaching and learning grammar without difficulty. Today, the computer is making a significant contribution to the development of the Tamil language. This article attempts to examine how teachers use computers for teaching.

Keywords: Tamil computing, Internet, Teaching, Software, Websites

Introduction

Human languages are the astonishing creations of the human brain. Human society has continuously strived to develop the linguistic ability, a special skill of the human brain. The result of this effort is the written forms of languages. The written form of language is the first language technology created by humankind. Languages that have surpassed various stages of development are being further modernized. Tamil is a notable language among them. Tamil is used in computers second only to English. This article examines the development of Tamil in computing.

Early Development of Tamil in Computing

Facilities for inputting Tamil into computers, Tamil fonts, and keyboards were all created about thirty years ago. A facility was also created to input Tamil text using Roman characters and then convert it into Tamil script. Software and fonts like Adami were created. As the next stage of development, Tamil keyboards were created. This resulted in the facility to directly input Tamil into the computer.

Tamil Computing

How learning and teaching become easier using computers, and how it paves the way for new inventions, can be understood in the following sections. The computer has become indispensable for learning and teaching today. Tamil computing is now used in all schools, colleges, educational institutions, and government offices. Educational institutions teach students learning Tamil the use of computers in Tamil itself. Tamil language can be taught through computer using both offline and online modes.

The Tamil Internet Academy is currently offering various Tamil degrees and diplomas through online learning. Through this, students who have received degrees are creating simple methods for computer-based teaching using new software. The internet is essential for learning Tamil through computers.

"Even though we use the internet in our daily lives, we should also know where and how we can use Tamil on it." [1]

By installing software on the computer, it is possible to type in Tamil without an internet connection. Today, all certificates can be easily obtained through computers. There is no need to know English for this. By typing in Tamil, we can search for and obtain the certificates and other information we need in Tamil ourselves.

The need for computers in today's teaching

New computer software is needed for teaching the Tamil language. The proverb 'Necessity is the mother of invention' serves as the foundation for many new inventions today. In that respect, it is worth considering how computers are needed in today's teaching methods. The invention of the computer has laid the foundation for many new inventions.

Necessity is the beginning of new inventions

In today's education system, we are trying to find new methods through computers to simplify teaching and make learning enjoyable, and to implement them. It is because of such efforts that many new teaching methods are taking place today. In the past, both teaching and learning were based on memorization. But today, with the help of computers, learning and teaching have become easier.

The world's functioning is now in the smartphones in our hands; the reason for this is the internet, which is a high-speed application.

It has become rare today to find villages without internet access or smartphones without internet. Although the use of the internet has grown at various levels, in some places it leads to various crimes. The reason for these crimes is the misuse of the internet, not using it for its intended purpose. Some people consider the internet to be unnecessary because using it in inappropriate places and at inappropriate times leads to various problems.

Today, we learn about the information from hundreds of newspapers through short messages on the internet. If the internet did not exist today, we would not be able to get live news updates instantly.

Through the internet, one can visit many websites and read new information as breaking news instantly. It can also foster a research-oriented mindset in students. There are many websites dedicated to books. Here are some notable websites.

- https://www.tamilvu.org
- https://ta.wikipedia.org
- https://en.wikibooks.org/wiki/Subject:Internet
- https://www.projectmadurai.org
- https://chennailibrary.com/
- https://www.keetru.com

We can visit websites like these and download the books we teach and learn from.

Such software is needed for teaching and learning the Tamil language not only to Tamils but also to people from other states and countries in simple ways. Even simpler software is being developed. Just like there is software for the English language (like Grammarly) for typing, we need similar software for Tamil. Software like Menthamizh, Naavi, and Spell Checker exist to detect spelling and grammatical errors. However, they need to be made even easier to use, similar to the software available for English.

Tamil Fonts

In Tamil, fonts such as TSC, Unicode, TAM, and TAB were released with the contribution of the government. Even today, fonts are being created individually or in groups, and they are designed to be used on

operating systems according to the keyboard layout. The 'Muyilai' font is designed to produce Tamil letters by typing in English.

Problems and Solutions for Tamil Computing

Although the development of using Tamil through software like Word and WordStar on computers occurred, there were many difficulties in encoding Tamil fonts on computers. The inability to read or edit a Tamil document typed using one specific software with another Tamil software persisted. The ASCII encoding method also posed an obstacle to this. Tamil keyboards were also not standardized. However, due to the efforts of international companies in creating Tamil websites, Unicode encoding was introduced. Separate Unicode numbers were assigned to Tamil. As a result, there are currently no obstacles to inputting Tamil on electronic devices. Tamil can be input and all applications can be used on mobile phones as well.

Tamil Spell Checker

A spell checker has been released that corrects errors in Tamil words when typing them on a computer. Similarly, tools for correcting grammatical errors and punctuation errors also help in the use of Tamil on computers. The creation of these types of spell checkers increases and simplifies the use of Tamil on computers. A software called a spell checker indicator was also created, similar to the spell checker. This software only indicates spelling errors. The emergence of Tamil on the computer internet

The use of the internet on computers was made possible by the American superpower. With the advent of the internet, obtaining information through search engines like Google has become easy. For the development of a language, its multifaceted nature and influential characteristics are essential. The Tamil language possesses these qualities.Tamil serves as an official language and a recognized language in several countries, and is the mother tongue of the Tamil people. In this context, Tamils living in various countries, seeking to unite themselves through the development of the internet, embarked on an effort to establish Tamil's presence online. Tamils living all over the world wished to exchange information in Tamil through the internet. They wanted to create Tamil websites to preserve their heritage and to learn about and understand their literature, history, culture, and arts. Tamils proficient in computers attempted to introduce Tamil into computer and internet usage.

The State of Tamil's Development on the Internet

Among the world's eight ancient classical languages, Tamil and Chinese are the languages that remain in use by the largest number of people today. In this era, where Tamil is a rich and modern language, computer Tamil stands as the fourth form of Tamil, alongside the three traditional forms: prose, music, and drama. Tamils who had migrated to foreign countries for work, lacking opportunities to speak and write Tamil, used the internet to connect with each other, utilizing Tamil emails, online magazines, and websites. For example, the BBC is a world-renowned news organization. It publishes news in many languages, and Tamil is one of them. China Radio International broadcasts in approximately 43 languages. Besides Urdu and Bengali, it broadcasts only in two Indian languages: Tamil and Hindi.

Tamil Online Dictionary

An effort to create equivalent Tamil words for English terms used in fields such as computers, science, economics, education, and commerce was undertaken by a person named Umar. As a result, the Tamil Online Dictionary was created. Using this dictionary, one can find the Tamil meanings of English words.

Tamil in Email

With the advent of communication devices, it is now possible to exchange information in just a few seconds. With a computer and an internet connection, information can be easily exchanged via email. To convey messages to someone far away and receive their reply, we need their telephone or mobile number. Similarly, if we wish to exchange messages via email, we need the email address of the person to whom we want to send the

message. Email is the method of receiving information in written form through electronic communication, instead of exchanging it with each other via postal mail or through human messengers. Emails can also be sent in the Tamil language through the internet. There is no need to pay a separate fee for this.

Blogs in Tamil Development

The internet holds an unshakeable place in scientific advancement. The internet is providing immense assistance to people worldwide in the field of information technology, regardless of language or race. It contributes significantly not only scientifically and technologically but also to the development of literature. For the Tamil language, which is growing and receiving countless literary forms on the internet, a new literary form called blogs has emerged and is playing a major role. Categorized into blogs covering diverse topics such as literature, devotion, spirituality, computers, and medicine, they explain and promote Tamil culture.

Classification and Development of Tamil Blogs

A blog has emerged as a distinct literary genre. A blog is an online service that allows an individual to share information, including text, audio, video, graphic files, drawings, and images, with others around the world via the internet. In English, a blog is called a blog. In Tamil blogs, many blogs have been created for poetry. Furthermore, blogs have been created to express various ideas. For example, In the blog "Vergalai Thedi" (Searching for Roots), some Tamil teachers upload literary-related ideas. Some blogs have also been created in Tamil to present mathematics, science, space, and modern technologies. Blogs related to women have also been created, publishing ideas about employment opportunities, women's liberation, and health. Due to the advent of blogs, Tamil literature is becoming known to the outside world. Tamil Digital Library

The Tamil Digital Library and online library is a platform that compiles and provides all Tamil books in one place. A library is a place where printed books are collected and organized. In this increasingly mechanized world, where the interest in visiting libraries to read is declining, many digital libraries are emerging on the internet. Digital libraries are also useful for creating copies of books. UNESCO and the US Library of Congress jointly manage the World Digital Library. As a result, culture-related information is increasing on the internet. It facilitates making important information about global culture available on the internet. The Tamil language stands as a pioneer for Tamil people worldwide and speakers of other languages by creating and publishing a digital library on the internet.

Tamil E-books

An e-book is a book that is read in digital format with the help of a computer. E-books are created by typing on a computer and making them available for reading online. E-books are also produced in a way that allows them to be downloaded from the internet to a computer and read whenever needed. Such e-books are being created in all the world's languages. E-books have become widely used in the Tamil language. The creation of e-books in the Tamil language demonstrates the acceptance and flexibility of Tamil. Private publishing companies, individuals, and groups of people are designing and publishing e-books.

Tamil on Social Media

Social media is a medium accepted by all people in society. Through social media, news can be sent easily and free of charge. One can also communicate face-to-face. Our speech can also be published as a video. Facebook, WhatsApp, and other messaging applications were created with these purposes in mind. All of these can be used by anyone, anywhere in the world, at any time, and in all languages. The Tamil language is widely used in such social media.

Computer Festivals

The Computer Tamil Association based in Chennai organized a computer festival in Madurai under the name "Computer Tamil". This festival was held to promote Tamil software and to inform people about Tamil

software. Similarly, awards were also given to appreciate the good people who worked for the use of Tamil on the internet. Tamil internet conferences were also held in various parts of the world.

Problems in Computer-Based Learning

No technology has ever succeeded without problems. There are also problems in computer-based learning. They are as follows:

- Due to the lack of direct contact between teachers and students, teacher-student interaction does not take place.
- Teachers do not merely teach lessons. They also impart life skills and discipline to the students.
- The classroom environment, the way of interacting with fellow students, and functioning within society are all included within these methods.
- Due to continuous computer-based learning throughout the day, the light emitted from the computer screen easily affects the eyes.
- Everything can be learned through the internet. However, some people go astray due to the social media platforms used via the internet.
- Some social media platforms lead to undesirable paths.
- In the time remaining after computer-based learning, engaging in online games to pass the time leads to financial losses and mental stress.
- If the computer is used for teaching and learning, one can become an excellent scientist. Unnecessary distractions will lead to the wrong path; one must stay away from them.

Such problems can be observed in computer-based learning. These must be addressed.

Software for Tamil language teaching

Various software programs have been developed for teaching. The operating system (OS) is an electronic device that contains all the basic data necessary for the computer to function. Tamil can be learned by studying properly designed curricula and lessons online.

Therefore, functional search engines assist in education. Google's role in this is indispensable. Software such as Google Translate, Drive, Meet, Gmail, Scholar, Sheets, Slides, Forms, Docs, Voice, Calendar, Chrome, Fonts, Google Input Tools, Maps, Photos, Assistant, Classroom, Cast, Gboard, and Earth are all Google products. All of these are software programs for teaching the Tamil language. Tamil can be taught easily through these.

The Use of Computers in Teaching

Today's computers play a major role in teaching. The Tamil learning facilitated by smartphones is so significant that it can be said that desktop computers or laptops do not provide the same level of functionality. In modern times, smartphones offer various applications in Tamil.

“Although the internet is accessed through various devices such as computers, laptops, tablets, and smartphones, it is the smartphones that receive special attention. These are the devices that greatly help in accessing social media.”3

The computer plays a crucial role in teaching. Teaching students visually through a device called a projector is made easy.

1. With the burden of books reduced, students are learning joyfully. The Tamil Internet Education Academy and other online educational institutions teach Tamil online. Computer-based learning is easier for students who learn Tamil as a second and third language. They learn Tamil through computers and the internet, rather than directly from Tamil teachers in other countries.
2. By teaching through computers to speakers of other languages, it is easy to provide them with necessary examples, and with the help of search engines, it is possible to immediately translate and show them in their own language. They learn by easily understanding through pictures and visuals.

Conclusion

In today's scientific world, the use of computers has become indispensable. The need and use of computers have increased to such an extent that there are virtually no places where computers are not used. If used appropriately, no adverse effects will occur. It is a great help not only for the development of computer technology but also for the development of other fields. Through this, all of today's human activities are under the control of computers. Therefore, we should use the computer for our needs. If we act according to its needs, we will have to live without peace of mind.

Computer Tamil books and computer applications are useful in various stages for learning and teaching. They should be used accordingly. All scientific tools were invented to simplify and expedite human work. The same will be true for future inventions. At the same time, the duties that a human being must perform should be done by humans themselves. Learning and teaching belong to humanity.

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Library Digitalization and Its Role in Building an Inclusive Knowledge Society

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Abstract

Digital transformation has significantly reshaped the way information is created, stored, and accessed, with digital libraries emerging as key instruments in promoting inclusive knowledge societies. This study examines the role of digital library initiatives in ensuring equitable access to information and in fostering digital literacy, community participation, and inclusive knowledge creation. Adopting a descriptive and analytical research design, the study is based entirely on secondary data drawn from academic literature, government reports, policy documents, and digital library case studies. Content and thematic analysis were used to identify key trends, impacts, and challenges associated with digital library implementation.

The findings suggest that digital libraries enhance access to information for marginalized and diverse populations by reducing physical and economic barriers. Additionally, digital libraries contribute to digital skill development and encourage community engagement through participatory knowledge-sharing practices. However, issues such as unequal digital access, limited awareness, and infrastructure gaps continue to restrict their effectiveness. The study underscores the need for supportive policies, digital literacy initiatives, and inclusive design to maximize the social impact of digital libraries and strengthen their role in building an inclusive knowledge society.

Keywords: Digital libraries, Inclusive knowledge society, Equitable access, Digital literacy, Community participation

Introduction

Digital technology has changed how people find, use, and share information. Libraries are no longer only physical buildings with books. When libraries turn their collections and services into digital form, they can reach people who cannot visit the building. Digital libraries let learners, researchers, and ordinary people search and read materials online. This change helps remove time and distance barriers so more people can learn (IFLA, 2011).

One big benefit of library digitalization is better access. A person in a far village can use a digital library to read textbooks, watch lectures, or study local history without travelling long distances. In countries like India, national platforms collect many resources in one place so learners from different regions and languages can search easily (National Digital Library of India, n.d.). Digital access makes it easier for students to keep up with school and for adults to learn new skills (NDLI, n.d.).

Digital libraries can also help include people who are often left out. When libraries create materials in local languages, add audio versions for people with low sight, and provide simple user interfaces, more people can use them. This kind of inclusive design makes it possible for children, women, older adults, and people with disabilities to take part in learning and community life. International guidance says digitization should be respectful of local culture and make space for many voices, not replace them. (IFLA, 2011).

But there is an important problem: the digital divide. Not everyone has good internet, a smartphone, or the skills to use online tools. Many people in rural or low-income areas do not have regular internet or cannot afford data. Also, in several places fewer women use the internet than men. If libraries only go digital without helping people get online and learn how to use devices, the gap between rich and poor can grow. That is why connectivity and training are needed alongside digital collections (ITU, 2023).

Policy makers and library leaders must work together to make sure digital libraries are fair and useful. International organizations encourage countries to link libraries with education, connectivity, and community programs. This approach means governments support not only digitization but also training, affordable internet, and content in many languages. When policy, infrastructure, and local voices come together, digital libraries can help build a true knowledge society one in which everyone has a fair chance to learn and grow (UNESCO, 2024).

This study explores how digital libraries can build an inclusive knowledge society. It looks at policy ideas, how people get access, and what works on the ground to include those who are left behind. The goal is simple: to find ways so digital libraries help more people learn, participate in community life, and use new opportunities. The study believes technology can widen knowledge only when it is joined with connectivity, training, local content, and care for people's rights and cultures.

Review of Literature

Library digitalization has emerged as a transformative force in reshaping access to information, knowledge sharing, and educational opportunities across diverse populations. The shift from traditional print collections to digital platforms has enhanced accessibility and reach, allowing users to access digital content remotely, 24/7, and across geographic boundaries, which was previously limited by physical library constraints (LIS Academy, 2025). Digital libraries transcend location barriers, enabling learners in rural and underserved areas to access the same resources as those in urban centers, contributing to a form of knowledge democratization (LIS Academy, 2025). Scholars argue that digital libraries not only support research and academic needs but also advance inclusive knowledge societies by making information available to users irrespective of geographical constraints (Bhat, 2024). Moreover, advancements in digital search, multimedia integration, and metadata capabilities have transformed how users interact with information, making retrieval faster and more efficient than in traditional libraries (LIS Academy, 2025). The integration of digital literacy training in these services further empowers users to navigate complex information landscapes, reinforcing equitable access and supporting lifelong learning (Injomoe et al., 2025).

Despite these advancements, the literature highlights persistent challenges and inequalities associated with digital library adoption. The digital divide—a gap between those with reliable access to technology and those without—remains a central issue in discussions of digital library impact (Vassilakopoulou & Hustad, 2021). The divide reflects both infrastructural limitations and socio-economic disparities that disadvantage specific populations, such as rural communities, low-income groups, and those lacking digital literacy skills (Vassilakopoulou & Hustad, 2021).

Libraries are positioned as important institutions in narrowing this divide by providing free internet access, training, and digital resources (Jutras, 2023). Research from developing countries shows that digital libraries can enhance access to educational materials and support local learning when complemented by training programs that strengthen users' digital skills and confidence (Maysa et al., 2025). However, insufficient infrastructure, limited funding, and uneven policy implementation create barriers to effective digital library use, reducing the potential for equitable participation in digital knowledge ecosystems (Parashar & Singh, 2025). Furthermore, digital library initiatives face challenges in maintaining long-term sustainability, ensuring preservation of digital content, and supporting open access models that avoid subscription barriers limiting access for economically marginalized users (Patra & Sahoo, 2022).

In addition to access and equity issues, research underscores the evolving role of librarians and libraries in fostering inclusive digital knowledge societies. Librarians are increasingly recognized as champions of digital literacy and custodians of digital heritage, tasked with bridging technological gaps and guiding communities in information use (Rozak et al., 2025). They play a critical role in designing digital literacy programs, advocating for policies promoting inclusion, and preserving digital memories that reflect local cultures and histories (Rozak et al., 2025). Libraries' digital transformation also includes using innovative tools such as virtual reality and

interactive digital platforms to support new forms of learning and engagement, demonstrating that digital libraries are not just repositories but active learning spaces (ScienceDirect, 2023).

Research further highlights digital libraries' potential in promoting multilingual inclusivity by digitizing content in regional languages, which is essential in culturally diverse contexts with multiple linguistic groups (IJHSSI, 2024). By incorporating user-centric services, digital libraries can address specific community needs, making them central to strategies for achieving inclusive knowledge societies where information equity, cultural preservation, and digital participation are prioritized. However, effective outcomes depend on sustained community involvement, policy support, and ongoing evaluation of digital initiatives to ensure that they are accessible, relevant, and responsive to user needs (ScienceDirect, 2025).

Research Gap

Despite evidence that digital libraries enhance access and user engagement, most existing research focuses on technological advancements and infrastructure rather than on how these digital initiatives affect socially marginalized populations at the grassroots level. There is limited empirical work on the user-level impacts of digital library services, especially in terms of long-term social inclusion, cultural preservation, and community participation. Additionally, studies frequently overlook the interplay between digital literacy training, policy implementation, and local cultural contexts. Research on digital library impact tends to be descriptive rather than evaluative, leaving gaps in understanding the effectiveness of specific digital strategies in building truly inclusive knowledge societies. This study seeks to bridge that gap by examining both digital library deployment and its social outcomes in a defined community setting.

Objectives of the Study

1. To examine how digital library initiatives influence equitable access to information and knowledge for diverse and marginalized user groups.
2. To evaluate the role of digital libraries in fostering digital literacy, community participation, and inclusive knowledge creation within the target population.

Research Methodology

The study adopts a descriptive and analytical research design using secondary data to address the objectives. To examine how digital library initiatives influence equitable access to information and knowledge, the study relies on published research articles, government reports, digital library records, and case studies from academic databases like JSTOR, ScienceDirect, and Google Scholar. To evaluate the role of digital libraries in fostering digital literacy, community participation, and inclusive knowledge creation, relevant literature, policy documents, and organizational reports were reviewed. Data were critically analyzed using content and thematic analysis, focusing on patterns, outcomes, and best practices in digital library implementation. The study emphasizes understanding trends, challenges, and impacts reported in secondary sources to draw evidence-based conclusions. By systematically reviewing existing studies and documentation, the research assesses how digital libraries contribute to inclusivity, knowledge accessibility, and community engagement within marginalized and diverse populations.

Bridging the Knowledge Gap: Digital Libraries and Equitable Access

Digital libraries have emerged as a critical tool to expand access to knowledge and information, particularly for marginalized and diverse user groups. These libraries provide online access to books, journals, databases, and multimedia resources without requiring physical presence. This capability is significant for individuals in rural, remote, or economically disadvantaged areas, where traditional libraries may not exist or may be poorly resourced (Liu, 2018). By offering digital platforms accessible through computers, tablets, or smartphones, digital libraries reduce geographic and economic barriers to learning.

Several studies highlight the role of digital libraries in promoting equitable access. For instance, Amadi and Nwosu (2020) observed that digital libraries in Nigerian universities enhanced access for students from remote locations who previously had limited opportunities for research materials. Similarly, Sharma and Verma (2019) reported that digital library initiatives in India's rural districts allowed students and community members to access educational content, government publications, and scientific articles online, fostering inclusion in knowledge sharing. Such access is particularly relevant for marginalized groups such as women, indigenous communities, and economically disadvantaged students who might otherwise be excluded from mainstream knowledge resources.

Digital libraries not only increase availability but also offer flexibility in timing and format. Unlike traditional libraries with fixed operating hours, digital libraries can be accessed at any time, which is especially useful for working adults, part-time students, or children with household responsibilities (Kumar, 2021). Furthermore, many digital libraries provide content in multiple formats, including text, audio, and video, catering to different learning needs and literacy levels. This multimodal approach ensures that knowledge is not restricted to those who can read traditional printed materials, thereby enhancing inclusivity.

Despite the benefits, challenges persist in achieving equitable access. Internet connectivity remains a major constraint in many rural and underdeveloped areas. According to a UNESCO (2022) report, nearly 40% of rural households in low-income regions lack reliable internet access, limiting the potential reach of digital library resources. Additionally, access to devices such as computers or smartphones is uneven, and many users lack familiarity with digital interfaces (Bhatia, 2020). Addressing these challenges requires integrated strategies, including public Wi-Fi programs, low-cost device provision, and community training sessions, ensuring that digital library initiatives translate into actual access for marginalized populations.

Furthermore, policy frameworks play a vital role in promoting equitable digital access. The Indian Government's National Digital Library (NDL) initiative, for instance, aims to aggregate learning resources from multiple sources and make them freely available online (Ministry of Education, 2020). Case studies indicate that NDL has significantly improved access to educational materials in remote areas, enabling students, teachers, and community members to participate in knowledge-driven activities. Similarly, global initiatives like the World Digital Library provide multilingual content, allowing users from different linguistic backgrounds to access cultural and educational materials (UNESCO, 2020). These programs highlight how digital libraries can bridge the knowledge gap and make information more inclusive and accessible.

Empower, Engage, Create: Digital Libraries as Community Catalysts

Beyond access, digital libraries play a central role in fostering digital literacy, encouraging community participation, and promoting inclusive knowledge creation. Digital literacy involves the ability to search, evaluate, and utilize information from digital sources effectively. Studies have shown that digital library users often develop these skills while navigating online catalogs, databases, and research portals (Kaur & Singh, 2021). For marginalized populations, such skill development is crucial, as it enables them to participate in education, vocational training, and social initiatives.

Digital libraries also act as platforms for collaborative learning and knowledge sharing. Community-based digital initiatives often encourage users to contribute content, annotate resources, and participate in forums or discussion boards. This participation fosters inclusivity by giving voice to groups historically excluded from mainstream knowledge production. For example, the Digital Public Library of America (DPLA) provides mechanisms for local communities to digitize and upload historical records, cultural artifacts, and indigenous knowledge, ensuring that diverse voices are represented online (Smith, 2019). Similarly, in India, university-led digital archives allow students and local organizations to contribute materials about local history, folklore, and culture, enabling knowledge co-creation.

In addition to content creation, digital libraries enhance community engagement through workshops, webinars, and training sessions. These activities teach users how to navigate online resources, evaluate digital information, and use e-learning platforms effectively (Jain, 2020). Programs that specifically target women, youth, and marginalized populations help overcome barriers such as low literacy levels or unfamiliarity with technology, increasing participation in knowledge communities. Studies in African contexts indicate that digital literacy training linked with digital libraries boosts confidence, social inclusion, and employability among rural youth (Mwangi, 2018).

Digital libraries further facilitate inclusive education by offering resources tailored to diverse needs. Multilingual interfaces, audio-visual content, and open educational resources (OERs) allow learners with varying abilities and language backgrounds to access the information they require (Alawadhi, 2021). For instance, the National Digital Library of India includes resources in multiple Indian languages, supporting equitable participation among students from different linguistic communities. Similarly, global initiatives like Europeana emphasize cultural diversity by providing digitized content from multiple countries, enabling cross-cultural knowledge sharing and collaboration (Europeana, 2020).

Despite these advantages, challenges in fostering community participation persist. Many users, especially in rural areas, may not be aware of digital library resources or lack confidence to use them (Bhatia, 2020). There is also a need for localized content that reflects community knowledge and priorities, ensuring relevance and engagement. Effective digital library programs often combine technological infrastructure with community outreach, training, and culturally sensitive content, making digital literacy and participation more meaningful.

Moreover, digital libraries can drive social development and inclusion. By facilitating equitable access to knowledge and empowering users to participate actively, these platforms contribute to skill development, employability, cultural preservation, and social cohesion (Liu, 2018). Communities that engage with digital libraries tend to exhibit higher participation in educational programs, local governance initiatives, and knowledge-based activities. This impact aligns with the broader concept of an inclusive knowledge society, where information and resources are accessible, participatory, and collaborative, bridging social and economic divides.

Thus, digital libraries are not just repositories of information; they are catalysts for social change. By providing equitable access, fostering digital literacy, encouraging community participation, and supporting inclusive knowledge creation, digital libraries enable diverse populations to engage with information meaningfully. Studies consistently highlight that successful digital library initiatives require a combination of robust technology, supportive policies, and active community engagement (Sharma & Verma, 2019; Kaur & Singh, 2021). They demonstrate that digital libraries can play a central role in building inclusive knowledge societies, where every individual has the opportunity to access, share, and create knowledge.

Limitations of the Study

- **Dependence on secondary data:** The study relies only on secondary sources such as published articles, reports, and policy documents. As a result, it may not fully capture real-time user experiences or recent local developments in digital library usage.
- **Variation in data quality:** Secondary data come from different regions, contexts, and time periods. Differences in scope, methodology, and focus of existing studies may limit direct comparison and generalization of findings.
- **Lack of micro-level insights:** Since no primary data were collected, the study cannot deeply explore community-specific challenges, perceptions, or behavioral changes related to digital library use at the grassroots level.

Conclusion

Digital library initiatives play a significant role in reducing knowledge inequalities and promoting inclusive access to information in contemporary society. Based on the analysis of secondary data, this study highlights that digital libraries help overcome barriers related to geography, cost, and physical infrastructure, thereby improving access for marginalized and diverse user groups. By offering online resources, multilingual content, and accessible formats, digital libraries contribute to more equitable knowledge distribution. The study also finds that digital libraries act as important platforms for developing digital literacy, encouraging community participation, and supporting inclusive knowledge creation. Through training programs, open-access resources, and community-oriented digital collections, libraries empower users to actively engage with information rather than remain passive consumers. However, challenges such as the digital divide, lack of awareness, and uneven infrastructure continue to limit the full potential of digital libraries. Thus, the study concludes that digital libraries, when supported by inclusive policies, digital skills development, and community involvement, can serve as powerful tools in building an inclusive knowledge society and promoting lifelong learning for all.

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Impact of Library Orientation Programs on Undergraduate Students; Special Reference to the Uva Wellassa University Sri Lanka

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Abstract

Library orientation programs play a vital role in introducing undergraduate students to academic library resources, services, and information literacy skills. This study examines the impact of library orientation programs on students' awareness, utilization of library facilities, research confidence, and academic engagement at the Uva Wellassa University of Sri Lanka. A mixed-method research approach was employed, incorporating structured questionnaires, library usage statistics, and focus group discussions among first-year undergraduates. The findings indicate that well-structured orientation programs significantly enhance students' ability to locate and evaluate information, utilize electronic resources, and engage in independent and lifelong learning. The study underscores the importance of continuous, interactive, and technology-supported orientation initiatives in fostering academic success and effective library use.

Keywords: Library Orientation, Undergraduate Students, Information Literacy, Academic Libraries, User Education, Learning Support

Introduction

Academic libraries function as essential learning and research hubs within higher education institutions. For undergraduate students—particularly first-year entrants—unfamiliarity with library systems, digital platforms, and research tools often presents a significant barrier to effective academic engagement. Library orientation programs are therefore designed to bridge this gap by familiarizing students with physical and electronic resources, library policies, and academic support services.

This study investigates the effect of the library orientation program on the use of library resources by newly admitted undergraduate students at the Uva Wellassa University of Sri Lanka. Library orientation is considered a core function of academic libraries, emphasizing user education, guidance, and awareness-building to enable students to identify, access, and utilize information resources efficiently and ethically.

Guided by two research objectives and two corresponding research questions, this study adopted a descriptive survey research design. Data were collected through a structured questionnaire distributed to a representative sample of students across all degree programs. A total of 600 questionnaires were administered, and responses were analyzed using Microsoft Excel. The findings suggest that a well-organized library orientation program enhances user confidence, promotes effective library use, and supports the development of lifelong learning and research competencies.

Objectives of the Study

The main objectives of this research are to:

1. Assess students' awareness of library resources and services following participation in orientation programs
2. Evaluate the impact of orientation on students' information-seeking behavior
3. Measure changes in library usage patterns among undergraduate students
4. Identify students' perceptions of the effectiveness of the orientation program
5. Propose recommendations for improving future orientation initiatives

Literature Review

The academic library is one of the most structured units within higher education institutions, entrusted with the responsibility of collecting, organizing, preserving, and disseminating both print and non-print information resources to support teaching, learning, and research activities. As library collections and information technologies continue to expand, the need for systematic orientation and user education programs has become increasingly critical.

Previous studies have demonstrated that library orientation programs significantly enhance students' information literacy skills and academic confidence (Owusu-Ansah, 2004; Julien & Genuis, 2011). Interactive and hands-on instructional approaches, particularly those incorporating digital literacy components, have been found to be more effective than traditional lecture-based methods.

The conceptual framework for information literacy adopted in this study is informed by the Association of College and Research Libraries (ACRL, 2000), which defines information literacy as the ability to: "Determine the extent of information needed, access the needed information effectively and efficiently, evaluate information and its sources critically, incorporate selected information into one's knowledge base, use information effectively to accomplish a specific purpose, and understand the economic, legal, and social issues surrounding the use of information, and access and use information ethically and legally."

Fleming (2010) describes user education as a range of instructional and exploratory programs designed to enable users to make effective and independent use of library resources. Similarly, Mews (2012) and Fjallbrant (2010) emphasize the role of user education in building confidence and competence in locating and utilizing library materials. Singh (2010) and Bello (2013) further argue that user education facilitates efficient information retrieval and promotes result-oriented use of library services. Collectively, these studies highlight the central role of orientation programs in strengthening students' academic performance and research capabilities.

Methodology

This study employed a mixed-method research design combining quantitative and qualitative approaches.

Population: The study population comprised first-year undergraduate students drawn from all academic faculties of the Uva Wellassa University of Sri Lanka, specifically the Faculty of Applied Sciences, the Faculty of Animal Science and Export Agriculture, and the Faculty of Management and Technological Studies. This inclusive approach ensured broad representation of diverse disciplinary backgrounds, academic orientations, and information needs, thereby enhancing the generalizability and validity of the research findings across the university context.

Sample Size: 600 students

Data Collection Tools

- Structured questionnaires
- Library usage statistics (pre- and post-orientation)
- Focus group and random interview discussions

Data Analysis

- Quantitative data were analyzed using descriptive statistics, including frequencies and percentages
- Qualitative data were analyzed through thematic analysis to identify recurring patterns and perceptions

Significance of the Study

This study highlights the importance of structured and continuous library orientation programs in promoting independent learning, academic success, and research competence among undergraduate students. The findings offer practical insights for librarians, academic administrators, and policy-makers in designing

student-centered, technology-driven, and sustainable orientation initiatives that enhance institutional learning outcomes.

Results and Discussion

The data collected through the questionnaire were analyzed using descriptive statistical methods.

Research Question 1

What is the students' perception of the relevance of the library orientation program at the Uva Wellassa University Library, Sri Lanka?

Table 1: Respondents' Perception of the Relevance of the Library Orientation Program (N = 600)

Option	Frequency	Percentage%
Relevant	508	84.67
Very Relevant	82	13.67
Irrelevant	01	0.17
Very Irrelevant	02	0.33
Not response	07	1.16
Total	**600**	**100**

The results indicate that a substantial majority of respondents (98.34%) perceived the library orientation program as either relevant or very relevant. This finding demonstrates the perceived value of the program in supporting students' ability to locate and utilize appropriate information resources, both in physical and digital environments.

Research Question 2

What are the effects of library orientation on newly registered library users at the Uva Wellassa University Library, Sri Lanka?

Table 2: Effects of Library Orientation on Newly Registered Library Users (N = 600)

Effect of Library Orientation	Frequency
Library orientation enhances my reading skills and transforms me into a regular library user	502
Library orientation has significantly improved my ability to identify, access, and retrieve information from the library	581
Library orientation made me aware of the broadness of the library's resources	590
Library orientation made me realize the importance of libraries in my academic pursuits, improved my academic performance and long-life learning	600
Library orientation has introduced me to various bibliographic databases available at the library	589

The findings reveal that library orientation has a strong positive effect on students' academic and research behavior. All respondents acknowledged the role of orientation in improving their understanding of the

importance of libraries in academic success and lifelong learning. A high proportion of students also reported improved skills in accessing information and greater awareness of both print and electronic resources.

Table 3: Confident Using the Library After the Orientation

Yes, very confident	588
Somewhat confident	10
Neutral	02
Not very confident	00
Not confident at all	00

Table 4: Library Orientation Clear and Easy to Understand

Yes, completely	109
Mostly clear	369
Somewhat clear	22
Not clear at all	00

These results demonstrate that the majority of students found the orientation program both clear and effective, contributing to increased confidence and improved library engagement.

Figure 1: Comparison of Library Resource Usage Before and After the Library Orientation Program at the Uva Wellassa University of Sri Lanka

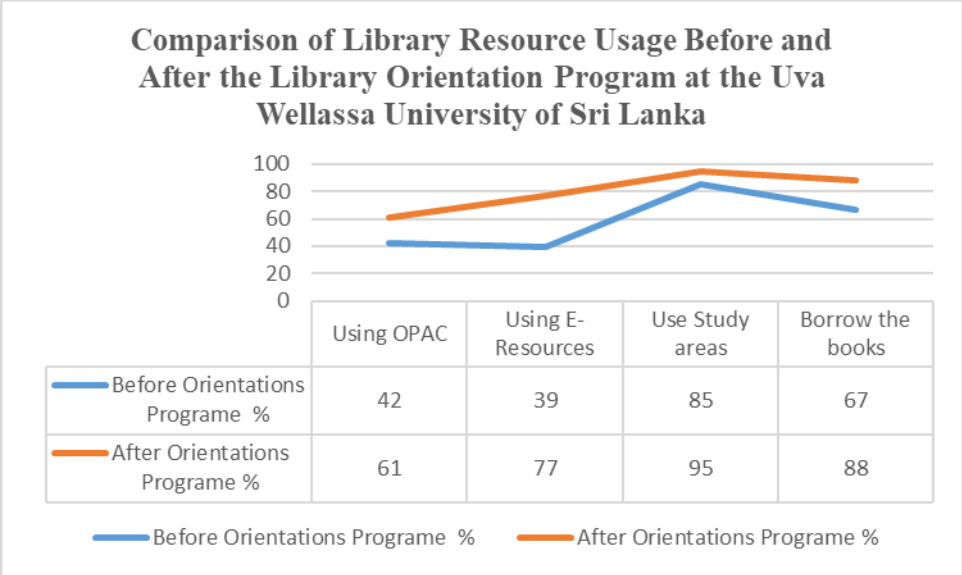


Figure 1 presents a comparative analysis of students' library resource usage before and after participation in the library orientation program. The results demonstrate a substantial improvement across all measured service areas following the intervention.

Usage of the Online Public Access Catalogue (OPAC) increased from 42% to 61%, indicating enhanced awareness and ability to locate library materials efficiently. Similarly, the use of electronic resources showed a marked rise from 39% to 77%, reflecting improved digital literacy and familiarity with academic databases and online research tools.

The utilization of study areas also improved, rising from 85% to 95%, suggesting that students increasingly recognized the library as a conducive academic environment for independent and collaborative learning. Furthermore, book borrowing activity increased from 67% to 88%, highlighting greater engagement with print collections and effective use of circulation services.

Overall, the findings illustrate that the library orientation program had a positive and significant impact on students' information-seeking behavior, resource utilization, and academic engagement, reinforcing the importance of structured orientation initiatives in academic libraries.

Qualitative feedback from random interviews further reinforced these findings. Students expressed strong appreciation for the guidance provided by library staff and described the library as a supportive and conducive academic environment. Many respondents emphasized that the orientation program significantly enhanced their research confidence and understanding of academic support services. A recurring suggestion among participants was the need for a faster and more efficient book borrowing system. Students highlighted the importance of reducing waiting times and streamlining circulation processes, particularly during peak academic periods. This feedback points to the potential benefits of introducing automation, self-checkout facilities.

Recommendations

- Introduce blended orientation programs (physical + online modules)
- Conduct follow-up training sessions during the academic year
- Integrate orientation programs into the academic curriculum
- Use interactive tools such as quizzes, videos, and virtual library tours
- Students should create time to attend library orientation programmes
- The management should support the programme with funds and facilities that would better improve and put to use to satisfy the users' needs for their education

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Personalized Information Services (PIS) and UX Design in Anna Centenary Library and Kalaignar

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ABSTRCT

The UX is abbreviated as user experience, it is used interchangeably like as user interface design or usability and the function of the library to meet their needs. The UX design is concerned with the entire process of libraries organizing their library resources, services, and space for people with disabilities. The International Organization for Standardizations define as "A person's perception and responses that result from the use or anticipated use of a product, system or service. The personalized services predict all the information provided to the customer user's needs libraries. The tailoring of the information and experience for every individual's needs and suggest guidance to users on how to use the libraries and access the resources and services. The study revealed the personalized services and UX design in Anna Centenary Library, Chennai and Kalaignar Centenary Library, Madurai, and they provide information resources and services to the user communities to develop the knowledge and fulfil their needs.

Keywords: Personalized Information Service, UX Design, User, Anna Centenary Library, Kalaignar Centenary Library

INTRODUCTION

Dr.S.R.Ranganathan public library as a "library owned and maintained by the public of its area for the socialization of its books and kindred materials for free service to the people of the area". It is the people's university, and the public library is commonly described as a systematic collection of books and other informational materials maintained for reading, study, and reference purposes (Onwubiko & Uzoigwe, 2004; Nnadozie, 2007). The Bernard Library Glossary (2017) provides a more detailed definition, describing a library as a space where information is acquired, stored, processed, organized, retrieved, and made available to users as needed. UNESCO defines a public library as a local center for information that provides access to knowledge and ideas. Public libraries are considered essential components of knowledge societies and are responsible for: Information: Providing access to a wide range of information and ideas free from censorship Education: Supporting formal and informal education at all levels, including lifelong learning.

Define User, UX Design and Personalized Information Services

According to Whittaker (1993), a user could also be defined as an individual who uses one or more of a library's services a minimum of once a year. According to the Oxford English Dictionary, it is revealed that the user is the person who uses the library's resources and services.

Nielsen Norman group determined that user experience happens through meeting the real needs of the user and through products that are fun to use, and user experience with satisfaction, the degree to which user expectations of a product, service or system are met. According to Vannevar Bush identified the necessity of a personalized information environment, and he felt that current mechanisms for dealing with information were wholly inadequate given the volume of work being produced. In the technology world, time to time increasingly tailored to users of centric services from the libraries' information needs. The personized services, which describe the specific needs of users or individuals, are essential for the library experience, such as relevant recommendations, relevant long-lived information resources, and new technologies, provide need full space to users.

Profile of the Libraries

The Government of Tamilnadu giving ostrich schemes to the people, especially the Department of school education conduction various schemes for students' development and reaches the goals in education. The

Government concentrate in the development of public libraries in their state to use and access the resources and services to the user community to preparing competitive examination, research and other beneficiary from public by the Department of Public Libraries, it is introducing and conducting many programs for school and college students and publics like as literature program, children program, Kodaikondattam, Ponmalai Pozhuthu, AI training program for college students etc., through the Anna Centenary Library and Kalaignar Centenary Library.

The Anna Centenary Library is a modern library established to commemorate the 102nd birthday of Former Chief Minister of Tamil Nadu Dr C N Annadurai ("ANNA"). Dr Annadurai had a great love for books and libraries, which has led to this Library being named after him as a tribute to his memory. The Foundation Stone was laid on 16th August 2008, and it took very little time for the construction of the library to be completed before officially opening its doors to the public on 20th September 2010. This Library has a built-up area of 375,000 square feet on the ground and 8 additional floors. In addition, the library has approximately 500,000 titles to accommodate the Public, Academic and Corporate needs for all types of literature, both English-written and Tamil-written. The library provides a section of Braille Books, a Reading Section for personal books, a Children's Area, a Periodicals and Newspaper Section, an English Books section, a Tamil Books Section and a Digital library. In addition to these services available, there is Conference Room with a capacity of 150 seats.

The Tamil Nadu government has established a library in Madurai to honour the memory of Muthamizh Arignar Dr Kalaignar M. Karunanidhi by commemorating his 100th birthday. Muthamizh Arignar Dr Kalaignar M. Karunanidhi served as Chief Minister of Tamil Nadu five times and instituted many public welfare projects during his tenure. The Kalaignar Centenary Library will be an intellectual centre for the southern part of Tamil Nadu. The centre houses 3.64 lakh books, ranging from literary works to arts, cultural, science and technological literature. The six-story library will have a basement, ground and six upper floors to support children, students, youth, researchers, job seekers, women and older adults.

Objectives of Study

1. To examine and assess the personalized information services currently being offered from both Anna Centenary Library and Kalaignar Centenary Library.
2. To determine each user group's specific user needs for how they seek information, including student, researcher, professional and general reading audiences.
3. To analyse the usability and UX design, using comparative analysis, of both physical spaces, digital platforms and Library Information Delivery Systems, provided by both Libraries.
4. To evaluate how user satisfaction currently exists with the personalized services and Digital Resources that are currently available through both Libraries.
5. To establish a comparison of both Libraries' Personalized Service Models for UX practice, by analysing qualitative data, and then document each Library's successful practices through this assessment.
6. To recommend strategies, Policy and Practice Guidelines for developing Inclusive and accessible UX for personalized services to be used in libraries.

REVIEW OF RELATED LITERATURE

Kalyan Paik (2024) stated that the information generation of library and information science has entirely changed in the technological days to providing relevant information service to users, through the personalized information services (PIS) that indicate of single user preferences, their behaviors and immediate needs. These new innovations provide tailored recommendations, guidance for selective learning, and exact information to the users promptly. The study revealed how libraries can undertake personalization strategies inspired by Netflix's recommendations. This paper examines how libraries can adopt personalization strategies inspired by Netflix's recommendation engine to stimulate interest and improve information access.

Shivangi Gupta et al (2024) reveal that enhancing the user experience and services in the library. The user experience used to library through make the website and implement ideas to change how users use the library and be satisfied with the website. The study focused on the important problems encountered when trying

to make changes in the technology library, financial problems in implementing the technologies, while giving valuable guidance and suggestions and rectifying those problems. The technology changes provide relevant resources in the digital age, and services to various types of users and fulfil their needs using UX design with library websites.

Kasimani and Rajendran (2020) revealed that public libraries and their service to user communities by providing information resources, when users want to update sources. This paper examines the user satisfaction of public library resources in Anna Centenary Library, Chennai. The study adapted survey methods by the structured questionnaire and collected data from the study area, and result shows that 40.48% of respondents visit the library to read books, the majority of respondent's opinion as very satisfied in the library collection, service, staff support and library infrastructure. The overall satisfaction with Anna Centenary library are very satisfied.

METHODOLOGY

The study endorses the descriptive and analytical research to investigate the availability of information resources and services related to the effectiveness of personalised information services and users' experience in Anna Centenary Library and Kalaignar Centenary Library in Tamil Nadu. The primary data collection from users of the study area and secondary data were collected by interviews and discussions with users and library professionals of the libraries. The study was limited and response from the Anna Centenary Library and the Kalaignar Centenary Library.

PERSONALIZED INFORMATION SERVICE AND UX DESIGN IN LIBRARIES

Personalized Information Service

The library adapts facilities to allow user preferences of choices, uses of library technologies, resources and services and controls to their desires based on parameters of user behaviour and their needs. The service provides benefits in saving time to user by the help of the library's professional services, improving academic activities, research development by enhancing the relevance of retrieved information, building users' relationships and trust among the users and library staffs and accepting various types of users in the library without any discrimination. It is also a preference and attention in user satisfaction in uses of library resources and services. The following of steps of personalized services are

- Customise Content Services
- Notifying Services
- Interfaces of Tailored Library System
- User Assistants to provide relevant information
- Analysing user behaviour

Types Personalized Information Service

- **SDI-** It provides current information related to the relevant research article and books, direct and pre-defined information to students and research scholars. It is also maintained updated user profile as digital documentation, RSS feed or emails
- **OPAC and Discovery Services-** It is a library's catalogue for recorded physical information of library resources in an online database to the users for quick search and locating books and journals in shelves in a particular library. The user can search by author, title, publisher, ISBN, etc. The Discovery service is a specific online search in worldwide with the google-like to enable and find print and non-print information resources.
- **Research Recommendation System-** It is a content-based system for recommending library resources and datasets to research scholars to retrieve relevant information from navigate of reduce the information overload to develop their research activities and guide the locate high-quality information resources.
- **Customized Access -**The user expects their own views of information resources from the libraries and required spaces, and provides information as personalized services interfaces in the library.

- **Access and customized services to Membership-**The membership is the main service in every library to receive relevant of information to reach their goals, develop knowledge and make more connections with the library and interact among the users.
- **Notification and Alert-** The library notifies the user about the new arrival or acquisitions to the library.
- **Access E-Resources-** Direct access to the information resources from the library through search tools such as OPAC, databases, publisher sites, subscribed contents and open access in freely available resources from the library.

Impact of Technologies in Personalized Information Services in ACL and KCL



Image: RFID. Kiosks and VR

Image: RFID. Kiosks and VR

ELMS:-The Electronic Library Management System (ELMS) is a technology-focused approach to automating and managing library services effectively and efficiently. It allows library users to access, organize and distribute all the library's resource types (printed and digital). With the Electronic Library Management System, users have access to all kinds of information in one place. In addition, the system allows library staff to create a customized user experience and provide personalized service.

1. Online Public Access Catalogue (OPAC) Self-service
2. Check-in/Out
3. Digital Library Access
4. Personalized Notifications for New Arrivals and Due Dates
5. Internet Reservation & Renewal
6. User Profile Dashboard

RFID Circulation Services

It is the latest technology and uses in libraries for a theft detection system, combining the security system with efficient tracking of materials from the library, charge and discharge, and material handling. It works with radio-frequency technology, microchip technology in the tags affixed on the library study materials, and it can replace both of EM and Radio Frequency. LIBRARY RFID tags combine an ultimate EM security strip and barcode functionality. RFID technology simplifies the process of a patron checking out and returning their items themselves. Radio Frequency technology can process audio and video as well as print items, making it a complete solution for libraries. Anti-theft detection via Radio Frequency is revolutionary in terms of being safe

for the patron and the library. With an RFID system, you can also quickly conduct an entire inventory of your library collections and quickly locate any misplaced materials. As a library, you have the long-term benefit of continuing development because RFID technology follows an open standard, allowing libraries to develop and upgrade systems without the need for any unique software.

Kiosks and Self-Service

A digital kiosk with signs is a digital display/animation device that exists on its own and is often an interactive tool for consumers to find, order or use self-service resources while shopping or in an airport, mall or store. They are used to provide consumers with interactive, personalized ways of interacting with a business that offer more than traditional printed signs. Kiosks are constructed using screens, software and hardware and allow for the creation of multimedia from digital content through the integration of video, interactive menu screens, and digital maps to assist visitors in having a positive visitor experience while increasing the operational efficiency of a business.

Features/Functions

Interactive Touchscreens: They allow users to interact with each other to navigate to find what they are looking for or make choices. Digital Media: Displays dynamic videos, photos, menus, and real-time updates of what is going on. Self-Service: Allows users to place an order for food, check in, and find directions

Variety of Use Options: They can be placed in a variety of locations, including as freestanding units, mounted on walls, and integrated into an existing environment. Durable/Weather Resistant Construction: Kiosks are built from heavy-duty materials, including enclosures, antimicrobial coverings, and shatter-resistant glass, according to Samsung Business and KIOSK Information Systems.

UX Design Uses in Libraries

Concept of UX Design

It is an abbreviated word of "User Experience design", given by Donald Norman in 1995, which provides a relevant experience to users through library resources and experience as a process of integrating the library resources, functions for easy use, how to approach the library professionally, and ensuring accessibility to engage the learning environment and investigate the new knowledge.

Methods of UX design

The UX Design uses quantitative and qualitative methods, focusing with understand the users and their observations, feedback and evaluation for the development of physical spaces of digital libraries.

- Methods of UX Design
- Library Creative methods
- Testing Methods
- Analysis Methods
- Research and Discovery Methods
- Observation methods

Principles of UX design

Library User Experience (UX) Design Definition: to Create Holistic, User Centric and Empathetic Digital and Physical Spaces by Designing for Usability, Accessibility and Findability through Research & Testing to Ensure That Users Have Intuitive Experiences Across All Touchpoints (Websites, Services, Spaces) So They Feel Supported Rather than Frustrated (By Focusing on User Needs Before Feature Development, Providing an Easy Navigation Path and Meaningful Interaction Opportunities).

Key UX Design Principles for Libraries

- **User-Centricity & Empathy Principles:** Understand users' actual needs via ethnographic and tested research, not just your own perspective.
- **Holistic Experience Principles:** You should design the entire user experience rather than only one component of it (websites, signage, personnel, spaces, collections).
- **Usability & Simplicity First:** Users need to be able to navigate easily before becoming interested; therefore, ensure users have an intuitive navigation path to follow.

- **Accessibility for All:** Design accessible libraries and digital tools for varied populations (seniors, children, varying levels of digital literacy).
- **Findability & Information Architecture:** Users must quickly find the resources they require via numerous search methods (catalogues/databases/physical books).
- **Context Matters:** Designers must consider real-world use of library materials via various types of devices and totally different types of physical locations.
- **Research & Testing:** Validate the decision to use design choices via ethnographic method and user testing.

Digital UX

It is focused on the user, is easy to use and is accessible to everyone who uses library resources. Digital User Experience (UX) in Library Science goes beyond basic functions to also include how we feel, behave and what frustrates us when we use digital tools like websites, catalogues and databases. Digital User Experience (UX) ensures that digital library experiences remain relevant and user-friendly by utilizing design, conducting research and performing usability testing. Areas of concern for Digital User Experience (UX) in Library Science include optimizing library resource search processes, improving library navigation, providing personalized library services, creating mobile-friendly libraries, and integrating the library's digital experience with the physical library space to create a seamless user experience throughout the users' library journey.

Physical UX

Physical UX design centres on meeting the user's needs when examining either the use of a traditional physical library or the use of a digital collection. By establishing that the library user's experience is similar to that of a typical customer, User Experience revolves around providing users with the highest possible quality of service. This includes finding out how the library has positively impacted the experiences of library users through their methods and means of interaction with library services, as well as through the physical spaces and technology resources provided by the library. Through this information, UX serves as an excellent tool for providing users with valuable information concerning what they like about the library and what they do not and will continue to be an effective tool as libraries move to be customer-driven organizations, build user engagement strategies, and improve on an ongoing basis.

Accessibility and Inclusive of UX in Libraries

It means ensuring the service to the person with disabilities can use the library resource and services in accessibility of product of machine like digital and non-digital devices to serve disabilities in libraries like as NVDA (Non-Visual Desktop Access), Text to Voice file conversion, DAISY formatted books reading, Empross, etc. The inclusive UX services creative spaces for the workplace by avoiding language barriers and digital literacy. The universal design principles for making experience intuitive, user centric approach involving in diverse range of users to understand their needs. The equitable experience are build the effective library experience for every one of users.

Conclusion

The Anna Centenary Library and the Kalaignar Centenary Library exemplify the commitment of India's state government to modern library services through their establishment of Personalized Information Services (PIS) and the enhancement of User Experience at both locations in Tamil Nadu. Digital technologies, including Electronic Library Management Systems (ELMS), bolster the experiences offered by both libraries. The Anna Centenary Library and the Kalaignar Centenary Library have set a precedent for all public libraries in India to adopt this emerging framework of tailored customization and advancements in user experience.

Moreover, both libraries provide practical examples of how to foster Lifelong Learning in today's information society, promote digital inclusion, and cultivate sustainable public library systems through a strategic blend of planned customization and innovative user experience solutions. Finally, PIS and user experience practices are fundamental elements in the transformation of public libraries into vibrant, user-focused information centres in the rapidly changing information landscape.

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Reimagining Library User Experience in the Era of Smart Technologies

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Abstract

The contemporary library is undergoing a profound transformation driven by smart and emerging technologies that extend beyond automation to redefine the very nature of user experience. As users increasingly engage with libraries through a combination of physical spaces and digital platforms, expectations of seamless interaction, personalization, and intuitive service delivery have become central to library relevance. This article presents a holistic examination of how smart technologies reshape library user experience by enabling omnichannel services, enhancing human–technology interaction, and supporting systematic measurement of user satisfaction. Drawing upon theoretical foundations from Library and Information Science, Human–Computer Interaction, and User Experience Design, the study introduces original conceptual insights that reposition libraries as experience-oriented knowledge environments. The article contributes new perspectives for designing future-ready, user-centric smart libraries grounded in usability, inclusivity, and technological intelligence.

Introduction

Libraries have historically evolved in response to changes in knowledge production, information formats, and user behaviour. In the digital era, this evolution has accelerated due to the rapid advancement of smart technologies such as artificial intelligence, sensor-based systems, cloud platforms, and immersive digital environments. These technologies have altered how users discover information, interact with library systems, and perceive the value of library services. Consequently, user experience has emerged as a defining factor in the sustainability and effectiveness of modern libraries.

User experience in libraries now extends far beyond access to collections. It encompasses emotional engagement, ease of interaction, continuity across platforms, and the perception of relevance in a digitally saturated environment. Reimagining library user experience therefore requires a shift from technology-centric implementation to user-centric design, where smart technologies are aligned with human needs, behaviours', and expectations. This article argues that smart libraries must be conceptualized as integrated experience ecosystems rather than isolated technological systems.

User Experience as a Core Paradigm in Modern Librarianship

User experience in libraries is rooted in interdisciplinary scholarship that combines information behaviour studies, usability theory, and service design. Within this paradigm, a library is understood as an interactive environment in which users continuously negotiate meaning, access, and value. The quality of this interaction determines not only service satisfaction but also long-term engagement and trust.

In smart library contexts, user experience is shaped by both visible and invisible technological processes. Interfaces, discovery tools, self-service systems, and digital platforms form the visible layer, while algorithms, data analytics, and adaptive systems operate in the background. A user-centric approach ensures that these layers' function harmoniously, minimizing cognitive effort while maximizing usability and satisfaction. Theoretical models from human-centred design emphasize that systems must adapt to users rather than require users to adapt to systems, a principle that is especially relevant in technologically complex library environments.

Omni channel Library Services and Experience Continuity

The emergence of Omni channel library services represents a fundamental rethinking of service delivery. Unlike traditional models where physical and digital services operate independently, Omni channel design integrates all interaction points into a unified experience. Users can initiate an information search online,

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continue it through a mobile device, and complete it within a physical library space without disruption or loss of context.

This seamless continuity is enabled by cloud-based platforms, interoperable systems, and centralized user data management. Omni channel libraries recognize that user journeys are non-linear and context-dependent. By aligning physical spaces, digital platforms, and support services, libraries reduce friction and enhance perceived service quality. The result is a library experience that feels coherent, responsive, and personalized, regardless of how or where users engage.

Human–Technology Interaction in Smart Library Environments

Human–technology interaction is a critical determinant of user experience in smart libraries. Advanced technologies introduce new modes of interaction that can either enhance or hinder usability depending on their design and implementation. Artificial intelligence-based discovery systems, conversational interfaces, self-service technologies, and intelligent environments redefine how users interact with information systems.

Effective interaction design prioritizes clarity, transparency, and user control. Systems that adapt to user behaviour while providing meaningful feedback foster trust and confidence. Conversely, poorly designed automation can create confusion, anxiety, or resistance. In smart libraries, the challenge lies in integrating intelligent systems in ways that feel natural and supportive rather than intrusive or overwhelming. Human–technology interaction must therefore be guided by principles of simplicity, accessibility, and inclusivity.

Emerging Technologies and the Transformation of Library UX

Emerging technologies play a transformative role in reshaping library user experience. Artificial intelligence enables personalized discovery, recommendation services, and virtual assistance, allowing libraries to respond dynamically to individual user needs. Internet of Things technologies contribute to intelligent physical environments where space utilization, navigation, and resource management are optimized in real time. Cloud computing facilitates ubiquitous access to resources and services, ensuring continuity across devices and locations.

Extended reality technologies introduce immersive dimensions to library services by enabling virtual tours, interactive learning environments, and digital exhibitions. These technologies expand the experiential boundaries of libraries and support new forms of engagement, particularly in educational and cultural contexts. When integrated thoughtfully, emerging technologies enhance both functional efficiency and experiential depth, positioning libraries as adaptive and innovative institutions.

Measuring User Satisfaction in Smart Library Contexts

User satisfaction measurement is essential for evaluating the effectiveness of smart library services. In technologically enriched environments, satisfaction is influenced not only by service outcomes but also by interaction quality, perceived ease of use, and emotional response. Traditional assessment methods such as surveys remain valuable, but they are increasingly complemented by usability testing, interaction analytics, and experience mapping.

Continuous evaluation enables libraries to identify pain points, refine interfaces, and adjust service design in response to evolving user expectations. Satisfaction measurement in smart libraries thus becomes a strategic tool for evidence-based decision-making, ensuring that technological innovation remains aligned with user needs and institutional goals.

Conceptual Contributions and New Perspectives

This article contributes original conceptual insights by positioning user experience as a strategic framework for smart library development. It emphasizes that technological sophistication alone does not guarantee improved services. Instead, value emerges when technologies are embedded within thoughtfully designed user journeys and supported by continuous feedback mechanisms. By integrating Omni channel

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service design, human-technology interaction principles, and satisfaction measurement, libraries can transition from service providers to experience facilitators.

Challenges and Ethical Dimensions

Despite their potential, smart technologies raise significant challenges related to privacy, data governance, digital inequality, and professional skill development. Personalization and data-driven services must be implemented ethically, with transparency and user consent. Libraries must also ensure that technological advancements do not marginalize users with limited digital literacy or access. Addressing these challenges requires institutional commitment, professional training, and ethical frameworks that align technological innovation with the core values of librarianship.

Conclusion

Reimagining library user experience in the era of smart technologies requires a holistic, user-centric vision that integrates technological intelligence with human values. Omnichannel services, effective human–technology interaction, and systematic user satisfaction measurement form the foundation of this transformation. Smart libraries that prioritize experience over mere automation are better positioned to remain relevant, inclusive, and impactful in an increasingly digital knowledge society. Ultimately, the future of libraries lies not in technology itself, but in how thoughtfully it is used to enhance human engagement with information.

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The Quiet Intervention: Bibliotherapy as the Unspoken Role of the Academic Library

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Abstract

Academic libraries have expanded beyond their traditional roles as information repositories and academic support centers. Increasingly, they are recognized as inclusive environments that contribute to the emotional and psychological well-being of students. Bibliotherapy, which involves the intentional use of reading materials to support mental and emotional health, provides a useful framework for understanding this evolving role of academic libraries. This article examines the potential of academic libraries to function as spaces that promote emotional well-being through bibliotherapy-oriented resources and services. It discusses the concept and types of bibliotherapy, highlights the importance of emotional well-being in higher education, and explores the role of libraries and librarians in facilitating therapeutic reading practices. The article further identifies key benefits of bibliotherapy, including stress reduction, emotional regulation, and personal growth among students. It concludes that bibliotherapy represents a practical, non-clinical, and cost-effective approach for enhancing emotional well-being in academic environments and emphasizes the need for greater awareness and structured implementation within academic libraries.

Keywords: Bibliotherapy, Academic Libraries, Emotional Well-being, Therapeutic Reading, Student Mental Health

Introduction

Academic libraries have traditionally served as essential components of higher education institutions by supporting learning, teaching, and research activities. In recent times, however, the scope of academic libraries has expanded beyond academic assistance to address the broader needs of students, including their emotional and psychological health. Students today encounter various challenges such as academic stress, competitive environments, social adjustments, and uncertainty regarding career prospects, all of which can negatively affect their mental well-being.

In this context, bibliotherapy emerges as a valuable and supportive approach within academic settings. Bibliotherapy refers to the purposeful use of reading materials to help individuals understand emotions, manage stress, and develop coping strategies. Reading enables students to reflect on personal experiences, relate to literary characters, and gain alternative perspectives on life situations. This article explores how academic libraries can be redefined as spaces that actively support emotional well-being through bibliotherapy-based practices.

Concept of Bibliotherapy

Bibliotherapy is commonly understood as the use of books and other reading resources as tools for emotional and psychological support. The central assumption of bibliotherapy is that literature has the capacity to positively influence human emotions, attitudes, and behavior. Engagement with meaningful texts allows readers to experience emotional release, self-awareness, and reassurance.

Bibliotherapy is generally classified into three categories: clinical bibliotherapy, developmental bibliotherapy, and self-help bibliotherapy. Clinical bibliotherapy is administered under professional supervision for individuals with psychological disorders. Developmental bibliotherapy focuses on emotional and social development and is widely applied in educational environments. Self-help bibliotherapy involves independent reading aimed at personal growth and stress management. Academic libraries primarily support developmental and self-help bibliotherapy, as these forms align with educational objectives and do not require medical intervention.

Emotional Well-being in Higher Education

Emotional well-being is a critical factor influencing students' academic performance, motivation, and overall quality of life. Students in higher education frequently experience stress due to academic workload, examinations, interpersonal relationships, and future career concerns. If left unaddressed, these pressures may result in anxiety, reduced concentration, and emotional exhaustion. Higher education institutions are increasingly recognizing the importance of mental health support mechanisms. While counseling services play a crucial role, there is also a need for preventive and informal support systems. Academic libraries, as neutral and inclusive spaces, are well suited to contribute to emotional well-being by offering calm environments and access to therapeutic reading materials. Bibliotherapy complements professional support services by providing students with a self-directed and non-stigmatizing method of emotional care.

Academic Libraries as Bibliotherapy Spaces

Academic libraries provide environments that naturally encourage reflection, concentration, and quiet engagement with reading materials. By adopting bibliotherapy principles, libraries can enhance their contribution to emotional well-being. This may involve developing collections that include fiction, poetry, autobiographies, inspirational works, and self-help literature addressing emotional resilience, stress management, and personal development.Libraries can also organize bibliotherapy-related initiatives such as reading clubs, book discussions, and thematic displays focused on well-being. Reader advisory services may be adapted to recommend materials that support emotional needs while respecting user privacy. Through such initiatives, academic libraries can extend their role from academic support units to holistic spaces that nurture emotional and intellectual growth.

Objectives of the Study

The objectives of the present study are as follows:

- To examine the concept of bibliotherapy in relation to academic library services.
- To analyze the role of academic libraries in supporting emotional well-being.
- To identify bibliotherapy-oriented resources and practices in academic libraries.
- To understand students' perceptions of reading as a tool for emotional support.
- To explore the role of librarians in facilitating bibliotherapy initiatives in higher education institutions.

Methodology

The study employs a descriptive and qualitative research approach to examine bibliotherapy within academic library contexts. Secondary sources, such as books, scholarly journals, conference proceedings, and reports related to bibliotherapy, emotional well-being, and library services, were extensively reviewed to gather data. An observational method was also adopted to gain insights into students' reading behavior and their use of library spaces for emotional comfort. Informal observations and documented case examples were analysed to understand the therapeutic role of reading in academic environments.

Scope of the Study

The scope of the present study is limited to non-clinical bibliotherapy practices within academic library environments. It focuses on the role of libraries and librarians in supporting emotional well-being through reading-based initiatives. Clinical interventions and medical treatment of mental health issues are beyond the scope of this study.

Role of Librarians in Bibliotherapy

Librarians play an important facilitative role in bibliotherapy practices by connecting users with appropriate reading materials. While they do not function as mental health professionals, librarians can support emotional well-being by maintaining relevant collections, offering sensitive reader advisory services, and ensuring ethical practices such as confidentiality and voluntary participation.

Training programs and collaboration with student support services can strengthen librarians' ability to contribute effectively to bibliotherapy initiatives. Such collaborations help ensure that bibliotherapy services remain supportive, ethical, and aligned with institutional goals.

Benefits of Bibliotherapy in Academic Libraries

Bibliotherapy offers several benefits within academic library settings. It supports stress management, encourages emotional expression, and promotes empathy and self-awareness among students. Reading also fosters reflection and personal insight, contributing to emotional maturity and resilience.

Furthermore, bibliotherapy enhances the perceived value of library services by addressing users' emotional needs alongside academic requirements. Students who experience emotional support through libraries are more likely to engage with library resources and develop positive attitudes toward reading.

Discussion

The findings indicate that academic libraries play a supportive role in promoting emotional well-being, even in the absence of formal bibliotherapy programs. Students often perceive libraries as peaceful and secure spaces that provide relief from academic stress. Reading materials such as fiction, motivational books, and biographies is commonly used for relaxation and emotional reassurance.

The study also reveals that access to diverse reading collections and quiet reading environments contributes positively to students' emotional resilience. Librarians, though not directly involved in therapeutic interventions, support bibliotherapy indirectly through resource selection, reader guidance, and the creation of welcoming library spaces. These findings suggest that integrating structured bibliotherapy initiatives could further enhance the emotional support role of academic libraries.

Conclusion

Academic libraries have significant potential to function as spaces that support emotional well-being through bibliotherapy-based services. Bibliotherapy provides a non-clinical, accessible, and cost-effective approach to addressing mental health concerns in higher education environments. By promoting therapeutic reading and creating supportive spaces, academic libraries can complement formal mental health services and contribute to holistic student development.

Future research may focus on empirical evaluations of bibliotherapy programs, user satisfaction, and the role of digital resources in therapeutic reading. As awareness of emotional well-being continues to grow, bibliotherapy can become an integral component of academic library services.

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User-Centric Evolution of Academic Library Services: An Overview of Digital Innovations and Practices at CUTN Library

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Abstract

The rapid advancement of digital technologies has substantially reshaped academic library services in higher education, shifting the emphasis from traditional resource-centered operations to a more user-centric service orientation. At the Central University of Tamil Nadu (CUTN), academic libraries are increasingly adopting emerging technologies such as artificial intelligence, cloud-based platforms, and data analytics to improve information accessibility, enhance service efficiency, and enrich overall user experience. This transformation is largely driven by changing user expectations, the growing dependence on electronic information resources, and the demand for personalized and flexible library services. This paper provides an overview of the key trends influencing the user-centric evolution of academic library services at CUTN, including the expansion of digital collections, the implementation of virtual reference and consultation services, mobile-enabled access to information resources, and the use of AI-driven recommendation tools. It emphasizes the importance of ongoing user assessment and feedback mechanisms in the design of inclusive, responsive, and user-oriented library services. The paper also highlights major challenges associated with digital transformation, such as data privacy and security concerns, variations in digital literacy levels, and issues related to the digital divide among users. By adopting a user-centric approach, academic libraries can enhance their relevance, adaptability, and long-term sustainability in the digital era while supporting effective knowledge dissemination and lifelong learning. The paper concludes by outlining strategic practices and recommendations for leveraging digital technologies to develop flexible, integrated, and responsive academic library services at the Central University of Tamil Nadu.

Keywords: Library services, digital technologies, academic libraries, Central *University of Tamil Nadu.*

INTRODUCTION

The recent transformation of library services, propelled by rapid advances in information and communication technologies, has led to a significant shift from conventional library operations to dynamic, user-centric service models. Traditionally, libraries were perceived primarily as repositories of printed materials, and library professionals were regarded as custodians of books. In the contemporary information environment, however, library professionals have assumed the role of information scientists, responsible for managing, organizing, and disseminating knowledge through diverse digital and networked platforms.

The continuous growth of communication technologies and ongoing technological innovations has fundamentally redefined the role of academic libraries in the information age. Library services have gradually evolved from an exclusive focus on physical resource management to the provision of integrated digital services that prioritize accessibility, efficiency, and meaningful user engagement. This evolution necessitates adopting innovative tools, digital platforms, and service strategies to effectively address the expanding and varied information needs of academic communities.

In the current higher education landscape, academic libraries are actively modernizing their systems and services to deliver fast, interactive, and comprehensive information support to their users. Greater emphasis is now placed on understanding user needs and expectations and designing services that are flexible, inclusive, and responsive. As a result, librarians are increasingly expected to possess multi-dimensional competencies, including technological expertise, administrative capabilities, user service skills, and effective communication abilities. Technological proficiency has become indispensable for efficiently managing routine library operations and supporting advanced digital and user-focused services.

Within this context, academic libraries such as the Central University of Tamil Nadu (CUTN) Library are leveraging digital platforms, library websites, and online tools to enhance service delivery and user engagement.

This paper provides an overview of the user-centric evolution of academic library services in higher education by examining the adoption of digital practices at CUTN Library and highlighting the role of technology in shaping modern, responsive, and user-oriented academic library services.

The Shift towards User-Centric Library Services.

A user-centric library service model focuses on delivering personalised experiences, incorporating digital innovations, and fostering an inclusive environment. Key strategies include:

I. **Personalised Digital Access**

Libraries are leveraging artificial intelligence (AI) and machine learning to offer personalised recommendations, digital catalogues, and adaptive learning resources. Online platforms provide seamless access to e-books, audiobooks, and research materials, catering to remote users and those with accessibility needs.

II. **Enhanced User Engagement Through Technology**

Mobile apps, virtual reality (VR), and augmented reality (AR) are being integrated into library services to provide interactive learning experiences. Chatbots and AI-powered assistants enhance customer service by providing instant support and helping navigate resources.

III. **Community-Centred Initiatives**

Libraries are embracing their role as community hubs by hosting educational workshops, cultural events, and social programs. These initiatives promote inclusivity and lifelong learning, making libraries more than just repositories of books.

IV. **Data-Driven Decision Making**

Libraries are utilizing data analytics to understand user behaviour, improve resource allocation, and enhance service delivery. Real-time feedback mechanisms ensure continuous improvement based on user needs.

Objectives of the Study

The present paper aims to achieve the following objectives:

1. To examine the evolving nature of academic library services in higher education institutions.
2. To identify key digital innovations influencing user-centric library services.
3. To analyse the role of technology in enhancing user engagement and service delivery.
4. To highlight the importance of user assessment and feedback in academic libraries.
5. To provide an overview of user-centric digital practices adopted at CUTN Library.

Methodology

The study adopts a **conceptual and descriptive research approach**, based on an overview of existing practices in academic library services. Secondary data were collected from scholarly literature, institutional documents, library websites, policy reports, and relevant online sources related to digital library services and user-centric practices. The Central University of Tamil Nadu (CUTN) Library is considered as a contextual reference to understand the application of digital innovations in an academic library environment. The study does not employ a case study or survey method; instead, it focuses on synthesizing existing knowledge and practices to present an overview of user-centric digital transformation in academic libraries.

User-Centric Digital Innovations and Practices at CUTN Library

The Chozha Central Library of the Central University of Tamil Nadu (CUTN) has undergone a significant transformation by adopting a user-centric approach supported by digital innovations and modern

library practices. The library has evolved from a traditional repository of printed materials into a comprehensive Learning Resource Centre that emphasizes accessibility, inclusivity, digital engagement, and efficient service delivery. These initiatives are designed to address the changing information needs of students, research scholars, and faculty members.

The user-centric digital transformation at CUTN Library can be broadly categorised into **technology-enabled services**, **web-based access mechanisms**, and **research and publishing support systems**, all of which enhance user experience and academic engagement.

Technology-Enabled and Assistive Library Services

To ensure secure, efficient, and user-friendly library operations, the CUTN Library has implemented advanced technology-driven services. The installation of **CCTV surveillance systems** and **RFID-based security infrastructure** supports safe access to resources and minimizes unauthorized usage. RFID-enabled self-service kiosks enable users to independently issue, return, and renew books, thereby reducing wait times and improving service efficiency. The **book drop box facility** further enhances user convenience by enabling easy return of library materials beyond service hours.

In line with inclusive library practices, the Assistive Technology Centre at CUTN Library supports visually impaired and differently abled users. The centre is equipped with screen readers, scanning devices, talking libraries, and audio tools, ensuring equitable access to information resources and reinforcing the library's commitment to inclusive and user-friendly services.

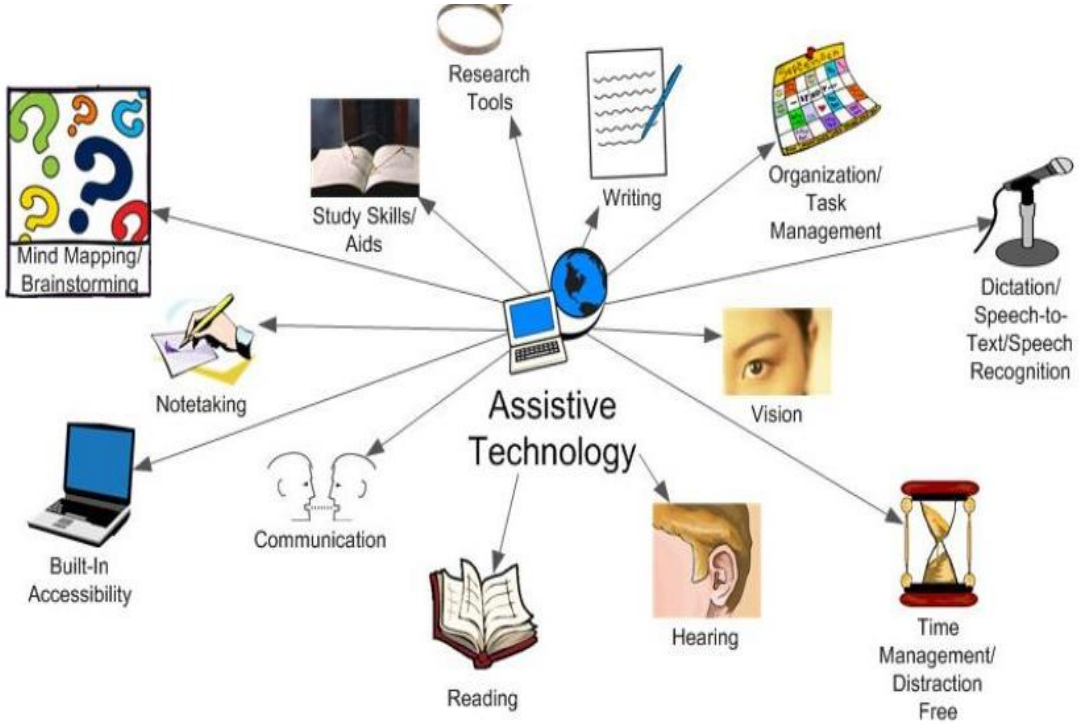


Fig. 01: Assistive Technology

Access to National and Remote Digital Resources

A significant user-centric innovation at CUTN Library is access to national-level scholarly resources through **One Nation One Subscription (ONOS)**. This initiative ensures equitable access to high-quality academic journals and research publications for students, research scholars, and faculty members. Additionally, access is facilitated through the **INFLIBNET Access Management Federation (INFED)**, which enables secure, seamless, and remote authentication to e-resources.


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Challenges and Considerations

Despite the advantages of user-centric digital transformation, CUTN Library faces challenges such as variations in digital literacy among users, financial constraints, and concerns related to data privacy and security. Addressing these challenges requires continuous user training, strategic planning, technological upgrades, and collaborative partnerships to sustain effective and inclusive library services.

Future Directions of Academic Library Services

The future of academic libraries lies in the strategic integration of advanced technologies with user-focused service design. Libraries are expected to expand the use of artificial intelligence for intelligent discovery systems, personalized learning support, and predictive analytics. Greater emphasis will be placed on mobile-first services, open access platforms, and collaborative digital spaces. Strengthening digital literacy programmes and ensuring inclusive access to resources will be crucial. Academic libraries must continue to adapt to emerging technologies while maintaining their core mission of knowledge dissemination and academic support.

Conclusion

The user-centric evolution of academic library services at the Central University of Tamil Nadu demonstrates how digital innovations can enhance accessibility, efficiency, and user engagement. By integrating advanced technologies and focusing on user needs, CUTN Library has strengthened its role as a dynamic academic support system. Despite challenges, the adoption of inclusive, flexible, and technology-driven practices positions academic libraries to remain relevant and responsive in the digital era. Continuous innovation, user feedback, and strategic investment will be crucial for sustaining and advancing user-centric library services in higher education.

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Evaluating the Impact of Library Services on the Academic Success of Undergraduate Students

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Abstract

Academic libraries play a vital role in supporting teaching, learning, and research in higher education institutions. This study evaluates the impact of library services on the academic success of undergraduate students. Using a survey-based methodology, data were collected from undergraduate students regarding their usage of library resources, services, and facilities. The findings indicate a significant positive relationship between effective library services and students' academic performance, learning outcomes, and research skills. The study emphasizes the importance of strengthening library services to enhance undergraduate academic success.

Keywords: Academic libraries, library services, undergraduate students, academic success, Information literacy.

Introduction

In the contemporary educational environment, academic libraries are no longer confined to book lending alone; they function as dynamic learning hubs offering both print and digital resources. Undergraduate students rely heavily on libraries for academic materials, research guidance, and learning support. Evaluating the impact of library services on students' academic success is essential to justify resource allocation and improve service quality. The academic success of undergraduate students depends on various factors such as availability of learning resources, quality of instruction, study environment, and access to information. Among these, library services occupy a significant position as they provide students with timely access to textbooks, reference materials, e-books, e-journals, and online databases. Effective library services enable students to complete assignments, prepare for examinations, and develop research and critical thinking skills.

Therefore, the present study aims to evaluate the impact of various library services on the academic success of undergraduate students. By analysing students' usage patterns, perceptions, and academic benefits derived from library services, the study seeks to highlight the role of academic libraries in enhancing undergraduate education.

Concept of Academic Success

Academic success among undergraduate students is a multidimensional concept that extends beyond examination scores and grades. It includes cognitive**,** behavioural, and affective outcomes that contribute to a student's overall educational development. Common indicators of academic success include grade point average (GPA), timely completion of assignments, research competence, class participation, retention, and progression to higher levels of study.

In addition to measurable outcomes, academic success involves the development of transferable skills such as critical thinking, problem-solving, effective communication, and information literacy. Undergraduate students are expected to locate, evaluate, and use information ethically and effectively. Academic libraries significantly influence these competencies by providing structured access to scholarly resources and guided learning support.

Objectives

The main objectives of this study are:

a) To examine the extent of library service usage by undergraduate students.
b) To evaluate the impact of library resources and services on students' academic performance.
c) To analysis students' perceptions of library support in achieving academic success.
d) To suggest measures for improving library services.

Fig: 1 Concept of Academic Success



Library Services Supporting Academic Success

Academic libraries offer a wide range of services that directly and indirectly enhance undergraduate learning.

Access to Information Resources

Libraries provide access to textbooks, reference books, journals, newspapers, e-books, databases, theses, and open-access resources. Availability of reliable, authentic, and up-to-date information enables students to complete assignments, projects, and examinations more effectively. Scholarly resources provided by libraries enhance the quality and credibility of academic work.

Reference and Research Assistance

Reference services such as help desks, one-on-one consultations, email support, and online chat services assist students in identifying relevant information sources. Librarians guide students in formulating research topics, developing search strategies, using academic databases, and applying appropriate citation styles. These services are particularly beneficial for first-year and first-generation undergraduate students.

Information Literacy Instruction

Information literacy instruction is one of the most impactful library services for undergraduate students. Through orientation programs, workshops, and course-integrated sessions, libraries train students to search for information efficiently, evaluate sources critically, and use information ethically. Participation in information literacy programs improves academic writing, research confidence, and awareness of plagiarism prevention.

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Study Spaces and Learning Environment

Modern academic libraries provide well-designed physical spaces such as quiet reading areas, group discussion rooms, and collaborative learning zones. A supportive and disciplined learning environment encourages concentration, peer interaction, and collaborative learning, which positively influence academic success.

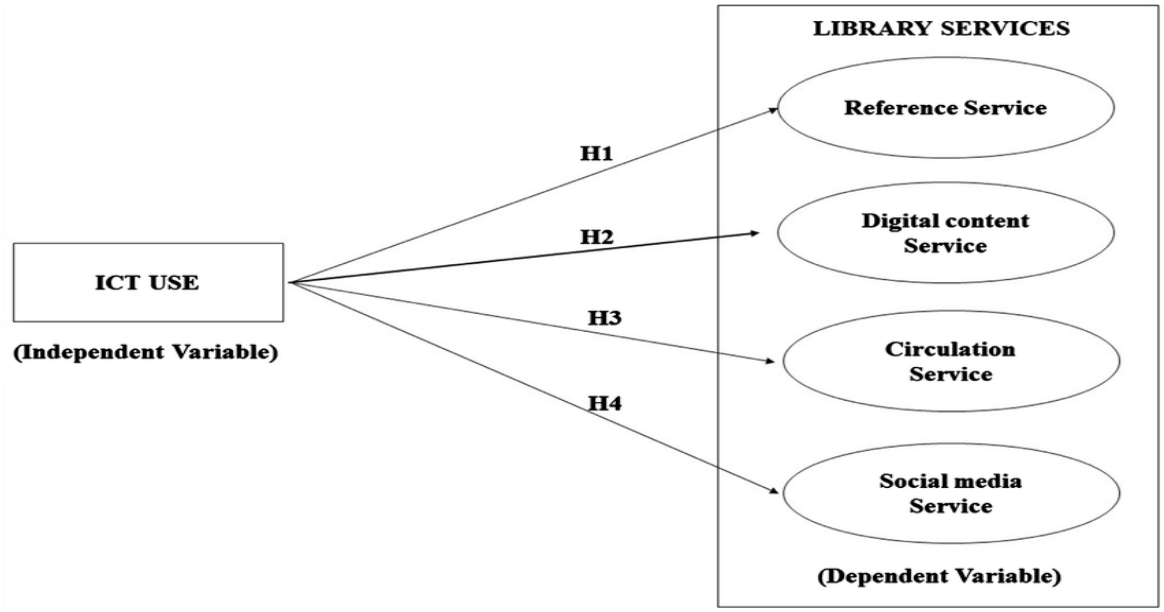
Digital and Technology-Based Services

Libraries offer access to computers, internet facilities, printers, scanners, and assistive technologies. Remote access to e-resources, institutional repositories, and learning management systems supports flexible and technology-driven learning. These services also help bridge the digital divide by ensuring equitable access to academic resources.

Various Types of Library Services

S. No	Type of Library Service	Description	No. of Students	Percentage (%)
1	Circulation Service	Issue, return, and renewal of books	85	85%
2	Reference Service	Guidance in locating information resources	70	70%
3	Digital Library / E-Resources	Access to e-books, e-journals, databases	75	75%
4	Reprographic Service	Photocopying and scanning facilities	60	60%
5	Current Awareness Service (CAS)	Information on new arrivals and updates	55	55%
6	Selective Dissemination of Info (SDI)	Personalized information service	40	40%
7	OPAC / Online Catalogue	Online search for library holdings	65	65%
8	User Education / Orientation	Training on library usage and information literacy	50	50%

Fig: 2- VARIOUS TYPES OF LIBRARY SERVICES



Impact of Library Services on Academic Performance

Numerous studies indicate a positive relationship between library usage and academic achievement among undergraduate students. Students who frequently utilize library resources and services demonstrate improved academic performance, stronger research skills, and higher levels of academic engagement.

Access to scholarly databases enables students to produce well-researched and well-structured assignments. Reference support and information literacy training contribute to proper citation practices and plagiarism-free academic work. Regular interaction with library services enhances students' confidence, independence, and motivation to learn.

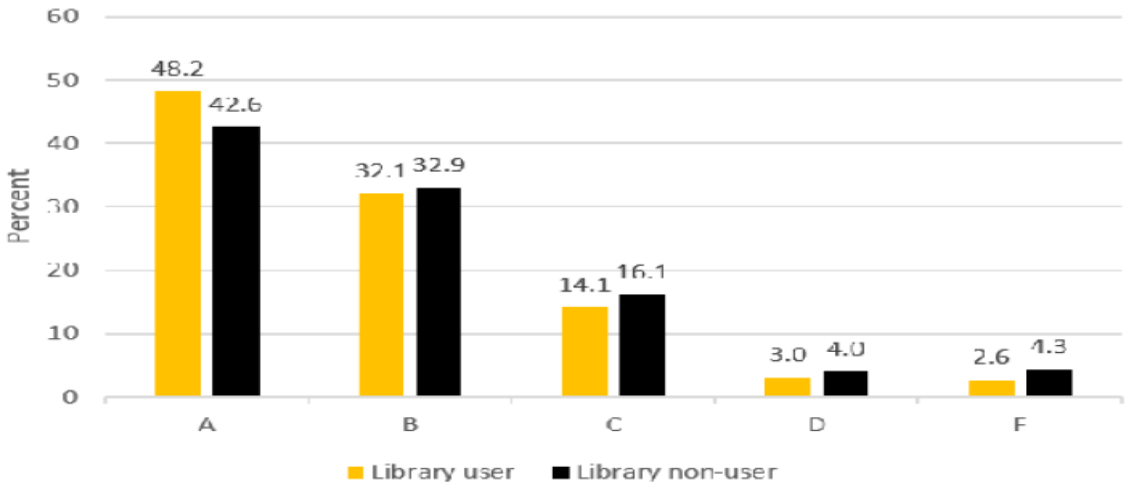
Frequency of Library Use and Academic Performance

Frequency of Library Use	Percentage of Students (%)	Academic Performance Level
Daily	30%	Very High
Weekly	40%	High
Occasionally	20%	Moderate
Rarely	10%	Low

Types of Library Services and Their Academic Impact

Library Service	Description	Impact on Academic Success
Print Resources	Textbooks, reference books, journals	Improves subject understanding and exam performance
Electronic Resources	E-books, e-journals, databases	Enhances research quality and assignment depth
Reference Services	Librarian guidance, help desks	Develops research accuracy and confidence
Information Literacy Programs	Training on search skills and citation	Improves critical thinking and plagiarism avoidance
Study Spaces	Reading halls, group discussion rooms	Encourages focused study and collaboration
Technology Services	Computers, internet, printers	Supports digital learning and academic task

Fig:III



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Role of Librarians in Academic Support

Librarians play a pivotal role as facilitators of learning and academic mentors. Through orientation programs, instructional sessions, workshops, and personalized guidance, librarians help students adapt to academic requirements and research practices. Collaboration between librarians and faculty members ensures that library instruction is aligned with curriculum objectives.

By promoting academic integrity, ethical use of information, and scholarly communication practices, librarians contribute significantly to the intellectual and academic development of undergraduate students.

Equity and Inclusion in Library Services

Academic libraries promote equity and inclusion by providing free and equal access to learning resources. This reduces financial barriers for economically disadvantaged students. Libraries also support students with disabilities through assistive technologies and inclusive services. Multilingual resources and user-friendly support systems further enhance access for students from diverse linguistic and cultural backgrounds.

Challenges in Maximizing Library Impact

Despite their importance, academic libraries face several challenges in maximizing their impact on undergraduate success. These include limited awareness of library services among students, budget constraints, rapid technological changes, staff shortages, and increasing user expectations. Many students rely heavily on freely available internet sources without recognizing the value of scholarly library resources.

Addressing these challenges requires continuous user education, proactive outreach programs, innovative service delivery, and strong institutional support.

Challenges and Strategies to Improve Library Impact

Sl. No	Challenges	Strategies for Improvement
1.	Low awareness of services	Orientation and awareness programs
2.	Overdependence on internet	Training on scholarly databases
3.	Budget constraints	Investment in digital resources
4.	Technological changes	Staff training and upgrades
5.	Low student engagement	Faculty–librarian collaboration

Strategies to Enhance Library Contribution to Academic Success

To strengthen the impact of library services on undergraduate academic success, higher education institutions should:

a) Integrate information literacy instruction into the academic curriculum

b) Promote collaboration between librarians and teaching faculty

c) Increase awareness of library resources and services through orientation and outreach programs

d) Invest in digital resources and user-friendly technologies

e) Conduct regular assessment of library services and user satisfaction

Research Methodology

1. The study adopted a **descriptive survey method**.
2. **Population:** Undergraduate students of a selected college/university.

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3. **Sample Size:** 100 undergraduate students selected using random sampling.
4. **Tool for Data Collection:** Structured questionnaire.
5. **Data Analysis:** Descriptive statistics such as frequency, percentage, mean, and standard deviation

Review of Related Literature

Previous studies have highlighted the role of libraries in improving students' academic outcomes. Research shows that frequent library use is associated with higher grades, better research skills, and improved information literacy. Digital library services, reference assistance, and information literacy programs have been found to contribute significantly to student learning and academic engagement.

Conclusion

Library services play a crucial and multifaceted role in shaping the academic success of undergraduate students. By providing access to quality information resources, research assistance, information literacy instruction, supportive learning environments, and technology-based services, academic libraries significantly enhance students' learning experiences and outcomes, evaluating and strengthening library services is essential to ensure that libraries remain integral to the teaching–learning process. When effectively integrated into higher education, library services become powerful drivers of academic excellence, student success, and lifelong learning.

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The Relevance of Books in the Internet Era: A Descriptive Study of Reader Perspectives

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Abstract

The transition from a print-based culture to a networked society has significantly altered reading habits, yet physical books maintain a unique relevance due to their cognitive, emotional, and social values. This study examines the continued importance of printed media in the digital age through a descriptive survey conducted at the 49th Chennai Book Fair. Using a convenience sampling technique, data were collected from 82 respondents, predominantly students and working professionals, to analyze their reading preferences and behaviors.

Findings reveal an overwhelming consensus on the resilience of print, with 95% of participants affirming that books remain relevant despite widespread internet use. The survey highlights a strongly transactional visitor pattern, as 71% attended primarily to purchase books rather than merely browse. Qualitative insights further indicate that readers prefer physical books for "deep immersion" and improved concentration, specifically to mitigate the "screen inferiority" and distractions associated with digital platforms. Additionally, library visitation remains structurally embedded in information-seeking behavior, with 69% of respondents visiting libraries "sometimes" or "often". The study concludes that a hybrid reading ecology has emerged, where physical books continue to hold a privileged status for focused learning and cultural preservation alongside digital convenience.

Keywords: Reading habits, Physical books, Chennai Book Fair, Digital age, Print culture.

Introduction

The transition from a print culture to a networked society has dramatically impacted the role of physical books in society. Although reading is an essential skill for academic success and lifelong learning, the widespread use of the internet and social media has dramatically changed the reading culture of literary engagement. Studies show that the "net generation" increasingly treats the internet as their main source of information and entertainment, leading to a sharp decline in the time spent on printed media. This trend has affected not only the reading habit but also the overall reading literacy, as readers increasingly rely on "passive sources" such as social media for information.

However, the use of digital media is largely driven by practical considerations such as portability and 24/7 accessibility. In contrast, physical books continue to have a unique relevance due to their enhanced social, emotional, and cognitive values. Physical books remain the book of choice for "deep immersion" and intense reading, while digital platforms are often associated with non-linear and potentially superficial reading. Moreover, physical books are less likely to be affected by physiological factors such as eye strain and visual fatigue compared to digital platforms. Keeping in mind the impact of internet as a whole, this study tried to find if the habit of reading physical books was still alive on the visitors of the 49th Chennai Book Fair.

Literature Review

The evolution of reading habits in the digital age is a multifaceted phenomenon, characterized by a complex interplay between traditional literacy practices and the burgeoning influence of information and communication technology (ICT). As modern society transitions from a predominantly print-based culture to a virtually networked one, the role and relevance of physical books are being redefined by shifting consumption values and the perceived relative advantages of digital media. While reading remains fundamentally recognized as an indispensable skill for academic success and lifelong learning (Carrell, 1989; Grabe, 1991), the proliferation of the Internet and social media has significantly altered the landscape of literary engagement.

The decline of traditional reading habits is often attributed to the "displacement effect," where time previously dedicated to books is now consumed by electronic media. Research indicates that the "net generation" of students increasingly views the Internet as a primary source for both information and

entertainment, leading to a significant decrease in the amount of time spent on printed materials (Roberts & Foehr, 2004; Loan, 2012). Huang et al. (2014) observe that this shift has not only resulted in a decline in reading frequency but has also negatively impacted overall reading skills, as readers become more prone to gathering information through "passive sources" such as television and social media. Despite this trend, scholars like Holte (1998) argue that reading printed books continues to add a unique quality to life, providing vital access to culture and heritage that digital browsing often lacks.

Theoretical frameworks such as Rogers' (2003) Diffusion of Innovations and the Theory of Consumption Values (TCV) proposed by Sheth, Newman, and Gross (1991) provide a lens for understanding why readers choose one medium over another. The adoption of e-books is largely driven by functional values, including high portability, accessibility, and the convenience of 24/7 information seeking (Nelson, 2008; Connaway et al., 2011). However, physical books maintain a distinct relevance through superior social and emotional values. Rainie et al. (2012) highlight that the tactile and physical nature of printed books makes them the preferred choice for specific social functions, such as gift-giving or the intimate experience of reading with children.

Furthermore, the physical medium offers cognitive and physiological advantages that current digital technology has yet to replicate. Printed books remain the favored format for "deep immersion" and intensive reading, whereas digital environments are often characterized by non-linear, interactive, and potentially superficial processing (Birkerts, 1994; Gibson & Gibb, 2011). Chartier (2004) suggests that digital reading can lead to a sense of textual incoherence, as the fluidity of the screen disrupts the structured boundaries of the traditional page. Additionally, physiological factors such as visual fatigue and eye strain are significantly more prevalent during prolonged screen reading compared to reading from the printed page (Cushman, 1986; Gibson & Gibb, 2011). The presence of interactive distractions, such as blinking graphics and vivid colors in online spaces, further hinders the conceptual focus required for literary reading (Schmar-Dobler, 2003).

The digital age has also transformed the very definition of "the book," uncoupling content from its traditional container and giving rise to new forms of literary production. Johnson (2021) discusses the emergence of the "citizen author" within digital communities like Wattpad and FanFiction.net, where writers bypass traditional gatekeepers to share their work directly with readers. This "social reading" environment facilitates real-time interaction between authors and their audiences, creating a communicative structure that is fundamentally different from the static nature of the printed word (Sedo, 2011; Johnson, 2021). Bhaskar (2013) and Keh (1998) argue that in this information age, the publisher's role is shifting from the purveyor of physical products to the purveyor of ideas and framed content that can be delivered across multiple formats.

However, this transition does not signify the obsolescence of the physical book. Instead, McLuhan's concept of the "rear-view mirror" suggests that we often understand new media via the codes and attributes of the old (McLuhan, 2003). The persistent desire for physical copies of works originally published on social media platforms indicates that the printed format still retains a level of cultural privilege and legitimacy (Johnson, 2021). While digital tools allow for innovative ways of connecting and sharing content, the physical book remains a vital artifact for focused learning and cultural preservation. Ultimately, the relevance of physical books in the digital age is anchored in their ability to offer a coherent, immersive, and conceptually demanding experience that complements, rather than is entirely replaced by, the convenience of digital alternatives.

Objective

This study aims to investigate the demographics, motivations, and visitation behaviors of attendees at the Chennai Book Fair, including their profession, primary reasons for visiting (e.g., buying books vs. browsing), first-time vs. repeat status, and satisfaction levels in finding desired items. It particularly examines attitudes toward the relevance of physical books in the internet age, alongside patterns of library usage and qualitative preferences for print over digital formats. The goal is to highlight the resilience of print-oriented reading culture among students, working professionals, and families, informing strategies for promoting physical books and libraries in a digital era.

Methodology

The present study adopted an in-person interaction research design to examine the relevance of physical books in the internet era. This method was chosen to collect first-hand data on reading preferences, attitudes, and behaviors of readers in a real-world setting where physical books are actively accessed and purchased.

In addition to structured questionnaire responses, informal oral interactions with respondents were also considered to enrich the understanding of reader perceptions. This combination helped capture both quantitative data and qualitative insights related to the continued importance of physical books.

Study Area and Context

The Chennai Book Fair is an annual event conducted by BAPASI (Book Publishers and Sellers Association of South India). The 49th such iteration was held this year at the YMCA grounds, Chennai. The book fair is one of the largest literary events in the country, attracting readers, writers, students, educators, families, and literature enthusiasts from across Tamil Nadu and other parts of India, with some international participation. The fair hosted nearly 1,000 book stalls, including publishers, bookshops, and library book sections, covering a wide range of subjects such as history, religion, literature, fiction, non-fiction, children's books, science, general knowledge, textbooks, guides, and cultural studies. Books were available in multiple languages including Tamil, English, Hindi, Urdu, and others. Reports indicate that around 20 lakh visitors attended the fair and approximately 50 lakh books were sold, with significant participation from youngsters, students, and families. This setting provided an ideal environment to study perceptions of physical books, as visitors were directly engaging with printed materials.

Population and Sample

The population for the study included book fair visitors, particularly:

- Students
- Working professionals
- Parents
- Retired workers
- General public

The sample consisted of 82 respondents, selected using a convenience sampling technique. Participants were chosen based on their availability and willingness to respond.

Data Collection Instrument

Primary data were collected using a structured questionnaire prepared by the researchers (First year students of the University of Madras pursuing Master of Library and Information Science). The questionnaire consisted of 6 close-ended questions with predefined options. They were designed to understand both reading habits and attitudes toward physical books in comparison to digital alternatives while maintaining simplicity for respondents.

Data Collection Procedure

The interviews were administered in person at the book fair between 2-6 pm on Friday, 21st Jan 2026. Respondents were informed about the purpose of the study, and participation was entirely voluntary. Informed consent was obtained verbally and no personal identifying information was collected. Responses were recorded digitally and later compiled into a spreadsheet for analysis. Care was taken to ensure data accuracy, completeness, and consistency.

Apart from the questionnaire, some respondents voluntarily shared their views through informal oral conversations with the researchers, which provided additional qualitative insights to complement the survey data.

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Limitations

As the survey was conducted within a book fair using convenience sampling, the responses may reflect a natural inclination toward physical books. However, this limitation is also a strength, as the study captures the perspectives of active readers and book buyers, who play a crucial role in understanding the continued relevance of physical books.

Results

A large share are students (45%), followed by working professionals (37%) and others (18%) as seen in Table 1, suggesting the fair primarily attracts an academically and professionally engaged audience with active information needs. This mix aligns with typical book-fair demographics, where students and educated workers form the core visitor base, often using fairs to supplement academic and professional reading.

Table 1. What is your profession?

Category	Count	Percentage
Student	37	45%
Working	30	37%
Others	15	18%

The majority report visiting to buy books (72%), while smaller groups come mainly to browse (16%) or for other reasons (12%) as seen in Table 2, which include volunteering, general visitor, and to purchase a subscription. This indicates a strongly transactional and goal-oriented pattern rather than casual leisure traffic. Such a high buying intent is consistent with studies showing that book fairs function as purchase-focused events where visitors come with pre-identified needs and titles in mind.

Table 2. Reason for visiting the book fair?

Category	Count	Percentage
Buy books	59	72%
Browse	13	16%
Others	10	12%

About 40% are first-time visitors, while 60% are repeat visitors, as seen in Table 3, indicating the fair has already established a stable loyal base while still attracting a substantial proportion of new attendees. In satisfaction research, a higher share of repeat visitors is usually interpreted as an indicator of prior positive experiences and perceived value, since people tend not to return to events that did not meet their expectations. A large majority (82%) report that they found what they were looking for, but nearly one in five (18%), as seen in Table 4, did not, which signals good overall performance with a meaningful minority of unmet needs.

Table 3. First time visitor to book exhibition?

Category	Count	Percentage
Yes	33	40%
No	49	60%

Table 4. Did you find what you are looking for?

Response	Count	Percentage

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Yes	67	82%
No	15	18%

A high proportion of book fair goers (95%), as seen in Table 5, affirm that books remain relevant in the age of the internet, showing a strong pro-book attitude in this population. This resonates with broader discussions that, even in digital environments, books are valued for depth, sustained attention, and reliability compared with fragmented online content. Given that most respondents are students and working professionals, this support likely reflects their reliance on books for structured learning, exam preparation, and professional development.

Table 5. In the age of internet, do you think books are relevant?

Response	Count	Percentage
Yes	78	95%
No	4	5%

Library visitation is moderate: 42% visit sometimes, 26% often, and 30% rarely, as seen in Table 6, suggesting that while libraries remain part of many respondents' information practices, they are not used intensively by a large minority.

Table 6. How often do you visit libraries?

Category	Count	Percentage
Rarely	25	30%
Sometimes	35	43%
Often	22	27%

Qualitative Observations

During the survey process, several meaningful oral responses were recorded:

- Many young respondents, especially students and working professionals, expressed that physical books help them connect better with reading and improve concentration.
- Several respondents stated that they felt more comfortable reading physical books than digital copies, especially during long reading sessions.
- Senior citizen respondents consistently expressed a strong preference for printed books over digital formats.
- Parents visiting the fair to purchase books for their children emphasized that physical books help reduce screen time and encourage healthy reading habits without digital distractions.

Discussion

The research findings delineate a resilient, print-oriented reading culture where students and working professionals continue to prioritize physical monographs and libraries. This behavior persists despite an internet-saturated environment, suggesting that traditional media remains central to their cognitive and professional habits.

The sample is predominantly composed of students (45%) and working professionals (37%). These cohorts typically engage in extensive reading for academic examinations and professional development,

anchoring their literacy practices in long-form, text-intensive materials. This aligns with literature suggesting that while ICT provides breadth, "deep immersion" and intensive reading are still best served by the printed format. Furthermore, the high proportion of visitors (72%) attending primarily to purchase books suggests that reading is a concrete practice involving the acquisition of physical resources rather than a merely aspirational activity.

While electronic media can displace time previously dedicated to books, many respondents seek a hybrid balance. They utilize the internet for rapid information retrieval while maintaining book-based engagement for conceptually demanding tasks. Qualitative feedback from young respondents regarding improved concentration and reduced distraction resonates with research on screen inferiority. This phenomenon suggests that readers experience superior sensory involvement and focus with print, as digital environments are often characterized by non-linear and interactive distractions. The overwhelming consensus (95%) regarding the continued relevance of books serves as empirical evidence of a resilient print-positive habit.

Parents surveyed emphasized printed books as a deliberate strategy to reduce screen time and foster healthy cognitive development in children. This underscores the role of physical books as tools for shaping social development amidst pervasive digital media.

Library visitation patterns—where 70% of respondents visit "Sometimes" or "Often" —indicate that libraries remain structurally embedded in the information-seeking behaviors of the community alongside the internet. Modern reading habits are characterized by the co-existence of print and digital modes. Readers often opt for digital platforms for accessibility (24/7 information seeking) while choosing print for contemplative, intensive study.

Conclusion

The transition from a print-based culture to a networked society has undeniably altered how information is consumed, yet this study confirms that physical books remain a cornerstone of intellectual and cultural life. Findings from the book fair demonstrate a resilient preference for printed media, with 95% of respondents affirming its continued relevance despite the ubiquity of the internet.

The data reveals that reading remains a goal-oriented practice, particularly among students and working professionals who rely on the structured nature of print for academic success and professional development.

Ultimately, while the internet provides breadth and speed, the physical book remains an indispensable tool for intensive study, focused learning, and cultural preservation. The enduring popularity of events like the Chennai Book Fair serves as a testament to the fact that the printed word continues to provide a unique, high-quality experience that digital alternatives cannot fully replicate. To conclude, the inculcation of reading habits from childhood is mandatory for good academic success and professional development and every parent should try to embed this practice in their children.

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Gamification in Libraries: Enhancing User Motivation and Discovery

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Abstract

The traditional library model, perceived by many users as a static repository of information, is undergoing a significant transformation. Gamification—the application of game-design elements in non-game contexts—has emerged as a powerful strategy to revitalize library services. This article explores the potential of gamification to enhance user motivation and facilitate discovery within academic and public libraries. Drawing upon contemporary literature, it examines how elements like points, badges, leaderboards, and narrative quests can increase student engagement, promote digital and information literacy, and encourage the exploration of library collections and services. The analysis synthesizes findings from key studies to present actionable strategies and discusses future challenges, positioning gamification not as a mere trend but as an essential component of modern, user-centered library practice.

Keywords: Gamification, Library Services, User Engagement, Information Literacy, Motivation, Discovery, Game-Based Learning, User Experience, Digital Literacy.

Introduction

In an era dominated by digital interaction and on-demand information, libraries are compelled to innovate to maintain their relevance and appeal. Gamification offers a compelling avenue for this innovation, moving beyond the stereotype of libraries as silent spaces to dynamic hubs of interactive learning. By integrating motivational dynamics from games into library contexts, institutions can transform routine tasks like searching catalogs, attending workshops, or exploring archives into engaging and rewarding experiences (Walsh, 2014). This shift aligns with the evolving expectations of users, particularly digital natives, who respond positively to interactive and goal-oriented environments. This article synthesizes recent research to argue that effectively implemented gamification strategies significantly boost user motivation and act as a catalyst fordiscovery, turning passive patrons into active participants and co-creators of their learning journeys.

Objectives of the study

The main objective of the current investigation are,

- To explore how gamification motivates library users.
- To identify gamification strategies for literacy and discovery.
- To propose a framework for integrating gamification.
- To assess the outcomes and challenges of these strategies.

Methodology for the study

This study employs a descriptive review of six selected publications (2014-2025).It applies thematic analysis to identify recurring concepts across the literature. The process involves extracting data on specific game mechanics and their contexts. Findings are synthesized to construct an evolutionary narrative of the field. A phased implementation framework is derived from the synthesized evidence. The methodology includes a critical evaluation of reported challenges. The analysis aims to integrate diverse perspectives from theory and practice. This approach provides a structured yet adaptable overview for library professionals.

Theoretical Underpinnings and Core Motivations

The efficacy of gamification is rooted in established motivational theories, including Self-Determination Theory, which emphasizes autonomy, competence, and relatedness. Walsh (2014) early on highlighted its potential in academic libraries to increase student engagement and achievement by making learning and interaction intrinsically rewarding. Game elements tap into users' desires for mastery, status, and achievement. For instance, earning a "Master Researcher" badge after completing a series of database tutorials provides a

tangible sense of competence. Leaderboards for most books checked out or most reference questions asked can foster a sense of friendly competition and relatedness among users (Haasio, Madge, & Harviainen, 2021). The core motivation is to make the library's vast resources less intimidating and more accessible, guiding users through a structured yet enjoyable process of discovery. As Rathod (2025) notes, this approach aligns with pedagogical strategies that favor active learning over passive reception, thereby fostering deeper engagement and retention of information literacy skills.

Gamification for Digital and Information Literacy: From Theory to Practice

A primary and well-documented application area is in promoting digital and information literacy. T R & Gala (2023), in their survey of web-based games in the Digital Humanities, provide a concrete taxonomy of how libraries implement gamification for learning. They categorize existing initiatives into:

- **Tutorial-based Games:** Interactive modules that replace static guides for database navigation.
- **Quiz and Puzzle Games:** Focused on skills like source evaluation, plagiarism awareness, and copyright understanding.
- **Simulation and Role-playing Games:** Where users might assume the role of a researcher or archivist to solve information-based problems.

These methods demonstrate a move beyond traditional, often ignored, tutorials. As Haasio et al. (2021) reinforce, games in libraries are not just for entertainment; they are serious tools for conveying complex information-seeking behaviours. Similarly, Dr. M.S. Girish Rathod (2025) discusses gamification as a strategy for targeted skill development, where missions and quests are designed around specific learning outcomes, such as mastering advanced search operators or understanding metadata. This approach transforms mandatory instruction into voluntary, curiosity-driven exploration, thereby enhancing the internalization of complex concepts and fostering lifelong learning habits.

Transforming Discovery and Collection Engagement

Gamification directly addresses the perennial challenge of discovery—helping users find resources they did not know they needed and promoting underused collections. Lim (2023) provides a detailed analysis of specific gamification elements like narrative storytelling, exploration, and feedback loops. For example, a "Library Explorer" quest might encourage users to visit different sections, scan QR codes for historical facts about the collection, and unlock a special collection or a reward, effectively using a narrative to guide physical exploration. Naik & Naik (2024), in "From Bookshelves to Screens," illustrate how this bridges the physical and digital divide. They argue that gamified mobile applications can use augmented reality (AR) overlays or location-based challenges to turn the library building itself into a game board, thereby increasing the visibility and usage of physical stacks and special archives. This transforms the library from a mere storage space into an experiential landscape for knowledge discovery.

Implementation Frameworks and Strategic Integration

Successful implementation requires a strategic, user-centered design philosophy rather than a haphazard addition of points and badges. Haasio et al. (2021) emphasize that gamification in libraries must be meaningful and integrated into core services to avoid being perceived as a superficial gimmick.

Points will be credited to their profiles such as Simple level – 10 points, Moderate level – 30 points, harder level – 50 points.

1. Basic Engagement (Awareness):

- The “Daily Login & Discover” Streak: Reward users for simply visiting the digital library homepage or app daily. A visual calendar shows their streak.
- Feedback Mini-Game: Instead of a boring survey, present feedback as agame and giving credit points to them.
- Summer reading programmes: Conducting it for Best readers and making them a way to meet famous authors for their future development.

2. Educational Integration (Literacy): Collaborating with faculty to embed information literacy games and quests directly into course curricula and learning management systems, making skill development a graded or rewarded part of academic work.

- Mini games in Searching catlog
- Duolingo inspired streaks for Weekly database explorations with MOODLEpartnership .
- Interactive modules within the Learning Management System (LMS). Students complete task like "Keyword Karate" (breaking down a topic into search terms).

3. Advanced Discovery & Community Building (Transformation): Developing large-scale, narrative-driven programs.collaborative challenges that require teams to use diverse library resources to solve a problem, fostering peer-to-peer learning .

- "The Great Library Mystery" - Narrative ARG (Alternate Reality Game): A mystery story delivered through email, the library blog, and physical QR codes around campus. Clues require players to use specific databases, decode historical documents from the digital repository, or interview a subject librarian.
- "Interdisciplinary Fusion" Challenges: Monthly challenges that require using resources from seemingly unrelated disciplines.Winners get featured in a library blog post.
- An open-source engine like Ren'Py, designed for creating visual novels, presents a unique opportunity. Library staff with scripting knowledge could develop interactive stories where users converse with virtual librarians or historical figures from the archives.

Outcomes and Challenges

This comprehensive three-tiered gamification strategy promises transformative outcomes by fundamentally reshaping the library's role from a passive repository to an active, engaging learning ecosystem. It fosters a culture of habitual discovery, scaffolds crucial information literacy skills directly into academic work, and builds collaborative learning communities through narrative-driven challenges. Successful implementation positions the library as a central pedagogical partner, drives deeper utilization of collections, and cultivates a generation of adept, interdisciplinary researchers. However, this ambitious vision faces significant strategic challenges, including the "implementation pyramid paradox" where the most impactful programs require the greatest resources for the fewest users, creating sustainability tensions. Success hinges on securing crucial faculty buy-in for curriculum integration, navigating complex data privacy and equity concerns to ensure inclusive access, and overcoming major organizational capacity constraints. The strategy demands a multidisciplinary skill set rarely found in traditional libraries, continuous content creation to avoid engagement fatigue, and robust technical integration across disparate systems. Ultimately, the journey requires strategic patience to achieve long-term cultural transformation while deliberately engineering short-term wins through phased pilots, clear pedagogical alignment, and a modular design that allows for iterative learning and adaptation.

Conclusion

Gamification represents a profound paradigm shift in how libraries conceptualize user interaction and service delivery. By leveraging the innate human propensity for play, challenge, and reward, libraries can significantly enhance intrinsic user motivation, making the pursuit of knowledge an active, social, and enjoyable endeavor. The literature confirms that from boosting digital literacy to unlocking the hidden treasures within collections, gamification is a potent tool for fostering discovery and creating a vibrant, modern library culture. For the contemporary library professional, understanding these principles and thoughtfully applying evidence-based strategies is essential to building dynamic, relevant, and resilient libraries of the future.

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Libraries as Community Hubs: Space Reallocation and Dynamic Services

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Abstract

The pervasive shift towards digital information consumption necessitates a fundamental re-evaluation of the library's physical form and function. As physical print collections contract in both size and relative usage, a critical opportunity emerges for libraries to strategically reallocate space towards dynamic, community-centric services. This article examines how this transformation—from static repositories to active, participatory hubs—reinforces the library's relevance in the 21st century. Drawing upon contemporary library science discourse, it analyzes the implementation of makerspaces, collaborative learning zones, and civic forums as manifestations of this shift. Furthermore, it argues that this spatial reallignment aligns with the principles of the Green Library movement, promoting not only environmental sustainability through efficient space use but also social sustainability by fostering inclusion and community resilience. The article concludes that embracing this evolution is essential for libraries to remain vital public institutions.

Keywords: Space Reallocation, Community Hubs, Green Libraries, Makerspaces, Third Place.

Introduction

The iconic image of the library as a silent sanctuary dominated by towering bookshelves is undergoing a profound metamorphosis. Triggered by the dual forces of technological advancement and evolving societal needs, libraries worldwide are reimagining their raison d'être. The transition from analog to digital collections has initiated a spatial revolution within library walls, challenging traditional space allocation models (Ludwig & Starr, 2022). This is not a marginal adjustment but a core strategic reorientation: a shift from being collection-centred to becoming community-centred. The liberation of square footage once dedicated to low-use stacks presents an unprecedented opportunity to convert libraries into vibrant "great good places"—social infrastructures essential for community health and democratic engagement (Oldenburg, 1999). This article explores this transformative journey, investigating how the deliberate reallocation of space for dynamic services is forging libraries into indispensable community hubs.

Objectives of the Study

This study aims to:

1. To explore why and how libraries are changing their physical spaces.
2. To identify the new community-focused services these spaces make possible (like makerspaces and learning labs).
3. To examine how this shift makes libraries more socially inclusive and environmentally sustainable.
4. To understand the role of the modern library as an essential community center.

Methodology

This study is based on a review and analysis of existing research. I examined key articles, books, and professional reports written by experts in library science and design. By comparing and connecting ideas from these sources, I identified common themes and trends related to how libraries are redesigning space and services to better serve their communities. This approach allows me to present a clear picture of the ongoing transformation of libraries into active community hubs.

From Stacks to Startups: The New Spatial Logic

The traditional library was architecturally determined by its collections, with space primarily serving storage and linear browsing. The contemporary model inverts this logic, designing space around human

activities and interactions. As Krachenberg (2021) notes, libraries are evolving from being "stacks" to acting as "incubators"—spaces that nurture ideas, skills, and community ventures. This requires a fundamental spatial reallocation. Compact storage solutions, shared print repositories, and a focus on digital access reduce the physical footprint of the legacy collection. The reclaimed space is then intentionally designed to be flexible, multi-functional, and user-responsive. This shift, as Ludwig and Starr (2022) articulate, represents the "shift from collection to connection," where the library's value is measured by the quality of interactions and experiences it facilitates, not merely the volume of items it houses.

Dynamic Services: The Manifestation of Community Focus

The reallocated space serves as a platform for a suite of dynamic services that directly address community needs:

- Makerspaces and Digital Creation Labs: Following the ALA's (2020) guidance, libraries are installing spaces equipped with tools like 3D printers, coding kits, and audiovisual studios. These labs democratize access to technology, fostering digital literacy, creativity, and hands-on learning, effectively turning patrons from consumers into creators.
- Collaborative Learning Commons: Moving beyond solitary carrels, libraries are creating zones designed for collaboration. As May and Leighton (2023) discuss in the context of "spatial equity," these areas—with movable furniture, writable surfaces, and booking-enabled rooms—support group study, peer-to-peer tutoring, and project-based learning, making the library an extension of the classroom and the innovation lab.
- Civic and Cultural Forums: Embracing Oldenburg's (1999) "third place" concept, libraries are dedicating space for public dialogue. They host lecture series, community meetings, art exhibitions, and cultural programming, positioning themselves as neutral grounds for civic engagement and cultural exchange, strengthening the social fabric.

Sustainability and the Green Library Synergy

This transformation is intrinsically linked to the Green Library movement. Antonelli (2021) emphasizes that green libraries advocate for sustainability in operations, design, and service philosophy. Space reallocation contributes significantly to this goal. Environmentally, reducing the energy-intensive stack areas lowers a building's carbon footprint. More profoundly, the green library concept extends to social sustainability. By creating inclusive spaces that promote sharing (of tools, knowledge, space), digital inclusion, and community resilience, libraries practice a form of social sustainability. Reusing existing structures for new, vibrant purposes is the ultimate form of recycling—breathing new life into a community asset and ensuring its long-term viability and value.

Challenges and Considerations

Implementing this vision is not without obstacles. Resistance from users attached to traditional library models, budget constraints for renovation and technology, and the need for continuous staff upskilling are significant hurdles. Ensuring equitable access to new services so that they do not inadvertently create new digital or social divides is paramount. Success requires participatory planning involving community stakeholders, phased implementation, robust staff training programs, and ongoing assessment to ensure services meet evolving community needs.

Conclusion

The strategic reallocation of library space from storing inert objects to hosting dynamic human activities represents a necessary and powerful evolution. It is a conscious move from a warehouse model to a workshop and forum model. This transition, supported by the literature, demonstrates that the library's future lies not in abandoning its physical space but in radically re-purposing it to serve as an inclusive, sustainable, and responsive community hub. By doing so, libraries reaffirm their role as critical infrastructure for democracy, lifelong learning, and community well-being in the digital age.

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Access Facilities and Their Impact on Digital and Self-E-Learning Resources: A Case Study of PROF. V.B.S. Rajan Library, AMET University

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Abstract

The rapid transformation of higher education into a knowledge-driven ecosystem has intensified the demand for efficient access to information resources. Academic libraries are no longer confined to physical collections but are evolving into hybrid knowledge centres that support digital access, remote learning, and self-directed education. This study examines the impact of access facilities provided through print resources, digital library services, and self e-learning platforms at Prof. V.B.S. Rajan Library, AMET University, Chennai.

The research adopts a descriptive case study approach to analyze the availability, accessibility, and utilization of electronic resources, web-based services, and remote access facilities. Emphasis is placed on Web OPAC, institutional repository services, INFED remote access, and national digital initiatives such as NPTEL, SWAYAM PRABHA, and the National Digital Library of India. The findings reveal that enhanced ICT infrastructure, combined with user awareness programs and faculty encouragement, significantly improves the effective use of e-resources. The study highlights that remote access facilities have reduced dependency on physical library visits and strengthened academic productivity among students and research scholars.

The paper concludes that the integration of digital library technologies with traditional library services plays a crucial role in supporting teaching, learning, and research in higher education institutions.

Keywords: Digital Library, E-Resources, Web OPAC, Remote Access, Institutional Repository

Introduction

Higher education institutions are under increasing pressure to produce graduates capable of functioning effectively in the information and knowledge society. Although information is abundant in the digital era, the challenge lies in ensuring sustainable, organized, and meaningful access to authentic knowledge resources. Academic libraries play a pivotal role in addressing this challenge by facilitating access to quality information through both print and electronic formats.

Advancements in information and communication technologies (ICT) have significantly altered the nature of library operations, resource management, and service delivery. Libraries are transitioning from conventional repositories of printed materials into digitally enabled knowledge hubs that provide anytime, anywhere access to scholarly resources. Rising enrolment, escalating costs of information resources, and growing demand for remote access have further accelerated the adoption of digital library systems.

In this context, the present study investigates the access facilities provided by Prof. V.B.S. Rajan Library, AMET University, Chennai, with special emphasis on digital library services and self e-learning resources.

Profile of Prof. V.B.S. Rajan Library

Prof. V.B.S. Rajan Library operates in a dedicated building with an area of 21,499.97 square feet and is fully automated using AUTOLIB Integrated Library Management Software. The library is equipped with Web OPAC, RFID technology, barcode systems, and INFED remote access facilities. It was inaugurated on 4 September 2014 and is named in honor of Prof. V.B.S. Rajan.

The library supports academic, research, and administrative activities by providing access to both print and electronic resources. Value-added services include a digital knowledge center, institutional repository using DSpace, access to national digital platforms, audiovisual learning facilities, plagiarism detection software, and

user feedback mechanisms. Wi-Fi connectivity, CCTV surveillance, and fire safety systems ensure a secure and user-friendly learning environment.

Review of Literature

Swain (2010) highlighted the growing preference for electronic resources among students, particularly e-journals and e-books, due to their ease of access and usefulness. Dery et al. (2016) observed that adequate ICT skills among students enhance effective utilization of digital resources in academic environments.

Tlakula and Fombad (2017) examined the use of electronic resources in a historically disadvantaged university and emphasized the importance of user awareness and training. Parminder Singh and Payare Lal (2017) found that awareness programs and improved infrastructure significantly influence the usage of e-resources in academic libraries.

These studies collectively underline the role of digital access facilities, user education, and technological infrastructure in maximizing the benefits of electronic resources.

Objectives of the Study

The objectives of the study are:

1. To examine awareness of e-learning and digital education resources among users.
2. To assess access to and use of e-books and e-journals.
3. To analyse the effectiveness of digital access facilities in AMET University Library.
4. To study the role of the institutional repository in scholarly communication.
5. To evaluate the impact of remote access services on learning and research.

Methodology

The study follows a descriptive research design based on a case study approach. Data were collected from library records, digital resource statistics, institutional repositories, and access platforms. Secondary sources such as library databases, annual reports, and usage records were analysed to assess the availability and accessibility of print and electronic resources.

Library Resources and Access Facilities

The library houses over 1,03,648 printed books and provides access to more than 2.29 lakh e-books and 49,718 e-journals through subscribed and open-access platforms. Major digital resources include DELNET, J-GATE, NDLI, Shodhganga, IEEE, and NPTEL.

Web OPAC enables users to search library holdings remotely using author, title, and subject keywords. INFED remote access allows off-campus access to subscribed resources, ensuring uninterrupted learning. The institutional repository preserves theses, dissertations, question banks, and rare documents, thereby supporting long-term knowledge preservation and global visibility.

Findings and Discussion

The study reveals that digital access facilities have significantly enhanced information retrieval and academic productivity. Students with higher ICT competence and faculty guidance demonstrate greater utilization of e-resources. Remote access facilities reduce physical constraints and promote self-learning. Awareness programs conducted by the library have positively influenced user engagement with digital platforms.

Conclusion

The study concludes that digital library services and self e-learning facilities at Prof. V.B.S. Rajan Library have substantially improved access to academic resources. The integration of Web OPAC, remote access, and institutional repositories has transformed the library into a dynamic learning environment.

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Continuous investment in ICT infrastructure, user training, and faculty support is essential to maximize the impact of digital resources in higher education.

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Accessibility of Library Resources for Users: A Case Study of the Public Library in Kannampalayam, Coimbatore

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ABSTRACT

Access to information is a core principle of librarianship, and public libraries play a crucial role in ensuring equitable access to knowledge for diverse communities. This study examines the accessibility of library resources, focusing on their physical, digital, and service-related dimensions. It assesses the availability and usability of print and electronic resources, infrastructural facilities, assistive technologies, and user support services for various groups, including persons with disabilities, senior citizens, and marginalized populations. Using a descriptive research design, data were collected through questionnaires and interviews with library users and professionals. The findings, analyzed with appropriate statistical tools, reveal gaps in infrastructural accessibility, a limited availability of assistive technologies, and varying levels of user awareness and utilization of resources. The study underscores the need for inclusive policies, improved infrastructure, staff capacity building, and the adoption of assistive and digital technologies to enhance accessibility. Ultimately, the outcomes aim to support evidence-based planning and policy formulation to strengthen inclusive access in the Kannampalayam Public Library in Coimbatore.

Key Words: Public Library; Accessibility; Library Resources; Services; User Community.

INTRODUCTION

Public libraries stand as foundational pillars of democratic society, operating as community-based institutions dedicated to the principle of free and equitable access to information, knowledge, and cultural resources for individuals of every age, socioeconomic status, and background. Far more than mere book repositories, they are dynamic agents of social and intellectual development. Their core mission extends to actively promoting literacy from early childhood reading programs to adult basic education—and fostering a culture of lifelong learning that empowers individuals at every stage of life. As inclusive social institutions, public libraries are intentionally designed to serve a remarkably diverse spectrum of users. They provide safe, welcoming environments for children discovering the joy of reading, students seeking academic support, researchers accessing specialized materials, senior citizens engaging with community and technology, and marginalized populations finding a critical bridge to essential services and social inclusion. This deliberate inclusivity is central to their role in strengthening informed citizenship, ensuring all community members have the resources needed to participate fully in civic life.

The service model of the modern public library is comprehensively multifaceted. It encompasses not only vast collections of print and digital media but also expert reference and research assistance, public internet and computer access, and a rich calendar of community programs—from author talks and technology workshops to job-seeking clinics and cultural events. These offerings collectively support the educational, recreational, and day-to-day informational needs of the public. In the digital era, this role has expanded decisively. Public libraries now function as essential gateways and guides to the digital world, providing free access to computers, high-speed internet, e-books, online databases, and digital literacy training. In doing so, they perform a crucial civic function by helping to bridge the persistent digital divide, ensuring that technological advancement does not deepen existing social and economic inequalities.

This study analyzes the accessibility and utilization of resources at the Kannampalayam Public Library in Coimbatore. It specifically examines the availability and usage patterns of its collections, assesses user interests and visit frequency, and evaluates the services provided by library staff. The Public Library started in 1965. By investigating these operational dimensions, the research seeks to understand how effectively this community institution fulfils its core mission of providing equitable access and fostering engagement, thereby contributing to individual empowerment and community development as outlined in the preceding principles.

Resources of the Public Library, Kannampalayam, Coimbatore

Subject wise book collections	**No. of book collections**
Novels	10000
Spiritual books	2000
Medicine books	1895
Literature	3500
Folklore books	1000
Grammar	1000
General books	6815
Total Books	**26210**

DEFINITION OF PUBLIC LIBRARY

According to Ranganathan (1940), a library is a public institution or establishment charged with the care of a collection of books, the duty of making them accessible to those who need the use of them and the task of converting every person in its neighborhood into a usual library gore and reader of books.

According to Oxford Learner's Dictionaries (n.d). "A building in which collections of books, CDs, Newspapers, etc. are kept for people to read, study, or borrow from a public, reference, university etc. Library is a room where most of the books are kept to enkindle knowledge. This library also contains some personal collections of books, music, etc".

As per IFLA/UNESCO Public Library Manifesto, **(1997)** , "public library is the local access to knowledge, providing a basic order for lifelong learning, independent assessment making and cultural development of the individual and social groups. Knowledge is an important resource and a public library is not only a cultural institution but also an essential welfare through the minds of people".

LITERATURE REVIEW

Mushtaq and Arshad (2022) Mushtaq and Arshad (2022) examined the most and least frequent activities of public library users, demographic differences in library use, and users' perceived importance of library resources, services, and facilities. Their findings indicate that expanding reading hall space and providing a more comfortable reading environment would enhance library usage. The study also highlighted the value of community programs such as storytelling sessions, workshops, and interactive activities—in supporting lifelong learning. These results suggest that public libraries can strengthen their services by addressing demographic variations in user behavior. This research is especially significant in contexts where studies on demographic, particularly gender-based, differences in public library use are limited, as it contributes valuable insights into how users perceive library resources, services, and spaces.

Sin (2011) analyzed variations in public library funding and services across different neighborhoods. Utilizing GIS techniques, inequality measures, and regression analysis on data from the Public Libraries Survey and census tracts, the research assessed how library resources differ based on neighbourhood income and urbanization levels. The findings revealed significant disparities among nearly 9,000 library systems, particularly in digital collections, professionally trained staff, and library programs, with lower-income and rural areas receiving less funding. However, access to public internet terminals showed no significant association with income, suggesting some success from targeted funding efforts. The study underscores the need to reassess library funding mechanisms and encourages further research into how structural information inequities shape user information behaviour.

Zhou, Duan, Qiu, and Yang (2024) investigated the influence of organizational learning on service innovation in public libraries, paying particular attention to the role of librarians in this process. The study found

that organizational learning has a significant positive effect on service innovation. Specifically, knowledge acquisition and knowledge application strongly contributed to service innovation, while knowledge sharing showed a relatively weak impact. Additionally, employee psychological empowerment was found to negatively moderate the relationship between knowledge sharing and service innovation, but it had no significant moderating effect on the relationships involving knowledge acquisition or knowledge application.

Shuva (2023) evaluated public library use among Bangladeshi immigrants in Canada, focusing on their engagement with settlement services and their pre-migration access to public libraries. Using a mixed-methods approach, the study found that while public libraries play a positive role in supporting newcomers, immigrants' use of these libraries declines over time. The findings highlight the immigrants' limited familiarity with public libraries before arrival and underscore the necessity for stronger outreach initiatives. Consequently, the study recommends that public libraries develop meaningful partnerships with settlement agencies, ethnic community and religious organizations, and ethnic media to improve awareness and use of library services within immigrant populations.

Mainka et al. (2013) conceptualized "Informational Cities" as key spaces within the knowledge society, highlighting the crucial role of public libraries within their digital, smart, knowledge, and creative infrastructures. The study categorized library services into digital and physical components, empirically analyzing the core services of public libraries in 31 Informational World Cities through content analysis of library websites and an examination of their social media activities. The findings revealed that many libraries provide free digital resources—particularly e-books, e-journals, and bibliographic databases—alongside digital reference services delivered mainly via email and web forms. Furthermore, libraries actively use social media, especially Facebook and Twitter, for user communication. Physically, public libraries serve as architectural landmarks offering dedicated spaces for children, learning, collaboration, and community interaction, with widespread Wi-Fi provision and increasing adoption of RFID technology. The study concluded that modern public libraries fulfill a dual core function: delivering digital services and facilitating communication, while also providing inclusive physical spaces for learning, working, and social engagement.

OBJECTIVES OF THE STUDY

- To identify the demographic profile of the library's user community.
- To investigate the frequency and timing of user visits.
- To analyze the availability and usage of library resources.
- To categorize users by their primary affiliation or need (e.g., students, researchers, community members).
- To determine the primary purposes for visiting the library.

METHODOLOGY

This study adopts a descriptive survey method to assess the accessibility and use of resources at the Kannampalayam Public Library in Coimbatore. A structured questionnaire was designed based on the study's objectives and distributed to 130 library users, from which 100 completed responses were collected. The data were then simplified and analyzed using a simple percentage method. This approach was selected to gather data from a substantial number of respondents within a limited timeframe and to systematically collate their feedback for meaningful interpretation.

DATA ANALYSIS AND INTERPRETATION

Data analysis and interpretation form the heart of this research, as they are essential for addressing the study's core objectives. After data collection, the researcher's primary task is the systematic compilation and careful tabulation of the data, which enables meaningful inference. In this study, a structured questionnaire was distributed to 130 library users, yielding 100 duly completed responses. While collected data may be adequate, valid, and reliable, it serves no worthwhile purpose unless it is systematically classified, tabulated, scientifically analyzed, intelligently interpreted, and rationally concluded. A rigorous analytical process, guided by logical

reasoning, allows a researcher to examine each component of the data. Therefore, systematic data analysis is the most essential part of any scientific research, as it directly provides answers to the established research questions.

Table-1: Age wise distribution of respondents

Age Group	No. of Respondents	Percentage %
Below 18	10	10.00
19-36	25	25.00
37-54	35	35.00
55 Above	30	30.00
Total	**100**	**100**

The above table shows the Age-wise distribution of respondents. Out of the surveyed 100 respondents, there is 10 (10.00%) of respondents are Below 18 years; 25 (25.0%) respondents belong to the age group of 19-36 years; and 35 (35,00%) respondents belong to the age group of 37-54; 30 (30.00%) of them belong to 55 Above.

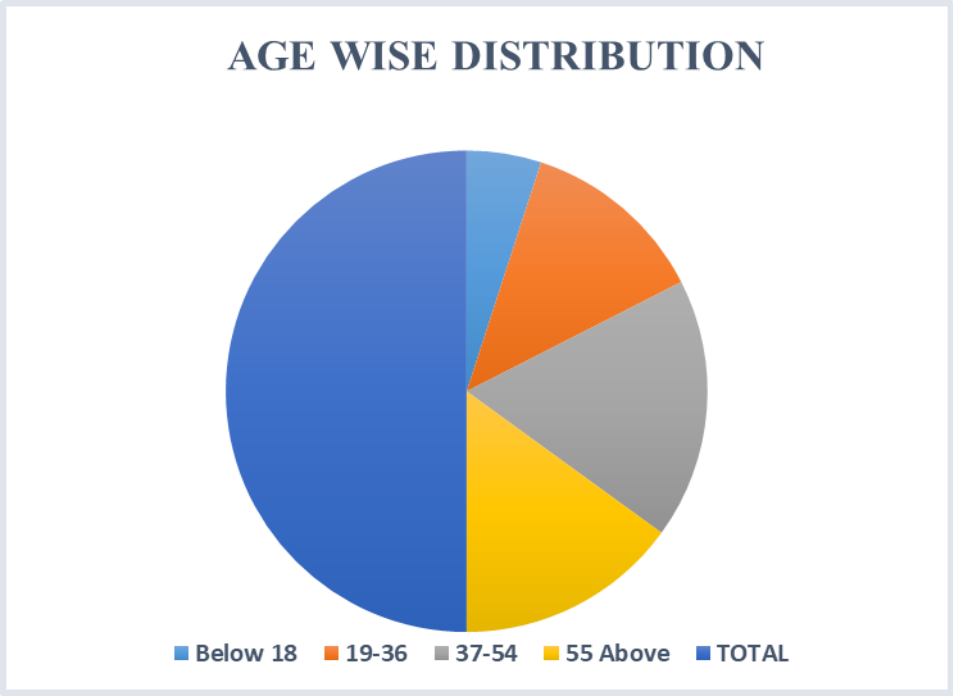


Figure-1: Age wise distribution of respondents

Table-2: Time spent in Library

Time spent in Library	No. of Respondents	Percentage %
Below 1 Hours	72	72
1-2 Hours	28	28
Total	**100**	**100**

The Table indicates users were asked to indicate the average time they spent at the library during each visit. Their responses were analysed and summarized. Among the 100 respondents, the majority, 72 users (72%), spent below 1 hours per visit. This was followed by 28 users (28%), spent 1 to 2 hours in the library.

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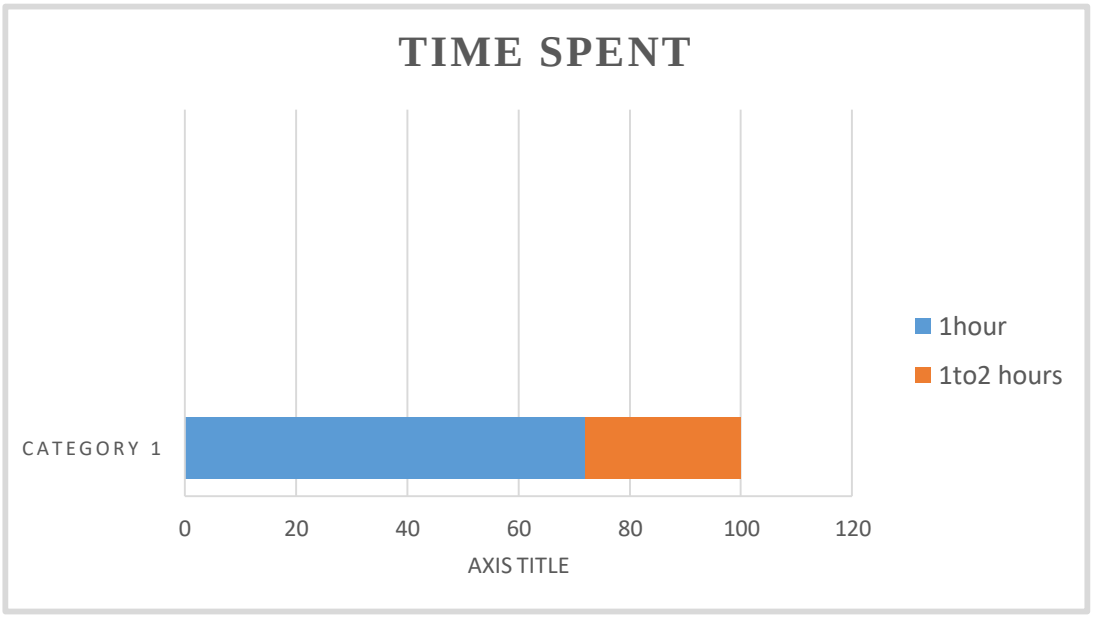


Figure-2: Time spent in LibraryTable-3: Users satisfaction with library collection

Satisfaction Level	No. of Respondents	Percentage %
Very Satisfied	82	82.00
Satisfied	18	18.00
Total	**100**	**100**

This Table presents the level of satisfaction with the collection at the Public Library, as reported by the user community. The findings reveal that the majority of users, 82 (82.00%), felt very satisfied with the library's collection. This is followed by 18 users (18.00%) who expressed being satisfied with the library's collection.

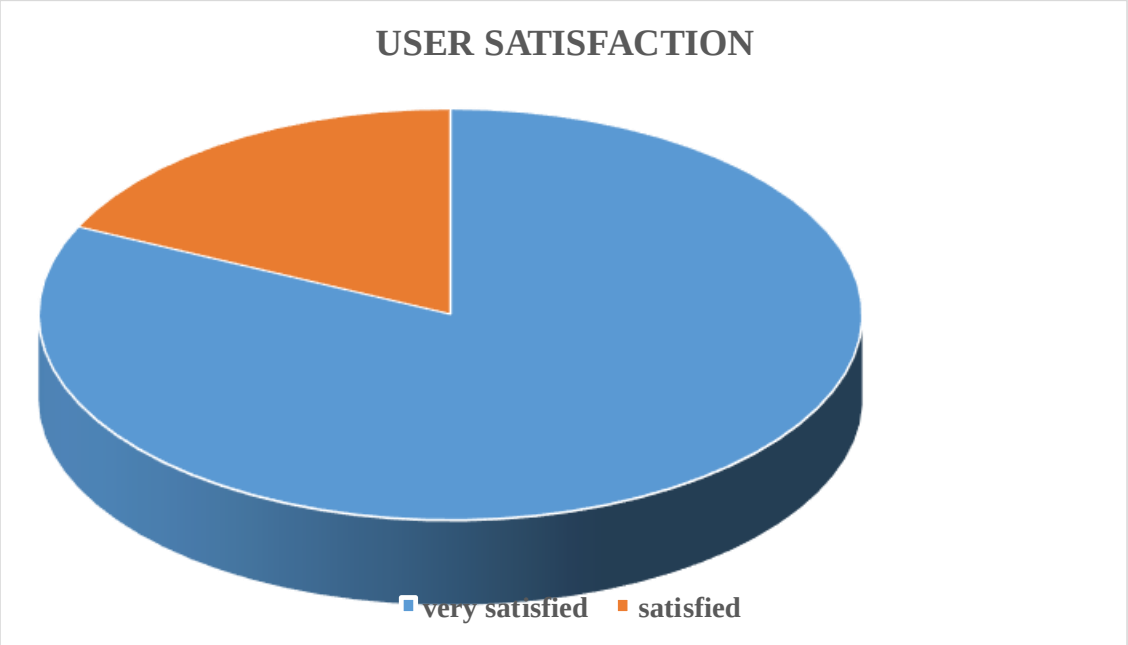


Figure-3: Users satisfaction with Library Collection

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Table-4: Satisfaction with Library Internet facility

Satisfaction Level	No. of Respondents	Percentage %
Yes	86	86.00
No	14	14.00
Total	**100**	**100**

Table 4 indicates A majority of 86 respondents (86.00%) answering "Yes" indicates modernization, while 14 (14.00%) answering "No" highlights limitations, underscoring the importance of internet access for improving user satisfaction and resource accessibility.

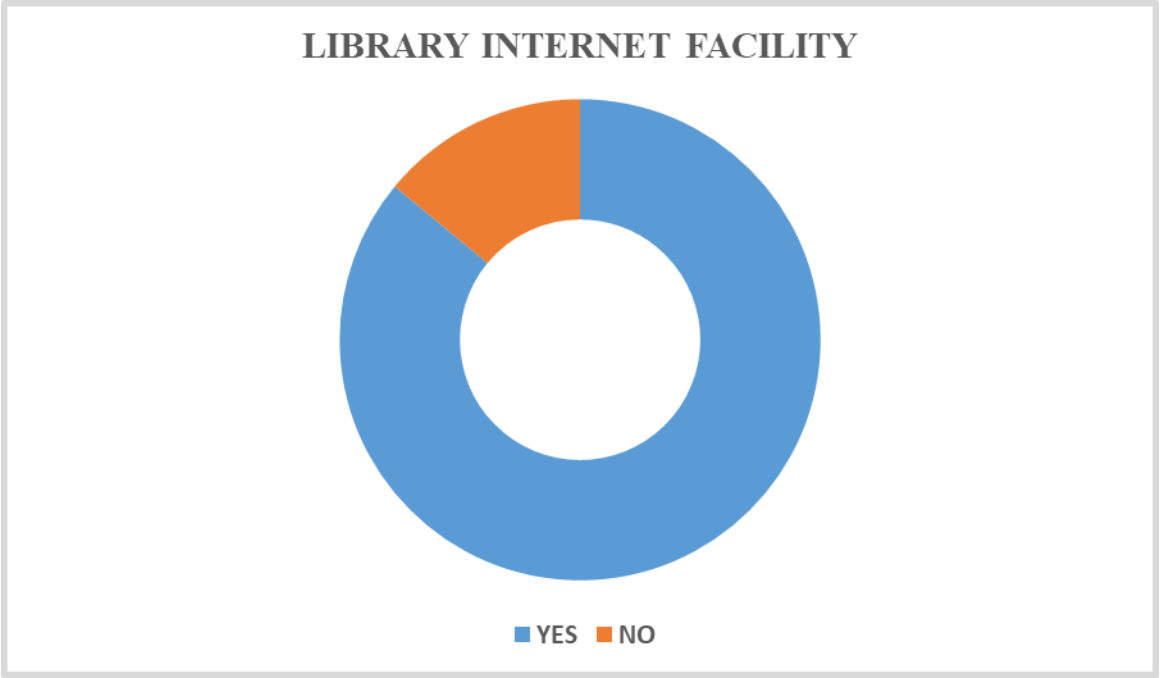


Figure-4: Satisfaction with Library Internet facility

Table-5: Types of library resources

Types of library resources	No. of Respondents	Percentage %
Books	62	62.00
Digital Content	24	24.00
Periodicals	14	14.00
Total	**100**	**100**

Table 5 provides information on the types of resources in the Public Library. The majority of users, 62 (62.00%), identified books as the most frequently used resource. This was followed by 14 users (14.00%) who mentioned periodicals, 24 users (24.00%) who indicated digital resources.

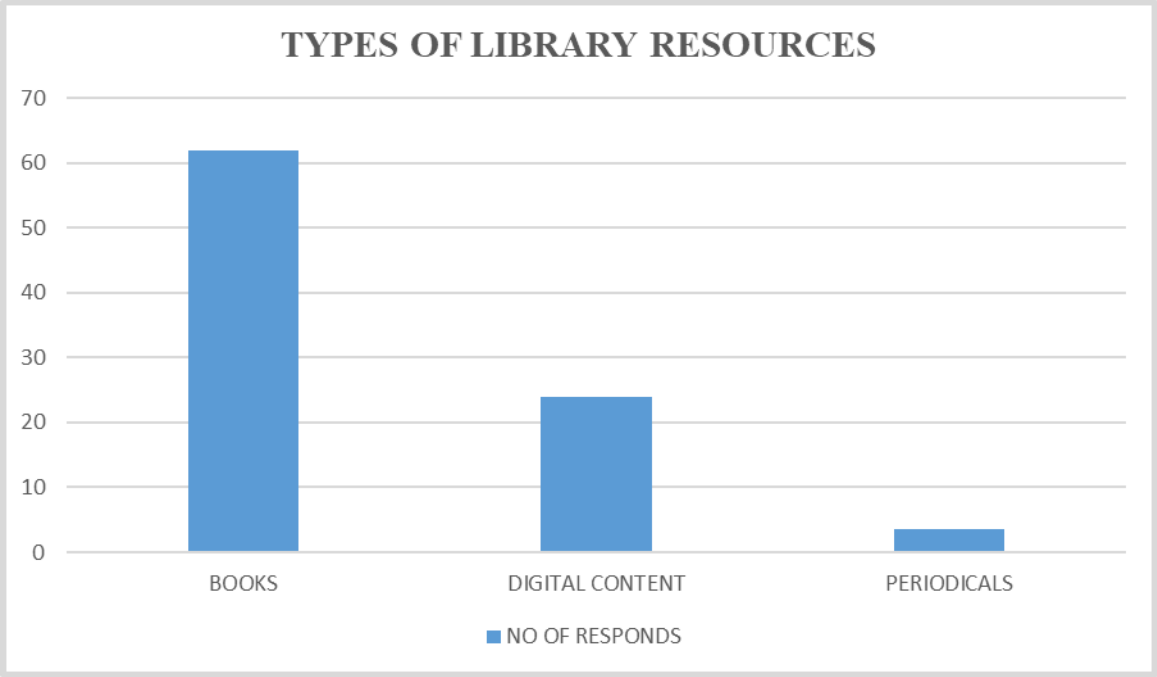


Figure-5: Types of library resources

FINDINGS AND SUGGESTIONS

The study concludes that while public libraries predominantly offer traditional print resources including books, newspapers, and magazines, they often lack updated reference materials and specialized collections. Although digital resources such as e-books, online databases, and internet services are present in some cases, their utilization is hindered by inadequate infrastructure, limited computer access, and unreliable connectivity. Physical accessibility remains a significant barrier, with many library buildings deficient in essential features such as ramps, elevators, clear signage, and assistive facilities for elderly and disabled users.

Further findings indicate low user awareness of available resources, particularly digital and assistive services, compounded by insufficient staff training in digital tools, which limits effective user support. Restricted operating hours and socio-economic barriers such as low digital literacy and a lack of personal devices among economically disadvantaged users further constrain access.

In response to these findings, the study recommends the regular updating of collections, enhancement of digital infrastructure, and improvements to physical accessibility through inclusive design. It also advocates for user orientation programs, ongoing staff training, extended library hours, digital literacy initiatives, and strengthened policy and funding support to ensure equitable and effective access to library resources for all segments of society.

CONCLUSION

This study examined the accessibility of library resources in a public library setting, focusing on users' ability to locate, access, and utilize both print and digital materials. The findings affirm the enduring role of public libraries in offering free and equitable information access across diverse educational, social, and economic backgrounds. While print resources remain highly utilized, access to digital resources is increasing, driven by technological adoption and growing user awareness.

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However, the study identifies persistent challenges to accessibility, including limited digital infrastructure, low user awareness of available services, insufficient information literacy skills, and physical barriers for elderly and disabled users. Inadequate staff support and outdated collections in certain areas further constrain effective information access.

The study concludes that enhancing accessibility requires a balanced development of physical and digital resources. Recommendations include strengthening ICT infrastructure, regularly updating collections, and implementing user education programs to improve information literacy. Special emphasis should be placed on inclusive services for disadvantaged groups. By addressing these areas, public libraries can substantially improve resource accessibility and reinforce their role as vital centers for learning, knowledge sharing, and community development.

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Institutional Repositories as Catalysts for Open Access and Research Visibility: The Evolving Role of Academic Libraries

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Abstract

Institutional repositories (IRs) have emerged as vital components of the open access (OA) ecosystem, enabling academic institutions to disseminate, preserve, and showcase their scholarly output. Managed primarily by academic libraries, IRs support open scholarly communication and enhance the visibility and impact of research. This paper examines the role of institutional repositories as catalysts for open access and research visibility, with a particular focus on the evolving responsibilities of academic libraries. Using a descriptive and analytical review of existing literature, the study identifies key functions of IRs, evaluates their contribution to research dissemination, and highlights challenges faced in their implementation. The findings indicate that academic libraries play a strategic role not only as repository managers but also as advocates, educators, and policy partners in the open access movement. Strengthening library-led repository services is essential for sustaining open and inclusive scholarly communication.

Keywords: Institutional repositories, Open access, Scholarly communication, Academic libraries, Research visibility

Introduction

The landscape of scholarly communication has undergone a significant transformation due to advances in digital technologies and growing demands for unrestricted access to research. Traditional subscription-based publishing models have limited access to scholarly literature, particularly for institutions and researchers in resource-constrained environments. The open access movement emerged as a response to these challenges, advocating free and immediate access to research outputs.

Institutional repositories represent a practical and sustainable mechanism for implementing open access at the institutional level. By providing platforms for self-archiving and dissemination of scholarly works, IRs enhance access to knowledge while preserving institutional intellectual output. Academic libraries, leveraging their expertise in information organization, preservation, and access, have assumed leadership roles in the development and management of these repositories.

Review of Literature

Institutional Repositories: Concept and Purpose

Table-1 Types of Institutional Repositories and Their Primary Functions

Type of Repository	Content Covered	Primary Purpose
Institutional Repository	Articles, theses, dissertations, conference papers	Preserve and disseminate institutional research output
Subject Repository	Discipline-specific preprints and postprints	Rapid dissemination within research communities
Data Repository	Research datasets	Support open data and reproducible research
Theses & Dissertation Repository	ETDs	Long-term preservation and access to student research

The concept of institutional repositories gained recognition in the early 2000s as universities sought to manage and disseminate their digital scholarly content. Lynch (2003) defined institutional repositories as a set of services provided by institutions to manage and preserve digital materials produced by their academic

communities. Crow (2002) emphasized their strategic importance in increasing institutional visibility and reshaping scholarly communication.

Institutional Repositories and Open Access

Institutional repositories are closely associated with the Green Open Access model, which allows authors to deposit versions of their scholarly works regardless of the publishing venue. Suber (2012) argued that repositories play a crucial role in expanding access to research without imposing financial burdens such as article processing charges.

Pinfield (2015) observed that academic libraries are central to the success of open access initiatives through repository management, advocacy, and policy development. Literature also suggests that institutional mandates significantly increase repository participation and content growth (Gadd et al., 2012).

Research Visibility and Impact

A substantial body of research indicates that open-access materials deposited in institutional repositories experience higher visibility and usage. Swan (2010) reported an open-access citation advantage across multiple disciplines. Xia et al. (2012) found that repository-hosted content is more discoverable through search engines, leading to broader dissemination.

Changing Role of Academic Libraries

Academic libraries have transitioned from traditional custodial roles to active participants in scholarly communication. Corrall (2014) noted that libraries increasingly support research dissemination, copyright guidance, and open access compliance. However, challenges such as low faculty engagement and copyright concerns persist (Kim, 2011).

Recent Review of Literature (2020–2025)

Recent studies reaffirm the growing importance of institutional repositories within the global open science framework. UNESCO (2023) emphasized institutional repositories as foundational infrastructures for equitable knowledge sharing, particularly in developing regions. Tenopir et al. (2023) reported that libraries increasingly integrate repository services with research data management and research impact assessment.

Recent empirical studies from developing countries indicate that while repositories significantly enhance research visibility, barriers such as lack of awareness, insufficient training, and technical limitations persist. These findings underscore the need for sustained institutional support and continuous professional development of library staff to maximize repository effectiveness.

Objectives of the Study

The objectives of this study are to:

1. To know the role of institutional repositories in promoting open access to scholarly literature.
2. To understand how institutional repositories enhance research visibility and impact.
3. To know the role of academic libraries in the management and promotion of institutional repositories.
4. To highlight the challenges faced by institutional repositories and the future directions for their development.

Methodology

This study adopts a descriptive and analytical research design based on a systematic review of secondary sources. Relevant literature was collected from scholarly journals, conference proceedings, reports, and authoritative books related to institutional repositories, open access, and scholarly communication. The collected literature was analyzed thematically.

Role of Institutional Repositories in Open Access

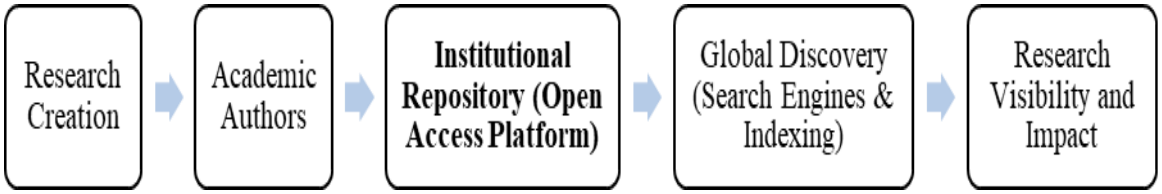
Institutional repositories facilitate open access by enabling researchers to self-archive scholarly outputs such as journal articles, conference papers, theses, and dissertations. By removing access barriers, repositories promote equitable access to knowledge and support global research collaboration. Academic libraries assist authors with copyright awareness, embargo management, and licensing options, particularly Creative Commons licenses.

Table-2 Role of Academic Libraries in Institutional Repository Management

Area of Responsibility	Library Functions
Repository Management	Platform maintenance, metadata creation, preservation
Scholarly Communication Support	Author rights education, OA advocacy
Policy Implementation	OA mandate compliance, deposit monitoring
Research Visibility	Metadata optimization, indexing, and outreach

The role of institutional repositories within the scholarly communication ecosystem is illustrated in **Figure 1**.

Figure-1 ***Institutional Repositories as a Hub of Scholarly Communication***



Institutional Repositories and Research Visibility

Institutional repositories play a vital role in enhancing the visibility and impact of scholarly research by providing open and unrestricted access to academic outputs. By hosting journal articles, conference papers, theses, dissertations, and other research materials, repositories ensure that scholarly works are accessible beyond subscription-based platforms.

One of the primary ways institutional repositories enhance research visibility is through **indexing and discoverability**. Repository contents are indexed by major search engines and academic discovery tools, enabling researchers worldwide to locate and access institutional research easily. The use of **standardized metadata** and **interoperability protocols** further improves discoverability across platforms.

Open access availability through repositories also contributes to **increased citation impact**. Studies indicate that research made openly accessible is more likely to be read, downloaded, and cited compared to restricted-access publications. This increased exposure enhances both individual researcher profiles and institutional reputation.

Institutional repositories also support **global knowledge dissemination** by removing geographical and financial barriers to access. Researchers from developing regions benefit from free access to scholarly literature, promoting international collaboration and knowledge exchange.

Additionally, repositories contribute to **long-term research impact** by ensuring the preservation and continued accessibility of scholarly outputs. Through systematic archiving and digital preservation practices, institutional repositories safeguard intellectual output and support sustained academic influence.

Overall, institutional repositories significantly enhance research visibility and impact by improving access, discoverability, citation potential, and long-term preservation of scholarly work.

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Role of Academic Libraries in the Management and Promotion of Institutional Repositories

Academic libraries play a central role in the successful management and promotion of institutional repositories. As key stakeholders in the scholarly communication process, libraries are responsible for the administration, organization, and sustainability of repository services within academic institutions.

In terms of management, academic libraries oversee repository platform maintenance, content organization, and metadata creation. Librarians ensure that deposited materials are accurately described using standardized metadata, which enhances discoverability and interoperability with global indexing and discovery systems. Libraries also play a vital role in digital preservation, ensuring the long-term accessibility of institutional research outputs.

Academic libraries actively support researchers by providing scholarly communication services, including guidance on copyright compliance, embargo management, and licensing options such as Creative Commons. Through training programs, workshops, and one-on-one support, libraries encourage faculty participation and facilitate self-archiving practices.

In promoting institutional repositories, libraries engage in open access advocacy and outreach activities. They raise awareness about the benefits of repositories, promote compliance with institutional and funding agency open access mandates, and monitor research deposits. Libraries also work to enhance research visibility by optimizing metadata, supporting indexing, and collaborating with academic departments.

Furthermore, academic libraries are increasingly assuming a strategic role within the research lifecycle. By bridging researchers, institutional leadership, and publishing systems, libraries contribute to strengthening open access initiatives and maximizing the impact of institutional research.

Overall, academic libraries are essential to both the effective management and sustained promotion of institutional repositories, supporting open access, research visibility, and long-term scholarly preservation.

Findings and Discussion

Analysis of existing literature reveals that institutional repositories significantly contribute to open access dissemination and research visibility. Key findings are summarized in **Table 3**.

Table-3 Benefits of Institutional Repositories for Researchers and Institutions

Stakeholder	Key Benefits
Researchers	Increased visibility, higher citations, global reach
Institutions	Enhanced reputation, preservation of intellectual output
Libraries	Strategic role in research lifecycle
Society	Free access to publicly funded research

Challenges and Future Directions of Institutional Repositories

Institutional repositories, despite their significant role in promoting open access and research visibility, face several challenges that affect their effective implementation and long-term sustainability. One of the major challenges is the **lack of awareness and participation among faculty and researchers**. Many scholars remain unfamiliar with repository services or are uncertain about self-archiving policies, copyright restrictions, and publisher embargoes, which limit content growth.

Another critical challenge is **copyright and licensing constraints**. Restrictions imposed by publishers often prevent authors from depositing the final published versions of their works. Although academic libraries provide guidance on author rights and Creative Commons licensing, navigating complex copyright agreements continues to be a barrier to open dissemination.

Technical and infrastructural limitations also pose challenges, particularly in developing institutions. Issues such as inadequate repository platforms, insufficient technical expertise, metadata inconsistencies, and long-term digital preservation concerns can affect repository reliability and discoverability. Additionally, ensuring interoperability with global indexing and discovery services requires continuous technical upgrading.

Sustainability is another pressing concern. Institutional repositories often rely on limited financial and human resources. The absence of strong institutional policies and mandates for open access deposit further weakens repository growth and management.

Future Directions

To address these challenges, **institutional commitment and policy support** are essential. The adoption of mandatory open access policies can significantly improve content submission rates. Academic libraries are expected to play an expanded role in **advocacy, training, and awareness-building** among researchers.

Future repository development should focus on **improving technical infrastructure**, adopting standardized metadata practices, and integrating repositories with research information systems. Emphasis on **long-term digital preservation strategies** will ensure continued access to scholarly outputs.

Moreover, strengthening collaboration between libraries, researchers, and institutional leadership will enhance repository effectiveness. By evolving as strategic hubs within the scholarly communication ecosystem, institutional repositories can continue to support open access, increase research visibility, and contribute to the global knowledge commons.

Conclusion

This study highlights the significant role of institutional repositories in advancing open access and strengthening scholarly communication within academic institutions. By enabling the self-archiving of scholarly outputs, institutional repositories remove access barriers and promote equitable access to knowledge, thereby supporting global research dissemination.

The findings indicate that institutional repositories substantially enhance research visibility and impact by improving discoverability through search engines and indexing services, increasing citation potential, and ensuring long-term preservation of scholarly works. Open access availability through repositories benefits not only researchers and institutions but also the wider academic community and society at large.

The study also emphasizes the pivotal role of academic libraries in the effective management and promotion of institutional repositories. Libraries serve as key facilitators by maintaining repository platforms, ensuring metadata quality, supporting copyright compliance, and advocating for open access practices. Their evolving role positions libraries as strategic partners in the research lifecycle.

Despite these advantages, institutional repositories face challenges related to researcher awareness, copyright restrictions, technical infrastructure, and sustainability. Addressing these challenges requires strong institutional commitment, supportive policies, and continued library-led advocacy.

Overall, the study concludes that institutional repositories, supported by proactive academic libraries, are essential components of the open access ecosystem. Strengthening repository infrastructure, awareness, and policy support will further enhance their contribution to research visibility, impact, and the global exchange of knowledge

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Bibliometric and Scientometric Tools for Knowledge Mapping: A Review

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Abstract

In today's rapidly evolving information and communication technology environment, an enormous volume of scientific information is generated daily in various formats. The academic and research community produces a vast number of scholarly publications, making it increasingly difficult to organize, manage, and analyze the expanding body of literature. With advancements in computer technology, automated data processing has become common, leading to the development of bibliometric and scientometric software tools. These tools, available as both open-source and commercial applications, assist researchers in analyzing research output, identifying scientific trends, and visualizing knowledge structures. This study reviews selected open-source bibliometric and scientometric tools and evaluates their usefulness and analytical capabilities for research analysis and knowledge mapping.

Keywords: Bibliometrics, Scientometrics, Knowledge Mapping, Science Mapping, Visualization Tools, Research Evaluation, Citation Analysis

Introduction

Bibliometrics and scientometrics are quantitative approaches used to study the growth, structure, and dissemination of scientific knowledge. Bibliometrics focuses on the statistical analysis of publications, while scientometrics extends this analysis to measure scientific development and research performance. These methods help evaluate information use, research productivity, collaboration patterns, and the evolution of disciplines.

Bibliometric studies are generally based on bibliographic data extracted from databases over a specific period. Such data provide essential details about publications, authors, institutions, and citations, enabling meaningful quantitative analysis. The increasing availability of digital bibliographic data has led to the development of various software tools that assist in performing statistical analysis, network construction, and visualization.

This study reviews major science mapping and visualization tools used in bibliometric and scientometric analysis, with special emphasis on widely used software packages.

Objectives of the Study

- To identify major bibliometric and scientometric software tools used for knowledge mapping.
- To examine the key features and analytical capabilities of selected tools.
- To understand how these tools support visualization and science mapping.
- To highlight the strengths and limitations of different tools for research analysis.

Scope of the Study

This study focuses on widely used bibliometric and scientometric software tools that support science mapping, citation analysis, and research evaluation. Both open-source and commercial tools are considered. The review is limited to tools that assist in data preprocessing, network construction, visualization, and interpretation of bibliographic data from major databases such as Web of Science and Scopus.

Methodology

This study adopts a descriptive and review-based methodology. Information about bibliometric and scientometric tools was collected from official software websites, published research articles, user manuals, and related literature. The tools were examined based on their functionality, data compatibility, analytical features,

and visualization capabilities. A comparative understanding was developed to assess their usefulness for knowledge mapping and research evaluation.

Mapping and Visualization Tools Used for Bibliometric and Scientometric

1. **BibExcel:** Bibexcel is a bibliometric tool developed at the University of Umeå (Sweden). This tool was pecifically developed to manage the bibliometric data and build maps, which can be read by software such as Excel, SPSS, UCINET and Pajek Bibexcel is freely accessible for academic non-profit use. Bibexcel can read data retrieved from different bibliographic sources, such as ISI, Web of Science (WoS), Scopus, and the Procite export format.
2. **BiblioTool:** BiblioTools is a freely available set of scripts developed to create maps of science based on bibliographic data. It gathers different python codes allowing their users to perform several tasks:
   - data mining: the software can handle bibliographic records exported from either the Web of Science or Scopus.
   - data processing: a script is dedicated to the pre-processing (parsing & filtering) of the raw data.
   - data analysis: description of a given corpus; generation of various co-occurrence (co-words, co-authors, co-citations, etc) networks; generation of bibliographic coupling networks and clusters.
   - data visualisation: results can be visualized and explored in BiblioMaps, a dedicated web-based interface; networks can also be exported in a format compatible with standard visualisation tools such as Gephi.
   - data report: automatic generation of reports in Latex.
3. **CiteSpace:** CiteSpace was developed at Drexel University (USA) and it can be freely downloaded. It is a software tool developed to detect, analyze, and visualize patterns and trends in scientific literature. Its primary goal is to facilitate the analysis of emerging trends in a knowledge domain. CiteSpace can read different formats of bibliographic sources, such as WoS, PubMed, arXiv, and SAO/NASA Astrophysics Data System (ADS). Furthermore, CiteSpace is able to read grants data such as NSF Awards and patent data from Derwent Innovations Index.
4. **CitNet Explorer:** CiteNetExplorer is a software tool for visualizing and analyzing citation networks of scientific publications. It was developed by Nees Jan van Eck and Ludo Waltman at Leiden University's Centre for Science and Technology Studies (CWTS).The tool allows citation networks to be imported directly from the Web of Science database. Citation networks can be explored interactively, for instance by drilling down into a network and by identifying clusters of closely related publications.
5. **VOSviewer:** VOSviewer is a software tool specifically developed for constructing and visualizing bibliometric networks. It provides graphical representations of network maps and is particularly effective for displaying large bibliometric maps using features such as zooming, clustering techniques, labeling algorithms, and density visualizations.

   The software was developed at the Centre for Science and Technology Studies (CWTS), Leiden University, and is freely available to the bibliometric research community. VOSviewer can be used to construct and visualize bibliometric maps based on various types of co-occurrence data, including co-authorship, co-citation, bibliographic coupling, and keyword co-occurrence.

   However, VOSviewer offers limited capabilities for advanced data preprocessing. Tasks such as detailed data cleaning, normalization, and custom matrix construction often need to be performed using external tools before importing the data into VOSviewer. While the software internally generates network structures from bibliographic data, it does not function as a full-featured data preprocessing environment.
6. **CopalRed:** CoPalRed is a Knowledge System developed by Rafael 3 Bailón-Moreno at EC Research Group at Department of Chemical Engineering. University of Granada, Spain in 2003. CoPalRed collects the information contained in the databases, e.g. WOS, Scopus, MedLine, ProCite, etc. and transforms it

into new knowledge, which was not explicit in the information contained in the databases, but is generated from the information contained therein. Since July 2011, CopalRed has changed its name to Techne Co Word, since it continues its development under the cover of the research group "Techne, Knowledge and Product Engineering". Its current stable version is 2.0 released in July, 2011. It works only on Windows operating system.

CopalRed, as a knowledge system, consists of mainly four modules, i.e. information capture, information debugging, knowledge base generation, and knowledge management module.

CoPalRed is mainly able to perform three types of analysis:

- Structural analysis: It reveals the network structure of the scientific field under study, defining the actors and their relationships.
- Strategic analysis: It places each actor in a relative position within the network, defining it according to the intensity of its external relations (centrality) and according to its internal cohesion (density).
- Dynamic analysis: It analyzes the transformations (translations-translations) of the actors over time. Identifies approaches, bifurcations, appearances and disappearances of the actors

CopalRed's knowledge management module is capable of performing various bibliometrics functions including drawing networks and exporting them to any image editor, rotating them, changing thresholds, Bradford distributions, Lotka distributions, affiliations, bibliographies, ranking of documents by relevance, and so on in any combination of themes or subnets

7. **CRExplorer:** The developers of CRExplorer are Andreas Thor, Werner Marx, Lutz Bornmann (Germany) and Loet Leydesdorff, (The Netherlands)

   The CRExplorer uses data from Web of Science or Scopus databases as input. User needs to download publication sets including the references cited to analyse in CRExplorer. The program focusses on the analysis of the cited references, in particular on the referenced publication years It reads files from Scopus. The file format "CSV" (including citations, abstracts and references) downloaded from Scopus.

   - CRExplorer exports files in the Web of Science and Scopus format. These files can be imported in other bibliometric programs (e.g. VOSviewer). Ø Internal file format: working files are/can be saved in the internal file format "*.cre".
   - Co-citation for cited references which are co-cited in a specific publication and data clustering.

8. **Inter Disciplinary Research (IDR) Toolkit:** The IDR toolkit offers a novel tool, the overlay maps of science, as a method to explore the degree of interdisciplinary of a set of publications. It was developed by Dr. Alan Porter andDr. Ismael Rafols.The overlay technique visualizes the spread of publications over the global map of science, i.e. the structure of science as obtained from the analysis of cross-citations between disciplines. It follows the method introduced in Rafols & Meyer (2010) to create the overlay map on the basis of a global map of science. It helps to visually locate bodies of research within the sciences, both at each moment of time and dynamically

9. **In-Spire:** IN-SPIRE Visual Document Analysis is powerful information visualization software developed by Pacific Northwest National Laboratory. It is designed to help analyst to uncover relationships, trends, and themes hidden within data which can lead to new knowledge and new insights that could be used to assess terrorist threats, determine how to treat a medical condition, or gather market research on the competition and many more.

10. **HistCite:** HistCite is a software package used for bibliometric analysis and information visualization. It was developed by Eugene Garfield, the founder of the Institute for Scientific Information and the inventor of important information retrieval tools such as Current Contents and the Science Citation Index. The main purpose of the software is to make it easier for individuals to perform bibliometric

analysis and visualization tasks. Bibliometric analysis is the use of the bibliographic information (titles, authors, dates, author addresses, references, etc.) that describe published items to measure and otherwise study various aspects of a specific field of scholarly endeavour. HistCite is no longer in active development or officially supported.

11. **Loet Leydesdorff's Software:** Leydesdorff's software is a set of command-line DOS based programs to analyse and evaluate bibliometrics data obtained from the data sources such as Scopus, Web of Science, and Google Scholar. The set of software / programs were developed by Loet Leydessorff at Science & Technology Dynamics, University of Amsterdam, Amsterdam School of Communications Research (ASCoR), The Netherlands.

The set of programs is freely available for academic and research community. The different programs allow the user to perform several bibliometric analyses, such as: co-word analyses, co-authorship, author bibliographic coupling, journal bibliographic coupling, author cocitation, animation of network data, co-word mapping of texts (lines), visualization of various networks and organization of Google Scholar files into files for relational database management (MS Access, dBase), etc. The institutional and international collaboration, even the collaboration at the level of cities can be analysed with the help of this program. The results can be visualized using external software, such as Pajek, UCINET, Network Workbench Tool or the Sci2 Tool. Also, the visualization of these collaboration networks can be done using Google Maps and external software.

12. **SciMAT:** SciMAT (Science Mapping Analysis software Tool) is an open source science mapping software tool which incorporates methods, algorithms, and measures for all the steps in science mapping workflow, from preprocessing to the visualization of the results. SciMAT allows the user to carry out studies based on several kind of bibliometric networks. Different normalization and similarity measures can be used over the data. Several clustering algorithms can be chosen to cut up the data. In the visualization module, three representations (strategic diagrams, cluster networks, and evolution areas) are jointly used, which allows the user to better understand the results.

    SciMAT has been developed using Java as programing language, so it run in the majority of the Operative System (Windows, Linux, MacOS, etc.) and plataforms. To run SciMAT, version 8 of Java has to be installed in the system. If you do not have Java installed or you have an early version, you can freely download it from www.java.com. To run SciMAT v1.1.06, unpack this zip file and execute the SciMAT jar file. Also, we provide specific exectuable version for Windows and Mac. To run this, just unpack one of the following files, and then double click on .app (osX) or .exe (Windows)

13. **Network Workbench (NWB) Tool:** The Network Workbench (NWB) project at Indiana University, USA developed a large-scale network analysis, modelling and visualization cyber infrastructure toolkit for biomedical, social science and physics research. The NWB can perform network analysis, modelling, and visualization with the most effective algorithms and a wide variety of reference datasets. The NWB tool supports network science research across scientific boundaries.

    The NWB tool has a menu driven interface that supports network/graph load, view and save operations, etc. The NWB tool includes GUESS, a powerful and flexible network visualization tool. The tool can load, process, and save various network file formats including NWB (*.nwb), GraphML (*.xml or. graphml), XGMML (*xml), Pajek (*.net), Pajek (*.mat), TreeML (*.xml), Scopus (*.scopus), NSF (*.nsf), Endnote (*.enw), Bibtex (*.bib), CSV (*.csv), ISI (*.isi) and two-column edge lists (*.edge). It also supports viewing and saving plain text files (*.txt) generated by algorithms

    Some of important scientometrics analysis features of NWB tool are

    - Removes ISI duplicate records and rows with multitudinous fields;
    - Detects duplicate nodes;

- Update network by merging nodes; and
- Extract directed network, paper citation network, author paper network, co-occurrence network of word and reference, co-author network, document co-citation network and co-citation similarity network

14. **Sci2 Tool:** The Science of Science (Sci2) is a modular toolset specifically designed for the study of science. It supports the temporal, geospatial, topical, and network analysis and visualization of scholarly datasets at the micro (individual), meso (local), and macro (global) levels. The Sci2 tool was developed by Cyber Infrastructure for Network Science Center Team, Indiana University, USA.

    The Science of Science (Sci2) Tool is a modular toolset specifically designed for the study of science. It supports the temporal, geospatial, topical, and network analysis and visualization of datasets at the micro (individual), meso (local), and macro (global) levels. Users of the tool can:

    - Access science datasets online or load their own.
    - Perform different types of analysis with the most effective algorithms available.
    - Use different visualizations to interactively explore and understand specific datasets.
    - Share datasets and algorithms across scientific boundaries.

    A number of data formats are supported on Sci2 platform, such as: NWB (*.nwb), GraphML (*.xml or. graphml), XGMML (*xml), Pajek (*.net), Pajek (*.mat), TreeML (*.xml), Scopus (*.scopus), NSF (*.nsf), Endnote (*.enw), Bibtex (*.bib), CSV (*.csv), ISI (*.isi), and edge lists (*.edge)

15. **SitKis:** Sitkis is a free Java and MS Access based software tool developed exclusively for bibliometric analysis. It helps researchers during computation process of research analysis and evaluation of scientific information. It provides tools for extremely streamlined analysis of bibliometric networks. User can calculate large amount of data in few minutes utilizing Sitkis

16. **VantagePoint:** VantagePoint is a powerful text-mining tool for discovering knowledge in search results from patent and literature databases. VantagePoint helps the user to rapidly understand and navigate through large search results, giving them a better perspective on their information. Vantage point is a commercial software tool developed by Search Technology, Inc., USA.

17. **Bibliometrix R Package:** Bibliometrix provides a set of tools for quantitative research in scientometrics and bibliometrics. Bibliometrix works with data extracted from the two main bibliographic databases: Scopus and Clarivate Analytics's ISI Web of Knowledge. Bibliometrics turns the main tool of science, quantitative analysis, on itself. Essentially, bibliometrics is the application of quantitative analysis and statistics to publications such as journal articles and their accompanying citation counts. Bibliometrix package provides various routines for importing bibliographic data from these two databases, performing bibliometric analysis

    Bibliometrix supports scholars in three key phases of analysis:

    - Data importing and conversion to R format;
    - Bibliometric analysis of a publication dataset; and
    - Building matrices for co-citation, coupling, collaboration, and co-word analysis. Matrices are the input data for performing network analysis, multiple correspondence analysis, and any other data reduction technique.

Conclusion

The review of bibliometric and scientometric software tools reveals a diverse and continuously evolving ecosystem that supports different stages of research analysis, from data collection and preprocessing to network

construction, visualization, and interpretation. Early tools such as BibExcel, HistCite, and Leydesdorff's software laid the foundation for citation and co-occurrence analysis, while modern tools like CiteSpace, VOSviewer, CitNetExplorer, and SciMAT emphasize advanced visualization and science mapping to identify intellectual structures and emerging research trends.

Flexible analytical environments such as Bibliometrix (R package), BiblioTools, and CRExplorer enable in-depth quantitative and network-based studies, whereas comprehensive platforms like the NWB Tool and Sci2 Tool extend analysis to temporal, geospatial, and multi-level perspectives. However, no single tool fulfills all bibliometric requirements. Some tools focus on visualization with limited preprocessing, while others offer powerful analytics but require technical expertise. Commercial tools such as VantagePoint may also be restricted by cost. Therefore, selecting appropriate tools depends on research objectives, data sources, and user expertise. In many cases, combining multiple tools provides the most effective approach for transforming bibliographic data into meaningful insights for research evaluation, science mapping, and strategic decision-making.

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Research Trends in Post-Transcriptional Gene Regulation: A Scientometric Study

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Abstract

This study aims to provide a scientometric overview of worldwide PTGR research using bibliographic records extracted from the Scopus database for the years 2010–2025. All 19,640 publications of 2,994 sources were subjected to bibliometric analysis using Biblioshiny and VOSviewer in terms of publication growth, citation impact, distribution of journals, authorship per article and institution/country contributions order; collaboration network-coloured networks, meanwhile, keyword co-occurrence was extracted using the software. Results: There is a trend in an ascending order of PTGR scientific output from 780 papers in 2010 and 2,110 publications in the year 2025 with a compound annual growth rate of 12.07%. The discipline has made a significant impact on research average citation count per document of 47.31, with a notably cooperativist research ethos only 422 papers being single-authored. A scatter of journals complies with Bradford's Law and seven core journals contribute 33.40% of the total publications. Top journals are PLOS One (973), International Journal of Molecular Sciences (617) and Nucleic Acids Research (5980). Analysis of the keywords found 79,942 keywords that, according to Zipf's Law, were produced with higher frequencies than expected for "Genetics," "Human," and "Metabolism. In the author analysis, He, C. (University of Chicago) is the top contributor with 46 papers and 109524 citations. At the institutional level, the University of Chinese Academy of Sciences (106) occupied the first place in terms of publication. In terms of countries, China ranked the highest (5286) in both total output and citation impact, indicating that Chinese research was not only of high quality but also internationally influential across 133 contributing countries. This paper indicates the fast development, international cooperation strategy and research hotness of PTGR. It also emphasizes the utility of scientometric approaches for charting trends in research and scholarly productivity, especially when big data and integrative biology are involved; indeed, PTGR now occupies a central role in driving progress in gene expression and RNA biology.

Keywords: Post-transcriptional Gene Regulation; Scientometric analysis; RNA biology; Research trends

INTRODUCTION

Post-transcriptional Gene regulation (PTGR) (Liu, 2017) is a keystone for gene expression and tunes the processing, transport, stability and translation of RNA after transcription (Dassi, 2022). Processes like RNA splicing, editing, polyadenylation, turnover of mRNA at the level of transcriptome and microRNA-mediated regulatory networks by RBPs provide fine-tunings to cellular responses, development, and disease processes. In the last 20 years, thanks to the huge progress in high-throughput technologies, next-generation sequencing and computational biology tools, a vast number of published results have been gained, advancing the knowledge on PTGR. With the fluorescent research in molecular biology and genomics, great advances have been obtained in PTGR, which has proved to be involved in complex biological processes such as the development of the nervous system, immune response, cancer progression and metabolic syndrome. The growing number of reports accounts for the interest among scientists in deciphering how post-transcriptional mechanisms modulate gene expression programs and impact cellular homeostasis. Nevertheless, the evidence was fragmented, and there is little summary data which can depict the developmental trends, knowledge structure and global trends in PTGR.

A scientometric study offers systematic and quantitative tools to investigate trends of publication, authorship patterns, collaboration structure, leading journals, as well as emerging themes in a specific field. By using bibliometrics methods to PTGR, we mean to uncover the development of this field, recognize the leading players and hotspots. This, in turn, allows us to identify knowledge gaps and future research opportunities, which are of interest to both the research community as well as the policy makers and funding agencies. For

researchers and policymakers, however, there is still no adequate evidence to assess the knowledge network about intellectual structure and global development of posttranscriptional regulation via this study. Based on an exhaustive analysis of articles indexed in leading databases, the aim of this paper is twofold: to map evidence about how PTGR research has developed over time and to identify the main themes that have shaped it while also yielding a set of emerging topics with potential influence in future research.

REVIEW OF LITERATURE

The study conducted by Santhakumar, Mahalakshmi and Kalaiappan (2024), for example, demonstrated the scientometric analysis of the trajectory of research in epigenetics on how dynamic fields about gene regulation could be quantitatively profiled with publication output, co-authorship networks and keyword clusters. Though not reported here, such methodological procedures also include mapping of PTGR trends and dynamics The scientometricvisual analysis of Lui, Gao and Piao (2024) mapped over the past decade growth in publications on RNA modifications like m⁶A, for example, essential to PTGR. The study also unveils worldwide collaboration links and hot terms, which are vital for trend prediction in RNA research. Basumatary& Gupta (2023) charted the landscape of genomics research from India and indicated that Indian contributions are increasing in domains that have synergy with RNA biology and gene regulation. They examined collaborations, thematic progression and influential institutions, demonstrating the usefulness of scientometric techniques for national research landscapes. Dandoti & Ansari (2023) utilized scientometric mapping to analyse global CRISPR studies and drew attention to RNA-guided genome editing as a fast-rising area with strong Indian presence. Methods of keyword cooccurrence and citation network analysis have been used. This work could serve as an empirical PTGR research mapping (Bonacina et al., 2023) studied scientometric review methodology with mood disorder genetics research and mapped intellectual structures of the field through co-citation analysis and keyword analysis. This work demonstrates the potential of scientometric methodologies to define intricate regulatory domains and to trace thematic development, even in fields that are not strictly RNA-centric.Zhang et al. (2023) presented a scientometric analysis of mTOR-targeted research in breast cancer. They employed citation and collaboration network visualization to assess the status quo and contributors to key nodes of related search. The methodological approach is similar to the PTGR trend mapping 2019–2018 Nair, Raja and Devapattabiraman (2019) in their study applied scientometric analysis to evaluate renewable biomass research in India for the period of 1999–2018. They combed publication trends, keyword co-occurrence and authorship patterns to identify key institutions and collaboration networks. The research shows the capability of scientometric techniques to comprehend Author(s): publication behavior and dynamics. Nair & Raja (2018) studied research output in India, based on genetic diversity by analyzing publication counts, citation analysis and collaboration networks. The study presented growth phenomena, thematic coverage and institutional productivity Indicators on how to use scientometric tools for discovering emerging new and productive authors. Sab, Dharani Kumar, &Biradar (2017) mapped the output of the country's biomedical research from 2012 to 2016. The objective was to identify the trends in publications, productive authors & collaborative networks at the national and institutional level. This study highlights the importance of scientometric analysis in characterizing research landscapes and informing priority setting and research policy.

OBJECTIVES OF THE STUDY

1. To analyse the growth and temporal distribution of research publications on post-transcriptional gene regulation over the study period.
2. To identify the leading authors, institutions, countries, and collaborative networks contributing to research in the field.
3. To determine the most influential journals publishing research on post-transcriptional regulation and to assess their productivity and impact patterns.
4. To evaluate the core journals using Bradford's Law, thereby identifying the nucleus, middle, and peripheral zones of literature distribution.
5. To examine keyword frequency and thematic patterns using Zipf's Law, in order to identify dominant research themes, concepts, and emerging topics in the field.

RESEARCH METHODOLOGY

This study adopts a web-based scientometric analysis to explore worldwide research on post-transcriptional gene regulation. The bibliographic information was retrieved from the Scopus dataset, ranging between 2010 and 2025. The search string based on Scopus to find suitable publications was: TITLE-ABS-KEY ("post-transcriptional gene regulation" OR "post-transcriptional regulation" OR "RNA regulation" OR post-transcriptional control") AND (LIMIT-TO (PUBYEAR, 2010–2025)) AND (LIMIT-TO (DOCTYPE, "ar") O-R LIMIT-TO (DOCTYPE, "ar")). The search results were saved in. csv format all with basic bibliographic fields. The country's publications dataset was cleaned and analysed using the Biblioshiny and VOSviewer tools to extract descriptive bibliometric indices and generate network maps for co-authorship, co-citation and keyword co-occurrence. Data summarisation and results visualisations were managed in Google Sheets, providing clarity and accuracy of publication trends, key contributors and thematic patterns.

ANALYSIS

A search of the Scopus core collection for documents published between January 2010 and December 2025 using a search term addressing the biochemical processes associated with regulation at the post-transcriptional level found 10 different document types totalling 19,640 documents. These articles were published on 2,994 sources: journals, books and conference proceedings. The age of the documents ranged from 1.3 to 13.5 years, which is a continuum between new studies and seminal research conducted on these topics. The influence of the literature is extensive (average citation per item 47.31: high visibility and relevance). There were 57,737 authors of these works, with only 422 single-authored documents, which demonstrates the highly cooperative nature of the research. The output of research is from 143 countries, showing wide participation within a context of global integration in the domain. The data reflect a robust, exponential, and linked global research road map.

Annual Publication Trends

The number of publications on post-transcriptional gene regulation effectively continues to increase from 780 articles in the year 2010 to 2,110 papers in 2025 with a total of 19,640 published documents during these 15 years. The field developed relatively rapidly in the first AGR reached a maximum of 17.05%, which was achieved in 2012, followed by 2025 WITH 10.77%, followed by small fluctuations and decreases. There were some slight decreases in 2015, 2019, 2022 and 2023, indicating small fluctuations in research activities. The average annual growth rate is 2.94%, which reflects the continuing increase in research for a long time into the future. The increasing number of publications indicates a slow process of accumulating knowledge, indicating ongoing international interest in conducting research.

Table 1: Annual Publication Trends

Year	No. of Publications	% of Publication	Cumulative Publications	AGR (%)	CAGR
2010	780	4.45%	780	-	-
2011	880	5.02%	1,660	12.82%	12.82%
2012	1030	5.88%	2,690	17.05%	14.88%
2013	1150	6.56%	3,840	11.65%	13.94%
2014	1190	6.79%	5,030	3.48%	11.38%
2015	1185	6.76%	6,215	–0.42%	8.75%
2016	1205	6.87%	7,420	1.69%	7.24%
2017	1250	7.13%	8,670	3.73%	6.82%

2018	1290	7.36%	9,960	3.20%	6.33%
2019	1225	6.99%	11,185	–5.04%	3.56%
2020	1330	7.59%	12,515	8.57%	4.19%
2021	1480	8.45%	13,995	11.28%	5.05%
2022	1270	7.24%	15,265	–14.19%	2.11%
2023	1090	6.21%	16,355	–14.17%	1.14%
2024	1170	6.67%	17,525	7.34%	2.94%
2025	2110	10.77%	19640	12.07%	9.559

Journal Metrics

The research productivity in the field of post-transcriptional gene regulation is scattered and distributed over 2994 journals, with Plos One, International Journal of Molecular Sciences and Nucleic Acids Research being identified as the leading sources. The PlosOne tops the list with 973 papers and 38,470 citations, showing that the journal is generally popular and making an impact in lots of places. International Journal of Molecular Sciences comes second with 617 papers and 20,930 citations reflecting good output in studies at the level of atoms and molecules. Nucleic Acids Research, a journal with fewer papers published (598), has a higher citation impact of 28,871 and the highest CiteScore (31.7), underlining that we publish world-leading research on post-transcriptional gene regulation. Together, these top journals encompass the set of primary sources contributing to knowledge spread and citations in this domain.

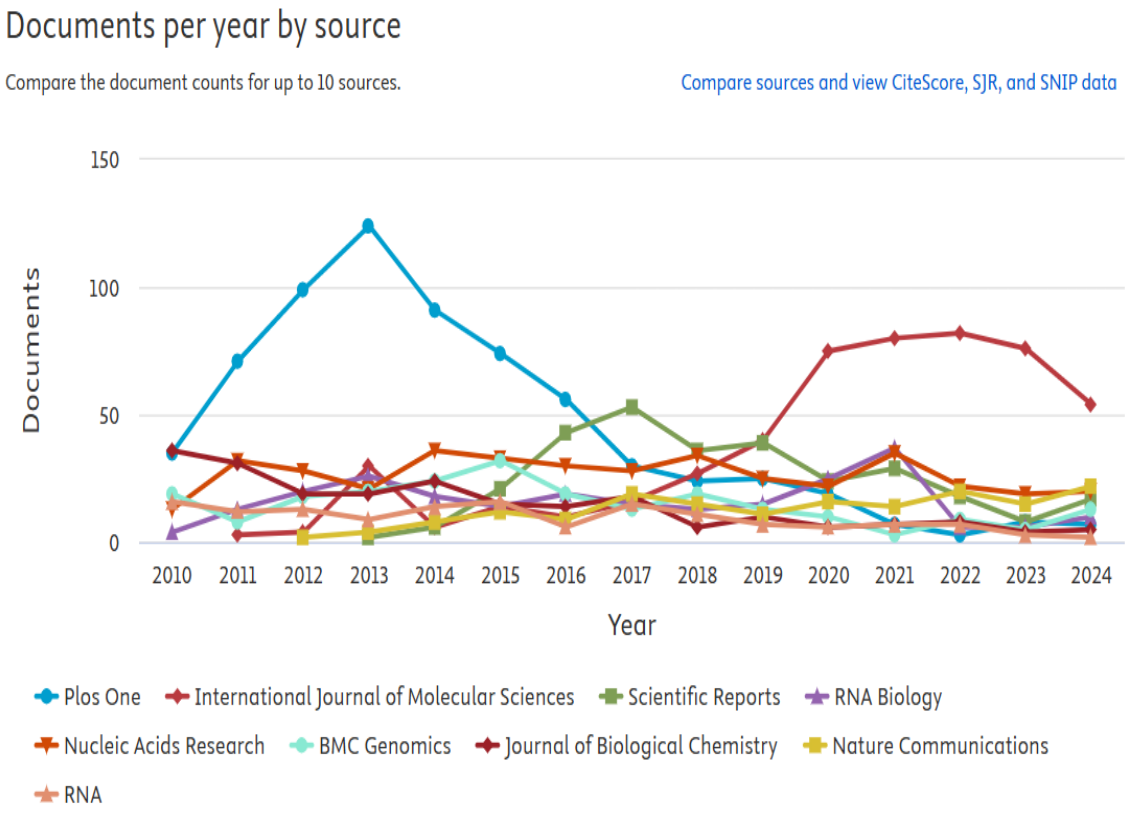


Fig 2. Documents per Year by Source

Table 2 Journal wise distribution (Top 10 Only)

Sl No.	SOURCE TITLE	Records	Citation	Cite Score	SJR	SNIP
1	Plos One	973	28470	5.4	0.803	1.065
2	International Journal of Molecular Sciences	617	20930	9	1.273	1.177
3	Nucleic Acids Research	598	28871	31.7	7.776	4.714
4	Scientific Reports	396	8193	6.7	0.874	1.213
5	RNA Biology	241	8882	8.6	1.651	0.767
6	BMC Genomics	225	8608	5.9	1.003	0.967
7	Journal of Biological Chemistry	222	11100	7.6	1.705	0.998
8	Nature Communications	167	8673	23.4	4.761	3.15
9	RNA	144	7771	6.9	2.512	0.946
10	Frontiers in Plant Science	143	5777	8.8	1.163	1.257
11	Cell Reports	141	6273	12.9	3.796	1.552
1	Plos Genetics	135	7060	7.9	1.945	1.046
2	Genes	134	2728	5.5	0.858	0.881
13	Frontiers in Genetics	133	1816	6.2	0.863	0.745
14	Methods in Molecular Biology	129	3301	2.1	0.354	0.868
15	Biochemical and Biophysical Research Communications	128	7983	4.9	0.748	0.555

Bradford's Lawof journal Scattering

Publications from post-transcriptional gene regulation adhering to Bradford's Law (Bradford, 1934) indicate the presence of a clear core-periphery pattern in journal publication productivity. Of the 17,525 documents published, from across 2,994 journals, in all four zones Zone1 is the smallest and found seven (07), where the total number of documents were 6560, which are 33.40%, being the highest in absolute output. The mid-level zone (Zone 2) consists of 6600 articles (33.60%), and the low productivity/long tail zone (Zone 3) corresponds to 6480 articles (33%), which appear across all the other journals. The Bradford factors (k) of the three zones are near 1, which means an even distribution between core and peripheral data sources. This distribution emphasizes that few journals are used as the originating source of most high-impact literature, with many contributing just a few publications.

Table 3 Zone wise distribution of Journals

Zone	Description	Articles	% of Total	Multiple Factors (k)
Zone 1 (Z1)	Core journals (7 journals)	**6560**	**33.40%**	1.006
Zone 2 (Z2)	Middle productivity zone	**6600**	**33.60%**	0.988
Zone 3 (Z3)	Low productivity, long tail	**6480**	**33.00%**	0.982
	Total	**19,640**	**100%**	2.976

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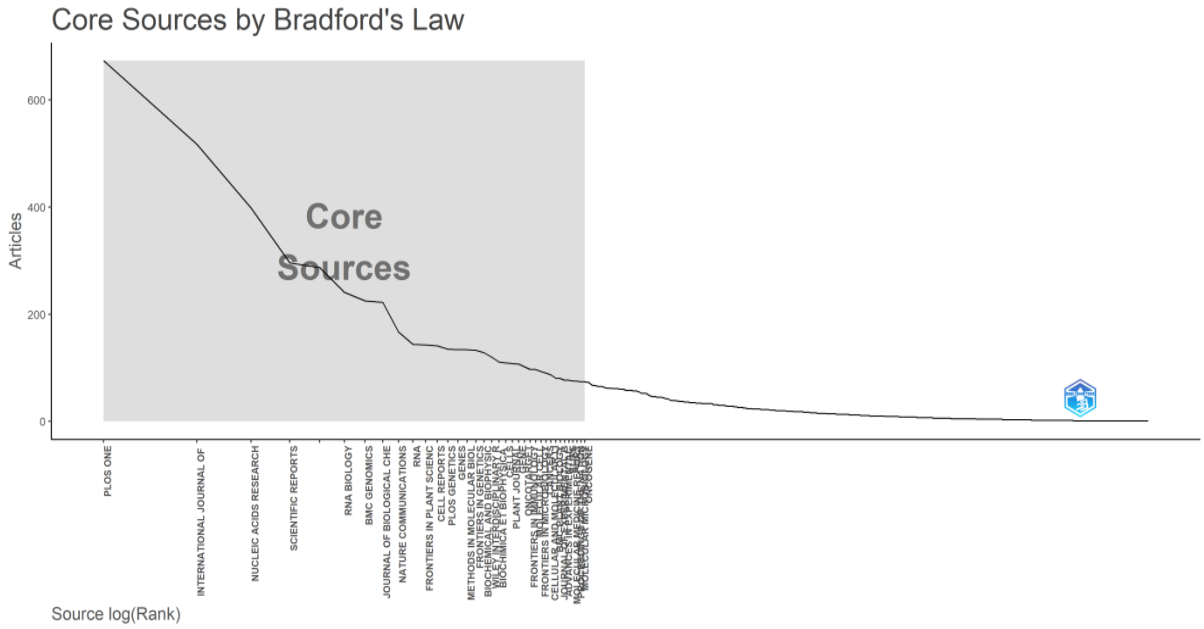


Fig 3 Core Sources byBradford's law

Author Metrics

Among 57,737 authors that contributed to research on post-transcriptional gene regulation, we can distinguish the 3 highest ranking for total number of publications and citations. He, C.; 46 articles; 109,524 citations; h-index of 155) from the United States' University of Chicago who is currently the most prolific researcher in this field. The number 2 position, with 49 publications, also goes to the United States' M. Gorospe from the National Institute on Ageing, whose work has been cited 45,030 times and has an h-index of 109. Vogel, J. (Julius-Maximilians-Universität Würzburg, Germany) contributed 36 record(s). Total number of citations: 31,526 Total number of publications: 36 h-index: 97. These three scientists, as a group, epitomize virtually all published research, and academic impact on the evolution of knowledge in this area.

Table 4 Author Metrics (Top 15 Only)

Author Name	Records	Affiliation	Country	Citation	h-index
Gorospe, M.	49	National Institute on Aging	United States	45030	109
He, C.	46	The University of Chicago	United States	109524	155
Vogel, J.	36	Julius-Maximilians-Universitat-Wurzburg	Germany	31526	97
Abdelmohsen, K.	25	National Institute on Aging	United States	22503	67
Yeo, G.W.	23	University of California, San Diego	United States	33592	93
Blackshear, P.J.	21	Duke University Medical Center	United States	23635	86
Janga, S.C.	21	University of Indianapolis	United States	4764	36

Nakajima, M.	21	Kanazawa University	Japan	16541	72
Sunkar, R.	21	Oklahoma State University	United States	17796	53
Rajewsky, N.	20	Max Delbruck Center for Molecular Medicine	Germany	60573	82
Zheng, Y.	20	Yunnan Agricultural University	China	4323	32
Hafner, M.	18	National Institute of Arthritis and Musculoskeletal and Skin Diseases, Bethesda	United States	14655	58
Goldenberg, S.	17	Instituto Carlos Chagas	Brazil	5675	40
Fernández-Hernando, C.	16	Yale School of Medicine	United States	18050	76
Franco, D.	16	Universidad de Jaen	Spain	4766	35

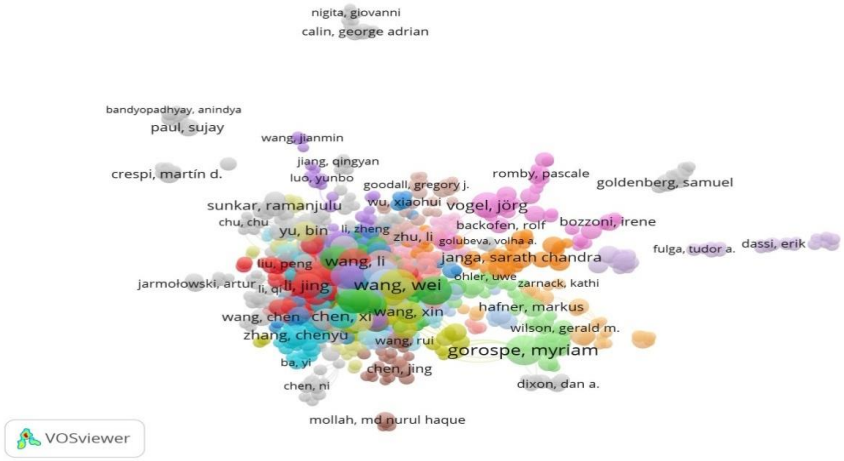


Fig 4 Network Visualization of Authors and Co authorship

Collaborative Institutions:

Top-3 productive institutions from the 29,759 collaborative institutes in post-transcriptional gene regulation have produced considerable combined scientific output. The University of Chinese Academy of Sciences, China, in Beijing leads with 106 papers and 5,599 writes, followed by INSERM Paris Île-de-France France with 72 documents and 3,717 citations. In third place is the University of Toronto Faculty of Medicine, Toronto, Canada, with 67 publications and 3,946 citations. These are the primary research and international collaboration hubs.

Table 5: Most Collaborative Institutions (Top 10 Only

Sl. No.	Organization	Documents	Citations
1	University of Chinese Academy of Sciences, Beijing, China	106	5599
2	INSERM, Paris, Île-de-France, France	72	3717
3	University of Toronto Faculty of Medicine, Toronto, ON, Canada	67	3946
4	Howard Hughes Medical Institute, Chevy Chase, MD, United States	53	8905

5	UCSF School of Medicine, San Francisco, CA, United States	52	5003
6	Sorbonne Université, Paris, Île-de-France, France	51	3891
7	Université de Strasbourg, Strasbourg, Grand Est, France	48	4139
8	Université Paris-Saclay, Gif-sur-Yvette, Île-de-France, France	48	1439
9	Harvard Medical School, Boston, MA, United States	46	8127
10	Université Paris Cité, Paris, Île-de-France, France	46	2187

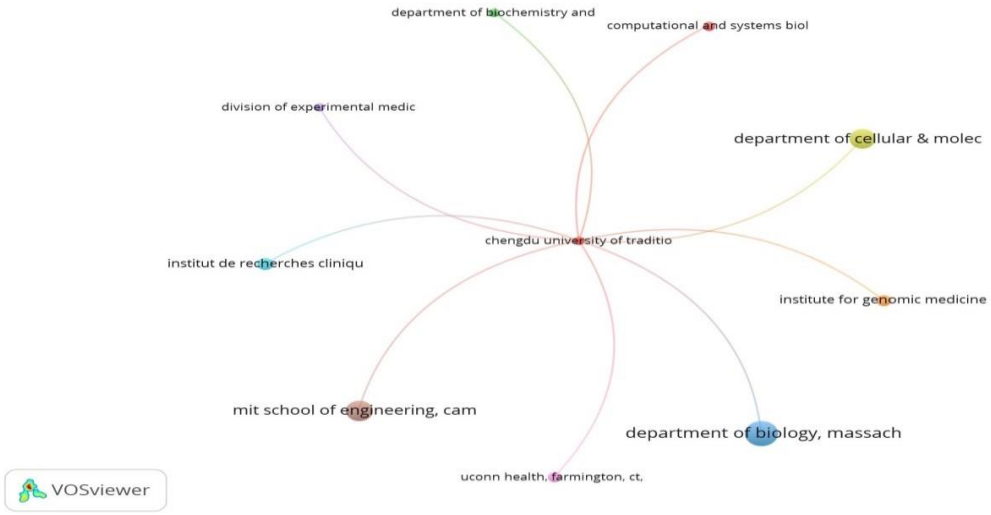


Fig 5 Network Visualization of Collaborative institution

Geographical Distribution

Out of the 143 countries involved in research covering post-transcriptional gene regulation, China, the USA and Germany are the top-performing and influential ones. Table 2: China ranks first in the number of publications and citations. Table 1 The top three, which originated from China, constitute a large number of publications, considering these contributing countries: abstaining and growing influence. The United States has 5,114 publications, which is a closely following number, yet exceeds, for example, all other regions in the citation impact (328,805 citations) to emphasize its overwhelming influence on worldwide research. Germany is in third place, with 1,382 publications and 82,135 citations, making it a major European contributor. Together, these three countries make up the base of global research productivity and scholarly impact in this discipline.

Table 6 : Country-wise Distribution

Sl No.	Country	Documents	Citation
1	China	5,286	206370
2	United States	5,161	328805
3	Germany	1,382	82135
4	United Kingdom	1,039	63055
5	Italy	957	43945
6	India	850	23102
7	France	787	40637

8	Japan	747	34775
9	Canada	634	32614
10	Spain	582	33790

Key words of Occurrence

The distribution of keywords collection in our research on posttranscriptional gene regulation exhibits Zipf's Law for the occurrence frequency (Zipf, 1949), which indicates that very few keywords appear quite a lot with high frequency, and most of them appear less frequently. This dataset considers a total of 79,942 keywords; among them, the most frequent are: Genetics (10,167 times), Article (9,967), Human (9,746), Nonhuman (8,631) and Metabolism (8,703). A log-log plot of keyword frequency log(f) and rank log(r) exhibits an inverse relationship, a key characteristic supported by Zipf's Law, which suggests that usage is dominated by a small number of heavily-written terms with the vast majority written infrequently. This structure underscores the key themes that characterize research discourse as well as the focus present in the field.

Table 7 Zipf's Law of Keyword of Occurrences

Rank (r)	Keyword	f(r)	ln(f(r))	ln(r)
1	Genetics	10,167	9.23	0
2	Article	9,967	9.21	0.69
3	Human	9,746	9.18	1.1
4	Nonhuman	8,631	9.06	1.39
5	Metabolism	8,703	9.07	1.61
6	Humans	8,020	8.99	1.79
7	Gene expression regulation	8,622	9.06	1.95
8	Controlled study	7,229	8.89	2.08
9	Unclassified drug	6,491	8.78	2.2
10	Microrna	7,480	8.92	2.3

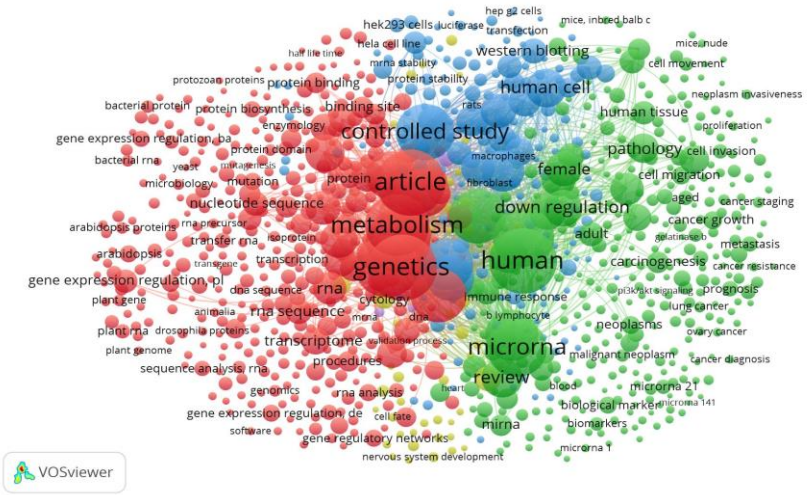


Fig 6. Network visualisation of Key words of Occurrence

DISCUSSION

The present scientometric study of post-transcriptional gene regulation (PTGR) research between 2010 and 2025 demonstrates that the research area is mature, highly impactful and has a global networked character. The identification of 19,640 papers from 2,994 source titles with an overall high average rate of citation (47.31 citations per paper) demonstrates good scholarly visibility and sustained scientific relevance. These trends conform with previous scientometric analyses of epigenetics, RNA biology and gene regulation showing rising publication output and interconnectedness of collaborative networks (Santhakumar et al., 2024; Liu et al., 2024). The increasing trend of annual publications with a CAGR of 2.94% indicates long-term rather than temporary research on the issue. While there were small decreases in some years, the aggregate growth represents the continually increasing worldwide attention for PTGR research. Comparable stabilization patterns after early growing movements have also been reported in scientometric investigations on RNA methylation and CRISPR research (Liu et al., 2024, Dandoti& Ansari, 2023).

Journal distribution analysis indicates that PTGR studies have been published in a few high-yield and influential journals such as PLOS One, International Journal of Molecular Sciences, and Nucleic Acids Research. Compliance with Bradford's Law indicates a core-periphery pattern in which there are few journals covering multiple publications. The same trend mirrors previous studies in the field of biomedical and genomics communications (Sab et al., 2017). Authorship analysis reflects a high amount of cooperation in PTGR, with few single-authored publications. Authors with a particularly high number of citations, e.g., He, C., Gorospe, M., Vogel, J. comprise the intellectual backbone of the field due to their productivity and citation impact. This bias of influence indicates that leading research groups contributed consistently through time to the research of PTGR. At the level of geography, China and the United States stand out as for both publication output and citation impact, while the United States was especially influential across world regions. Germany stands out as a major European donor. Research productivity remains focused in a limited number of countries, but involvement from 143 countries suggests broadening international activity. The similar geographical concentration was also found in the national and global scientometric research of genomics study (Nair & Raja, 2022; Basumatary& Gupta, 2018). 5 Keyword analysis depicts observed Zipf's Law, whereby a small number of most frequent keywords constitute the main research themes and most keywords represent diverse thematic topics. Terms like "Genetics," "Human," and "Metabolism" reflect that PTGR research is still embedded to some degree in the main biological and biomedical areas.

The results support the validity of scientometrics in reflecting growth profiles, collaboration networks and thematic priorities in PTGR research. The field shows a continued rise in activity, high-impact research and strong international cooperation, offering a sound basis for taking stock of emerging trends and research planning at global as well as national levels.

LIMITATION AND FUTURE RESEARCH

The present study is a web-based scientometric approach on PTGR-based research retrieved from the Scopus database between 2010 and 2025. Despite the broad scope of Scopus, the sole use of one database could have resulted in the exclusion of relevant studies that were indexed elsewhere or used alternative terminology. Also, the restriction to articles and reviews, as well as relying on citation-based indicators, are weaknesses that could limit access to new emerging research and recently published papers. The study is limited to quantitative bibliometric indicators and network visualisation, not assessing the qualitative or biological quality of studies. Limitations in the databases and keywords used in this study can be alleviated by using other complementary databases, additional keyword strategies or document types, and combining scientometric methods and qualitative reviews or text mining to extract relevant information for analysis in the future. Efforts such as these would give better pictures on emerging PTGR subfields, regulatory mechanisms and translational research.

CONCLUSION

This is a scientometric provided the analytical insights into trends of the worldwide research involving PTGR for the period 2010-2025. The results show that the publication output keeps growing, the impact of

citation is high and collaboration among countries is strong, demonstrating PTGR as a mature discipline and with significant international influence. Research is driven by a restricted core of journals, authors, institutions and countries, whereas the increasingly international participation shows the growing breadth of the field. The significance of this work is that it adopts a systematic approach to map intellectual structures, collaboration networks and thematic focus of PTGR research across Scopus-indexed literature. The study offers important information for scholars to identify core journals, key contributors and new areas of research by using well-entrenched scientometric indicators and visualization techniques. In addition, the results provide an evidence-based foundation for policy-makers, funding agencies and academic institutions for strategic decision-making, partnership development as well as future investigation planning in PTGR and related molecular/RNA biological fields development, and future research planning in PTGR as well as other related fields of molecular and RNA biology research institutions to support strategic decision-making, collaboration development, and future research planning in PTGR and related areas of molecular and RNA biology.

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Mapping and Visualisation Software in Scientometric Analysis: An Overview

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Abstract

Measurement of scientific productivity has been regarded as the main indicator of ascertaining the impact of research over scientific community. To showcase the impact of research using science mapping and visualization, social network analysis has been developed over the period of time. These methods help researchers to understand the structural, temporal and dynamic development of a discipline. The present paper provides a comprehensive overview of the widely used software for scientometric analysis, mapping and visualisation.

Keywords: Scientometrics, Data Analysis, Data Mapping, Visualisation Software, scholarly literature

Introduction

At present, the rate of publishing of scholarly communication is like a flood of scholarly literature which is being published regularly, hence it is exposing the weaknesses of current scientometric analysis-based methods for evaluating this scholarly literature. A novel and promising approach to examine and evaluate this large amount of literature by using scientometric analysis software like Bibexcel, Pajek, CiteSpace, SAINT, Publish or Perish, Network Workbench, SITKIS, Vantage Point or Excel, etc. This paper develops the most comprehensive list of the software available to date, assessing the potential value of data analysis by each one. This paper also analyses the overview of building and validating metrics drawn from the citation data for Social Network Analysis (SNA), Mapping and Visualization. These software are developed by experts to help in managing highly specialized databases to organize the large-scale data collected in a way which can be frequently updated, and to work with network analysis for mapping and visualization.

Scientometric Analysis, Mapping and Visualisation Software

Scientometric softwares can be defined in the light of definition of "Software" as provided in the Online Dictionary of Library and Information Science (ODLIS) as follows "A set of computer based programs, designed and developed to analyse citation based bibliographic data as input to perform the Specific tasks i.e. structural analysis of scholarly communication, mapping of scientific research, creation of metrics based social maps, information representation and organisation, visualization of research, Micro level analysis (co-word, co-author, cited references, bibliographic coupling, co-citation) etc. as output. A mapping and visualization software facilitates in scientometric analysis for its users to draw the maps for visual representation of scientific research based on citation data, to study the structural, temporal and dynamic aspects of a subject discipline. Most of this software is based on modern algorithms, mathematical and statistical methods, graph theory, network science, etc.



Figure 1: Mapping and Visualisation Software in Scientometric Analysis

Common Features of these Software are

- Facilitate structural, temporal and dynamic analysis of a subject discipline.
- Facilitates and supports mapping & visualization of a discipline.
- Able to import input data from the data sources, editing and clean acquired data.
- Helps to execute metrics-based evaluation of the data, creation of maps and networks for visualization.

Purposes

Mapping and Visualisation Software can be used for the following purposes:

1. To study the structural and temporal analysis of information and dynamics of scholarly communication.
2. Mapping of scientific research/subject and building of metrics-based social maps.
3. Facilitates application of modern science analysis, mapping and visualization techniques and methods.
4. Information representation, organisation and network visualization.
5. Performs micro-level analysis, such as:
    i. Co-word analysis – keyword-based approach of analysis
    ii. Co-author analysis – authorship-based approach of analysis
    iii. Cited references – document-based approach of analysis (bibliographic coupling, co-citation analysis, author bibliographic coupling, author co-citation, Journal co-citation and journal bibliographic coupling).

Mapping and Visualisation Software in Scientometric Analysis: Brief Profile

BibExcel (https://bibliometrie.univie.ac.at/bibexcel/)

BibExcel is free software designed by Olle Perrsson, Department of Sociology, Umea University, Umea, Sweden, to assist the user in analyzing the bibliographic data, or any data which is available in text formattable form in a similar manner. The concept behind this is the generation of data files that can be imported to Excel or any program that takes tabbed data records for further processing. This toolbox includes various tools; some are visible in the window, and some are hidden in the menus. Many of the tools can be used in combination to achieve a greater result.

Bibexcel Features:

- Able to do most types of bibliometric analysis (i.e. co-citation, bibliographic coupling, mapping and clustering analysis)
- Bibexcel allows easy interaction/interoperability with other software, e.g. Pajek, Excel, SPSS, etc.
- BibExcel's strength is a higher degree of flexibility in managing data and analysis.
- Possible to use other data sources than Web of Science, in fact, can deal with data other than bibliographic records.
- Able to import many different types of data.

CiteSpaceII (http://cluster.cis.drexel.edu/~cchen/citespace)

CiteSpace is developed by Dr Chaomei Chen, a Professor of Informatics, College of Computing and Informatics at Drexel University, Philadelphia, USA, for progressive knowledge domain visualization and analyzing trends and patterns in scientific literature. It is free Java-based software (runs on Java Runtime) used for structural and temporal analyses of networks derived from publication data, such as Collaboration Networks, Authors Co-citation Networks, and Document Co-citation Networks.

Data Source: The major data source for CiteSpace input is the ISI WoS database, which also supports data from PubMed, arXiv, ADS (http://adswww.harvard.edu/), and NSF Award Abstracts.

Features: It performs various functions to facilitate the understanding and interpretation of visualization, network patterns and historical patterns (i.e. to identify the fastest growing topics, to find out the hotspots of citations in a particular subject domain, fragmentation of a publication network into clusters, automatic labelling of clusters with terms from citing articles, and geospatial patterns of collaboration based on Google Earth.

Gephi (http://gephi.github.io)

Gephi is developed by a dedicated team of young engineers and researchers in computer sciences, web mining, network sciences and information visualisation. Presented by Mathieu Bastian, CTO. Gephi is an interactive Open Graph visualization and exploration platform for analysis of all types of networks, complex systems, dynamic and hierarchical graphs developed by the Young Team of engineers and researchers in the subject area of computer science, web mining, network sciences/complex networks and information visualization.

Features:

- Gephi is available under GNU (General Public License), runs on Windows, Linux, acOS X,.Gephi is used to reveal publication patterns and trends.
- Gephi used the 3D render engine to display large graphs in real-time and to speed up the exploration. Gephi is built on combined functionalities and flexible architecture to explore, analyze, spatialize, filter, cluster, manipulate, and export all types of networks.
- Gephi can do exploratory data analysis, link analysis, social network analysis, biological network analysis and poster creation, etc.

HistCite (http://interest.science.thomsonreuters.com/forms/HistCite)

The HistCite software package was developed by Eugene Garfield, the Father of Citation Indexing. It is used for bibliometric analysis and information visualization. HistCite operates on Windows computers with Internet Explorer, and a trial version is available free of cost. HistCite is designed to identify the significant (most cited) papers retrieved in topical searches of the Web of Science. HistCite operates on Windows with Internet Explorer.

Features: Being a bibliometric analysis and information visualization software, it performs the following core functions:

- Performs specific application: Conversion of bibliographies into diagrams (historiographs).
- It uses the bibliographic information (titles, authors, dates, author addresses, references, etc.) that describe published items for performing bibliometric analysis.
- It measures and studies various aspects of a specific scholarly knowledge domain.
- It analyse the literature published in a particular knowledge domain.
- Used to know the time and geographic region of publication.
- Identify prolific countries/major contributors to a particular subject.
- Identify the languages used frequently for publications.
- To know the important journals in a particular subject.
- To identify the key authors, institutions and articles in a particular subject area.
- To measure authors' impact on each other.

Network Work-bench (http://nwb.cns.iu.edu/)

Network Work-bench (NWB) developed at Indiana University, USA, is another free Java-based Network Analysis, Modelling and Visualization Toolkit. It is designed for handling Large-Scale data in the subjects of Biomedical, Social Sciences and Physics Research. It includes specific features for the execution of bibliometric studies.

Features

- NWB supports design, evaluation, and operates in a unique distributed, shared resources environment for managing large-scale data for network analysis, modelling, and visualization.
- NWB supports network science research.
- NWB users can access or upload major network datasets
- Effective algorithms enable NWB to be able to perform large-scale network analysis.

- NWB enables its users to generate, run, and validate network models to study the structural and dynamic properties of a network efficiently.
- NWB provides advanced features for visualization and analysis for doing specific network analysis
- Researchers will have access to the validated algorithms, developed in the past in time-consuming processes.

NodeXL (http://nodexl.codeplex.com/)

Created by Marc Smith and his team at Social Media Research Foundation. NodeXL is free open source software designed for Microsoft Excel 2007 and 2010, which makes it to explore network graphs. NodeXL graph gallery gives access to the community-generated network graphs. Different fonts for edge, vertex and group labels can be set in NodeXL. NodeXL has in built auto update feature.

Features

- Flexible Import and Export of graphs in GraphML format, supports software like Pajek, UCINet, and matrix formats.
- NodeXL is directly connected to personal social networks i.e. Twitter, YouTube, Flickr and email. NodeXL uses several plug-ins to get information of personal networks from Facebook, Exchange, Wikis and WWW hyperlinks, etc.
- To reduce clutter in the graph scale, the zoom option is available for areas of interest.
- Flexible Layout is possible by using force-directed algorithms used to lay down the graphs, or by dragging of vertices using the mouse.
- In setting the colour, shape, size, label, and opacity of individual vertices, network appearance can be easily adjusted by filling in worksheet cells.
- Using a set of sliders Dynamic filtering instantly hides vertices and edges. To automatically group powerful graph vertex NodeXL analyses their common attributes.
- NodeXL has advanced graph metrics; as a result, it easily calculates degree, betweenness centrality, closeness centrality, eigenvector centrality, Page Rank, clustering coefficient, graph density, etc.
- NodeXL can perform a set of repeated tasks with a single click.

Pajek (http://vlado.fmf.uni-lj.si/pub/networks/pajek/ and http://pajek.imfm.si/doku.php)

Pajek was developed by Vladimir Batagelj and Andrej Mrvar (some procedures were contributed by Matjaz Zaversnik). Pajek is a non-commercial, freely available software programme that runs on Windows. Pajek is able to execute various kinds of network analyses and visualizations activities. Bibexcel software may be used to format input data for Pajek.

Publish or Perish (http://www.harzing.com/pop.htm)

Publish or Perish (PoP) is a free software program that retrieves and analyzes academic citations from Google Scholar to measure the research impact. PoP is able to calculate the various citation-based metrics and indexes. It retrieves citations of publications via Google Scholar and Microsoft Academic Search for metrics-based analysis of citations. PoP was developed by Anne-Wil Harzing, Research Professor and Research Development Advisor of the ESCP Europe Business School. It is designed to evaluate the impact of research work not covered in the ISI.

Feature

Publish or Perish can perform the following metrics-based analysis:

- Total number of papers and total number of citations in a particular subject.
- Average citations received per paper, citations received per author, papers received per author, and citations received per year.
- Calculation of Hirsch's h-index and related parameters.
- Calculation of Egghe's g-index.

- Calculation of the contemporary h-index.
- Calculation of three variations of individual h-indices.
- Calculation of the average annual increase in the individual h-index.
- Calculation of the age-weighted citation rate.

R-Project (http://www.r-project.org/)

'R' was initially written by Robert Gentleman and Ross Ihaka, Department of Statistics, University of Auckland. Project R is a language-based environment for statistical computing and graphics. R is a GNU project capable of executing a wide variety of statistical computing (linear and nonlinear modelling of data, execution of classical statistical tests, time-series analysis, classification, clustering of data, etc.), and graphical formation techniques are highly extensible

Features

- The strongest ability of R is to produce the quality well-designed publication- lots, mathematical symbols and formulae as and when needed.
- R is available as open-source software and supports a wide variety of UNIX-based platforms and similar systems (including FreeBSD and Linux), Windows and MacOS.
- The R is an integrated software facilities data manipulation, calculation and graphical representation:
  - ✓ Data handling and storage facility,
  - ✓ Calculations on arrays for particular matrices R have a set of operators.
  - ✓ For data analysis, a graphical display, whether onscreen or in hard R, provides a large, coherent, integrated collection of intermediate tools.
  - ✓ R is developed on a programming language which incorporates conditionals, loops, user-defined repeatable functions and input and output facilities.

Science Assessment Integrated Network Toolkit (SAINT)

(http://www.rathenau.nl/en/ themes/theme/project/bibliometric-software tools/ saint.html)

SAINT is a fully integrated software developed by the Rathenau Institute, The Hague, Netherlands, for handling large-scale data for bibliometric and patent metric research and one of the few packages that can also be used for conversion of ISI data into relational database (dbm, accdb or sql files). SAINT is available for download from the official. Source code is also available under an open-source license to test and improve SAINT. This toolkit is easy to use for making research easier and more efficient. The issues related to SAINT can be discussed with community members via the discussion forum.

The 1.0 ready-to-use version has:

- To download Web of Knowledge bibliographic data, a parser program.
- A program for splitting the sentences into a database of separate words (i.e. useful in title or abstract level analysis).
- A tool for transformation of a database table or query into matrix format that can be executed by i.e. Pajek for visualization.

Sitkis (https://sites.google.com/site/ sitkisbibliometricanalysis/)

Sitkis is a free Java andMS Access based bibliometric software tool, helping researchers facilitating them during computation process of research analysis and evaluation of scientific information. Sitkis was developed exclusively for bibliometric analysis. It provides tools for extremely streamlined analysis of bibliometric networks. Utilizing Sitkis, one can calculate a large amount of data in a few minutes, which can take days to analyse.

VOSviewer (http://www.vosviewer.com/ Home)

VOSviewer is a free Java-based program, primarily developed by Nees Jan van Eck and Ludo Waltman at Centre for Science and Technology Studies (CWTS), Leiden University, used for data analyses and

constructing bibliometric network visualisation. VOSviewer creates network maps of individual publications, co-authorship, co-citation networks, keywords co-occurrence networks, etc. For constructing and visualizing co-occurrence networks of important terms extracted from a body of scientific literature. VOSviewer uses its built-in text mining function.

CitNetExplorer (http://www.citnetexplorer.nl/ Home)

In addition, like VOSviewer CitNetExplorer is also a free Java-based software tool developed by Nees Jan van Eck and Ludo Waltman at Centre for Science and Technology Studies (CWTS), Leiden University.

It is used for analyzing and visualizing citation networks of scientific publications for improved understanding to study the structure and dynamics of science communication. It supports direct data import from Web of Science for the creation of citation networks. Citation networks can be explored interactively.

Features of CitNetExplorer include:

- Analyse the development of a research field over time.
- Identifying the literature on a research topic.
- Exploring the publication oeuvre of a researcher.
- Supporting literature review.

Data Management

- Web of Science data import- data can be imported directly from the Web of Science database for network analysis.
- Pajek export- networks can be exported in the popular Pajek file format.
- Large networks. It supports very large networks (including millions of publications and tens of millions of citation relations.

Loet Leydesdorff (http://www.leydesdorff.net/)

Loet Leydesdorff provides a set of free DOS-based software to analyse and evaluate bibliometrics data obtained from data sources such as Scopus, ISI, and Google Scholar for metrics-based analyses such as co-authorship (international and institutional collaboration, collaboration networks), co-words analysis, Co-citation and bibliographic analysis and much more. These software are also helpful for preparing data for the creation of relational databases and information visualization by other visualization tools such as Pajek.

SciMAT(http://sci2s.ugr.es/scimat/description.html)

SciMAT stands for Science Mapping Analysis software Tool, a Java-based opensource science mapping software tool, developed at the research group Sci2s at the University of Granada, Spain. SciMAT has been supported by the Project of the Spanish Ministry of Education and Science. SciMAT was developed by M.J. Cobo, A.G. López-Herrera, E. Herrera-Viedma, and F. Herrera, which incorporates methods, algorithms, and measures for science mapping.

It is free to perform a science mapping and analysis. SciMAT handles bibliographic data in Sqlite 3 format (amendable at any time), to carry out bibliometric analysis-based studies. SciMAT uses several algorithms to edit data. Strategic diagrams, Cluster networks, and Evolution areas are three techniques jointly used by SciMAT for visualization).

SciMAT has the following modules:

- A dedicated module for the management of the knowledge base,
- Science mapping and analysis modules, and
- Results and maps generation module for visualization.

Features of SciMAT are

- Loaders for handling ISI Web of Knowledge format and RIS format.

- Bibliometric networks: Bibliometric networks are based on co-word, co-citation, and bibliographic coupling.
- Pre-processing: It includes de-duplicating, time-slicing, data reduction and network reduction.
- Normalization: Normalization association strength, equivalence index, inclusion index, Jaccard's index and Salton's cosine are used for normalization.
- Mapping: For mapping of data, simple Centers Algorithm, Single-linkage, Complete-linkage, Average-linkage and Sum-linkage clustering algorithms are used for mapping.
- Analysis: network analysis, performance and quality analysis, and temporal analysis can be executed using SciMAT.
- Visualization: for result visualization strategic diagram, cluster network, overlapping map, and evolution map can be created.
- Report: Outcomes generated in HTML and LaTeX format.

VantagePoint (https://www.thevantagepoint.com/)

Vantage Point is a powerful text mining tool for discovering knowledge in search results from patent and literature databases. It has visualization capabilities. Vantage Point is a 32-bit program powerful commercial text-mining tool compatible with Windows Vista, Windows 7, and Windows 8 platforms. VantagePoint is used for discovering knowledge in search results from patent and literature databases. Vantag Point helps to understand and work with search results retrieved from text databases.

Features of VantagePoint can be classified into the following five broad categories

- Importing – importing the data into Vantage Point and mining the raw data to get more data from it.
- Cleaning – data cleaning means transforming the data into a consistent set, combining the things that need to analyze as a group, and merging and normalizing data received from diverse sources. Vantage Point uses fuzzy matching techniques for data cleaning.
- Analyzing – analyzing gathered data in a variety of ways.
- Reporting – reporting prepares to display results.
- Automating – automating encodes the entire process to make it consistently repeatable.

CoPalRed (http://ec3.ugr.es/copalred/)

CoPalRed is a specialized computer program developed by Rafael Bailón-Moreno, Department of Chemical Engineering, University of Granada, Spain.

CoPalRed depended on the database for gathering information (i.e. Web of Science, Scopus, Medline, etc.). This citation data is used for analysis, and CoPalRed transforms this into new knowledge explicitly not explicitly available and generated before. The common errors occurred in a bibliographic database are corrected or cleaned by the CoPalRed before any analysis by its self-cleaning system. While doing analysis, CoPalRedmake performs preliminary filtering of the data received and executes three types of fully automated analysis:

- Structural analysis. It shows the structural network formation of a particular knowledge domain.
- Strategic analysis. Defining the relative position of the actor within the network, by defining its intensity, external relations (centrality) and internal cohesion (density).
- Dynamic analysis. CoPalRed, analyzes the transformations of actors over time in a network. It identifies approaches, forks, appearances and disappearances of actors in a network.

CoPalRed main modules are:

- Information capture module
- Module debugging information
- Generation module knowledgebase
- Knowledge Management Module.

IN-SPIRE™ (http://in-spire.pnnl.gov/)

IN-SPIRE™ Visual Document Analysis was developed by Pacific Northwest National Laboratory, US. It is licensed software, and the latest released version is the 5.9 of IN-SPIRE. It has various tools for exploring textual data, tools for handling Boolean and topical queries, and tools for time and trend analysis. The suite of tools allows the user to rapidly discover hidden information relationships by reading only pertinent documents. IN-SPIRE has been used to explore technical and patent literature, marketing and business documents, web data, accident and safety reports, newswire feeds and message traffic, and more. It has applications in many areas, including information analysis, strategic planning, and medical research.

The core features of IN-SPIRE are

- Quick creation of meaningful visualizations and
- Able to explore and understand a large textual database without reading every record.
- IN-SPIRE™ supports multiple types of text file formats (such as IN-SPIRE: supports encodings for ASCII, UTF-8, UTF-16 and is also compatible with PDF, MS-Word, MS-Excel, and RTF files, email, XML, HTML, RSS and spreadsheets.

UCINET (https://sites.google.com/site/ucinetsoftware/home)

UCINET 6 for the Windows is a software package for social network analysis, developed by Lin Freeman, Martin Everett and Steve Borgatti, and published by Analytic Technologies, USA (http:// www.analytictech.com/). It incorporates the Net Draw network visualization tool. UCINET 6 is available for download free of cost 90 day uses only or can be purchased. It allows students to purchase at the price as it is counted. In addition, several free tools, including Anthropac, NetDraw and Key Player, are also available. UCINET 6 is compatible with the Windows operating system (i.e.NT, 98, XP, etc). It can be run via Boot Camp, VM Fusion, Parallels or Wine to run it on Mac or Linux. It supports analysis of large datasets. UCINET 6 is able to analyse a maximum network size of about 2million nodes, but practically most UCINET procedures are very slow to run networks larger than about 5000 nodes. However, the situation varies from network to network.

Conclusion

The scientometric researchers need to know about the various popular data analysis, mapping and visualization softwares. Each of such softwares has specific characteristics which are different from each other. Many of this software run in java run time environment (JRE). Most of this software are available either free of cost or under open-source licensing. Some software is able to do scientometric analysis, some are able to create maps and networks, while some are specialized in information visualization. It is very hard to choose any software as the best among all. As many of this software are designed and developed in a way to capture the input data from the various popular data sources such as: Scopus, Web of Science, Google Scholar, PubMed and many others, now we can analyse the large-scale data in lesser time. Many of the softwares have data convergence and compatibility feature which supports interoperability and crosswalk of input and output data. These mapping and visualization softwares are now widely used by the researchers across the globe in scientometric analysis.

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Open Access (OA): Transforming Scholarly Communication and Research Dissemination in the Modern Academic Environment

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Abstract

Scholarly communication is essential for the creation, evaluation, and dissemination of research knowledge. Traditionally, scholarly publishing has relied on subscription-based models that limit access to research through high costs and restricted availability. Such barriers reduce the visibility and impact of scholarly work and hinder equitable access to information, particularly for researchers and institutions in developing regions. In recent years, Open Access (OA) has emerged as a transformative approach that enables free and unrestricted access to research outputs, thereby reshaping the landscape of scholarly communication. This paper examines the role of Open Access in modern research dissemination and its influence on scholarly communication practices. It discusses key Open Access models, including Gold Open Access, Green Open Access, and institutional repositories, and highlights their contribution to increasing research visibility, accessibility, and citation impact. Open Access supports faster dissemination of research findings, encourages interdisciplinary collaboration, and promotes the democratization of knowledge by making scholarly literature available to a wider global audience, including policymakers, practitioners, and the general public.

Keywords: Open Access; Scholarly Communication, Research Dissemination, Academic Publishing, Knowledge Sharing, Digital Scholarship

Introduction

Scholarly communication is the foundation of academic research, enabling scholars to create, share, and preserve knowledge. Traditionally, research findings have been disseminated through subscription-based journals, which often restrict access due to high costs and licensing limitations. These barriers limit the visibility and impact of scholarly work and create inequalities in access to information, particularly for researchers and institutions with limited resources. The rapid growth of digital technologies has significantly transformed the way scholarly information is produced and shared. In this context, Open Access has emerged as an important model for improving research dissemination by providing unrestricted access to scholarly literature. Open Access supports wider readership, faster dissemination of research findings, and greater collaboration among researchers across disciplines and geographical boundaries. This paper explores the role of Open Access in transforming scholarly communication in the modern research environment. It highlights how Open Access enhances accessibility, visibility, and knowledge sharing while also addressing the challenges associated with its adoption.

Open Access and Scholarly Communication

Open Access (OA) has revolutionized scholarly communication by making research freely available to anyone with an internet connection. Unlike traditional subscription-based publishing, OA removes financial and legal barriers, allowing researchers, students, and the general public to access scholarly work without restriction. This shift has transformed how knowledge is shared, increasing the visibility, reach, and impact of research. Through OA models such as Gold Open Access (publishing in fully open journals), Green Open Access (self-archiving in repositories), and hybrid approaches, scholarly work can reach a global audience quickly and efficiently. Open Access not only supports faster dissemination of research findings but also encourages collaboration across disciplines and countries. It democratizes knowledge, enabling researchers from developing regions to access the latest studies without financial constraints, and fosters innovation by providing open access to data, methods, and publications. In short, Open Access strengthens scholarly communication by making research more transparent, inclusive, and impactful, while also shaping the future of academic publishing in the digital age.

Objectives of the Study

1. To examine the role of Open Access in transforming scholarly communication by making research more accessible and widely available.
2. To analyze how Open Access enhances research dissemination, visibility, and impact in the academic community.
3. To identify the benefits and challenges of adopting OpenAccess for researchers, institutions, and publishers.
4. To explore the contribution of Open Access toward equitable access to knowledge and global academic collaboration.
5. To provide recommendations for strengthening Open Access initiatives and promoting responsible publishing practices.

Methodology

This study adopts a **descriptive and analytical approach** to examine the role of Open Access in scholarly communication and research dissemination. The methodology primarily involves a **literature review** of scholarly articles, reports, and policy documents related to Open Access, academic publishing, and knowledge sharing. Relevant case studies, Open Access initiatives, and global publishing trends are analyzed to understand the benefits, challenges, and impact of OA on research visibility and accessibility. The study also includes a **comparative analysis** of different Open Access models, such as Gold OA, Green OA, and institutional repositories, to highlight their contribution to enhancing scholarly communication. The focus is on evaluating the practical implications of OA for researchers, institutions, and the wider academic community. Since this is a theoretical study, **primary data collection** through surveys or interviews is not included. Instead, the methodology emphasizes synthesizing existing research and authoritative sources to provide a comprehensive understanding of Open Access and its role in modern research dissemination.

Scope of the Study

This study focuses on the role of **Open Access (OA)** in transforming **scholarly communication** and research dissemination in the modern academic environment. It examines different Open Access models, such as Gold OA, Green OA, and institutional repositories, and their impact on the visibility, accessibility, and reach of research publications. The study also explores the benefits of OA for researchers, institutions, and the global academic community, as well as the challenges associated with its adoption, including costs, quality concerns, and copyright issues. The research primarily emphasizes the digital and global aspects of scholarly communication, highlighting how Open Access supports collaboration, knowledge sharing, and equitable access to information. However, it does not cover detailed technical aspects of OA publishing platforms or specific case studies of individual journals in depth. The scope is limited to understanding OA's contribution to modern research dissemination and its implications for academic practices and policy development.

Model of Open Access

The **open access model** refers to a system of publishing and sharing academic research, where the content is made freely available to the public, usually through online platforms. The core idea is to eliminate barriers such as paywalls, subscription fees, or other access restrictions, making knowledge freely accessible to everyone. There are several models of open access, and they are often categorized based on how the content is made available and who bears the costs.

Gold Open Access

In this model, the final published version of the research (e.g., articles in journals) are made freely accessible immediately upon publication. **Funding** Authors, institutions, or research funders often pay Article

Processing Charges (APCs) to cover the cost of publication. This model is common in open access journals. **Example** Journals like *PLOS ONE* or *BioMed Central*.

Green Open Access

Authors deposit a version of their research article (often a preprint or postprint) in an institutional or subject-specific repository. These versions may not be the final published version, but they are freely accessible to the public. **Funding** there is typically no charge to the author for this model. The content is self-archived by the author after the peer review and publication process. **Example** Researchers might upload their papers to platforms like *arXiv* (for physics and related fields) or institutional repositories.

Hybrid Open Access

Traditional subscription-based journals offer authors the option to make individual articles open access for a fee. In this model, some articles in the journal are freely available, while others are behind a paywall. **Funding** Authors pay an APC for their articles to be made open access, but the journal as a whole remains subscription-based. **Example** Many Elsevier and Springer journals offer hybrid open access options.

Platinum/diamond Open Access

In this model, neither authors nor readers pay any fees. The costs of publication are typically covered by institutions, funders, or other sponsors. **Funding: The** funding model often comes from universities, government agencies, or private institutions that support the journal. **Example:** *The Journal of Machine Learning Research* operates under a platinum open access model.

Bronze Open Access

In this model, articles are made freely available, but the publisher does not formally license them under an open access license (e.g., Creative Commons). This means readers can access the content for free but there are often restrictions on reuse and redistribution.

Fundingthis model is typically not associated with any APCs and may be seen as a temporary measure by publishers. **Example** certain journals might allow free access to an article for a limited time but without offering open reuse rights.

Open Access Monographs (OA Books)

Similar to journals, this model applies to books. Publishers or academic platforms make entire books or book chapters available to the public at no cost.**Funding**Often funded by institutions, grants, or specific publishers with a mandate for OA books. **Example***Open Book Publishers* and *OAPEN* are platforms that support OA books

Digital Aspects of Scholarly Communication

Open Access Publishing

Open Access (OA) refers to the practice of making research outputs freely available to the public without any access barriers. OA is supported by digital platforms where research can be published and shared globally. OA repositories (e.g., arXiv, PubMed Central) and OA journals (e.g., PLOS ONE, DOAJ) are increasing in number. OA has been championed for democratizing access to knowledge.

- **Impact**: Researchers from lower-income regions can access the latest research without the need for expensive journal subscriptions.

Preprint Servers

Preprints are early versions of research papers made available before peer review. Preprint servers (like arXiv, bioRxiv, medRxiv) allow rapid dissemination of findings. These platforms make research more accessible and allow other researchers to comment and provide feedback before formal publication.

- **Impact**: Accelerated dissemination of research, especially in fields like medicine and physical sciences, allowing immediate access to important findings.

Digital Repositories and Institutional Repositories

Digital repositories are online databases where research outputs (e.g., articles, theses, and data) are stored and shared. Many universities and research institutions maintain their own repositories for sharing academic research (e.g., Institutional Repository at MIT, Harvard).

- **Impact**: Researchers can share their data sets, publications, and other scholarly materials, making research more transparent and accessible.

Research Data Sharing

Digital platforms facilitate the sharing of research data through platforms like Figshare, Dryad, and Zenodo. Increasing expectations for researchers to share their raw data and methodologies to support reproducibility and transparency.

- **Impact**: Greater collaboration and validation of results; increases trust in research outcomes.

Citation Management and Impact Metrics:

Digital tools like Zotero, Mendeley, and EndNote help researchers organize their references. Impact metrics like h-index, altmetrics, and Google Scholar citations provide quantitative assessments of research influence. These tools make it easier for scholars to manage sources and measure the reach of their work.

- **Impact**: Easier tracking of academic influence and visibility, but also raises concerns about metrics driving scholarly careers in problematic ways (e.g., overemphasis on citation counts).

E-Journals and Online Databases:

Digital versions of academic journals and research databases (e.g., JSTOR, ScienceDirect, SpringerLink) offer a platform for peer-reviewed papers. An increasing shift from print to digital publishing, with many journals now adopting digital-first or exclusively digital formats.

- **Impact**: Easier access, but concerns about subscription costs, digital divide, and the paywall model for journals.

Collaborative Platforms and Tools

Tools like Google Scholar, ResearchGate, and Academia.edu allow researchers to connect, share papers, and collaborate in real time. Collaboration software like Slack, Teams, or GitHub (for code-sharing) enables communication and data sharing between research groups across the globe.

- **Impact**: More interdisciplinary and international collaboration, but concerns about data privacy and the commercialization of scholarly networks.

Global Aspects of Scholarly Communication

Scholarly communication has expanded globally, allowing research and knowledge to move beyond national, institutional, and disciplinary limits. Researchers from different countries now collaborate more easily, working together on global issues such as climate change and public health. Open Access (OA) plays an important role by providing free access to research for scholars worldwide, ensuring equal opportunities for participation and knowledge sharing. Digital technologies and international publishing platforms have simplified the sharing of research by removing traditional paywall restrictions. Moreover, global research networks support linguistic and cultural diversity, promoting the exchange of ideas across languages and regions. Overall, global scholarly communication enhances collaboration, speeds up innovation, and improves access to knowledge for all.

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International Collaboration

Global research efforts, facilitated by digital tools, allow scholars from different parts of the world to collaborate on research projects. The rise of online conferences, research networks, and collaborative databases has made it easier for scholars from diverse regions to work together.

- **Impact**: Increased diversity of thought and expertise, as well as accelerated advancements in research, but also challenges in managing diverse time zones, languages, and institutional cultures.

Multilingualism and Cultural Barriers

Scholarly communication is not limited to English-speaking countries anymore. Many publications are emerging in languages other than English, and translation services are improving. Platforms like Google Translate, multilingual journals, and digital translation tools are helping bridge the language gap.

- **Impact**: Facilitates broader participation in the global research community, though language barriers can still pose challenges in terms of access and participation.

Global Access to Information

The internet has made it easier for researchers in developing countries to access global research, but challenges remain. Global initiatives like the Research4Life and HINARI programs provide free access to research articles for institutions in low-income countries.

- **Impact**: Encourages greater inclusion and participation from researchers worldwide, but the digital divide remains an issue, particularly in remote or under-resourced regions.

Scholarly Publishing Models

Traditional scholarly publishing has been dominated by major Western publishers, but there is a growing push for alternative models, including Open Access. Initiatives like the Plan S initiative in Europe are pushing for free and immediate access to publicly funded research.

- **Impact**: Western-dominated publishing models are being challenged, creating more equitable access to scholarly resources and supporting local publishers in other regions.

Citation and Impact across Borders

Citation patterns are increasingly global, with researchers from all over the world citing each other's work. Citation indices (e.g., Scopus, Web of Science) track global citations, but these platforms are often criticized for over-representing Western research and not adequately representing regional contributions.

- **Impact**: Encourages greater recognition of global contributions but also raises questions about biases in citation practices.

Global Conferences and Virtual Events

Digital platforms have revolutionized conferences, allowing researchers to present their work and engage with colleagues from all over the world without the need for travel. Virtual conferences, webinars, and online symposia have proliferated, especially during and after the COVID-19 pandemic.

- **Impact**: Facilitates access to conferences for a wider audience, reduces carbon footprint, but also raises questions about networking and engagement in virtual settings.

International Open Science Initiatives

The Open Science movement seeks to make research more transparent, accessible, and collaborative across borders.Organizations like UNESCO, the European Commission, and the Open Science Foundation are leading global initiatives to promote open science practices.

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- **Impact**: Global adoption of open science principles fosters greater transparency and collaboration, but it requires substantial investment in digital infrastructure and education.

Collaboration

Open Access (OA) significantly enhances collaboration in the modern academic environment by removing access barriers to scholarly research. By providing free and immediate access to research outputs, OA enables researchers from different institutions, disciplines, and countries to work together more effectively. Scholars can easily share articles, data, and findings, leading to stronger international and interdisciplinary collaborations. OA also supports collaborative platforms and open repositories, allowing early feedback, joint research, and knowledge exchange. Overall, Open Access promotes inclusive, transparent, and global collaboration, accelerating research innovation and dissemination.

Knowledge Sharing in Open Access (OA)

Open Access (OA) plays a pivotal role in facilitating **knowledge sharing** across the global academic community. By making research freely available to anyone with internet access, OA breaks down barriers that traditionally limited access to scholarly articles, data, and findings. This openness encourages the rapid exchange of ideas and information, allowing researchers, educators, and practitioners to build upon existing knowledge more effectively.

Global Access

OA ensures that research is accessible to scholars worldwide, regardless of their geographic or financial constraints. This fosters a more equitable distribution of knowledge.

Collaboration

OA platforms encourage collaboration by allowing researchers to freely share data, publications, and research methods. This leads to a more transparent, reproducible, and open exchange of ideas.

Interdisciplinary Insights

With OA, researchers from different disciplines can access each other's work, promoting interdisciplinary collaboration and the integration of diverse perspectives to solve complex problems.

Faster Dissemination

OA accelerates the speed at which knowledge spreads. Preprints, datasets, and other research outputs are shared instantly, enabling quicker feedback, replication, and innovation.

Knowledge Transfer

OA also supports knowledge transfer beyond academia, allowing industry professionals, policymakers, and the general public to access cutting-edge research and apply it to real-world challenges.

Role of Open Access in Research Dissemination

Open Access (OA) plays a vital role in making research more visible, accessible, and impactful. By removing paywalls and subscription barriers, OA ensures that scholarly work reaches a wider audience, including researchers, students, policymakers, and the general public. This broader access helps accelerate knowledge sharing, encourages collaboration, and supports interdisciplinary research. OA also increases the citation potential of research, as freely accessible papers are more likely to be read and referenced. Institutional repositories, preprint servers, and open journals provide platforms where researchers can quickly disseminate their findings, reducing the delay between discovery and sharing. Moreover, Open Access promotes transparency and accountability in research by allowing others to review, replicate, and build upon published work. In addition, OA fosters global equity in research by enabling scholars from developing countries to access the latest studies without financial constraints. This democratization of knowledge not only enhances the quality

of research but also strengthens the global academic community. Overall, Open Access is not just a publishing model, it is a key driver of modern research dissemination, making scholarly communication faster, more inclusive, and more effective in addressing the needs of the academic and wider communities.

Challenges of Open Access

Despite its many benefits, Open Access (OA) faces several challenges. One major concern is the **cost of publishing**, as some OA journals charge Article Processing Charges (APCs) that can be expensive for researchers or institutions with limited funding. Another challenge is **quality control**, since the rise of predatory journals that claim to be legitimate but lack proper peer review can undermine trust in OA publications. **Copyright and licensing issues** also create complications, as authors must understand how to share their work while protecting intellectual property. Additionally, a **lack of awareness or training** among researchers about OA options and policies can limit participation, especially in regions where Open Access is not widely promoted. These challenges highlight the need for strong institutional support, clear OA policies, and guidance for researchers to publish responsibly. Addressing these issues is essential to ensure that Open Access remains a credible, equitable, and sustainable model for scholarly communication.

Scope of Future Study

The study of Open Access and its impact on scholarly communication has significant potential for future research and development. Future studies can explore the **emerging trends in Open Science**, including open data, preprints, and collaborative research platforms, to understand how these innovations further enhance research dissemination. There is scope for **empirical research**, such as surveys and interviews with researchers, publishers, and librarians, to evaluate the adoption, perception, and effectiveness of Open Access in different regions and disciplines. Comparative studies on the impact of Open Access policies across countries or institutions can provide insights into best practices and challenges. Additionally, future research can investigate the **integration of advanced digital tools and technologies**, such as AI-driven publishing platforms, blockchain for intellectual property, and metrics for measuring OA impact, to strengthen scholarly communication. Studies can also focus on **addressing challenges,** such as funding models, quality assurance, and ethical publishing, to ensure sustainable and inclusive Open Access practices. Overall, the future scope of this study highlights that Open Access will continue to evolve as a critical driver of transparency, equity, and innovation in global research, offering numerous opportunities for academics, policymakers, and institutions to enhance knowledge sharing and collaboration.

Conclusion

Open Access has emerged as a transformative force in scholarly communication, fundamentally changing the way research is shared, accessed, and utilized. By removing paywalls and subscription barriers, Open Access ensures that knowledge reaches a wider audience, including researchers, students, policymakers, and the public. This increased accessibility enhances the visibility and impact of scholarly work, supports faster dissemination of findings, and encourages collaboration across disciplines and geographical boundaries. In doing so, Open Access promotes a more inclusive and equitable research environment, allowing scholars from developing countries or institutions with limited resources to engage fully in the global academic community. Despite its advantages, Open Access is not without challenges. Article processing charges, concerns about publication quality, copyright and licensing issues, and the rise of predatory journals can create barriers to adoption and trust. Moreover, a lack of awareness and understanding of Open Access policies among researchers can limit their effectiveness. Addressing these challenges requires coordinated efforts from institutions, funding agencies, publishers, and researchers themselves. Clear policies, adequate funding, training, and ethical publishing practices are essential to ensure that Open Access remains credible, sustainable, and beneficial for all stakeholders. Overall, Open Access is more than a publishing model; it is a catalyst for a modern, transparent, and collaborative research ecosystem. By embracing Open Access, the academic community can maximize the reach and utility of scholarly work, fostering innovation, knowledge sharing, and global scientific progress. Strengthening Open Access initiatives and encouraging widespread participation will ensure that research

knowledge is not confined by economic, institutional, or geographic barriers, ultimately advancing scholarship and benefiting society at large.

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Emerging Issues and Challenges in Open Access Products

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ABSTRACT

Open access products have transformed scholarly communication by enabling free and unrestricted access to academic literature, research data, and educational resources. They play a crucial role in enhancing visibility, knowledge sharing, and global research equity. However, the rapid growth of open access products has also given rise to several emerging issues and challenges. These include concerns related to quality control, sustainability of funding models, predatory publishing practices, copyright and licensing complexities, long-term digital preservation, and technological infrastructure. In addition, disparities in awareness, digital literacy, and institutional support affect the effective use of open access products, particularly in developing regions. Ensuring compliance with open access policies and maintaining the credibility of scholarly outputs remain significant challenges for researchers, publishers, and institutions alike. This abstract examines the key emerging issues and challenges associated with open access products and highlights the need for collaborative strategies, policy frameworks, and capacity-building initiatives to maximize their benefits while minimizing associated risks.

Keywords: Open Access, Open Access Products, Scholarly Communication, Predatory Publishing, Copyright and Licensing, Digital Preservation, Research Visibility

Introduction

The open access movement has significantly reshaped the landscape of scholarly communication by promoting unrestricted access to research outputs. Open access products—such as open access journals, institutional repositories, open educational resources, and open research data—aim to remove financial, legal, and technical barriers to information access. By enhancing research visibility, accelerating knowledge dissemination, and supporting academic collaboration, open access products contribute to inclusive and equitable knowledge sharing across the globe.

Despite these advantages, the rapid expansion of open access products has introduced a range of emerging issues and challenges that require critical attention. Concerns related to the quality and credibility of open access publications, the rise of predatory journals, and uncertainties surrounding sustainable funding models continue to affect the scholarly ecosystem. Additionally, copyright and licensing issues, particularly those related to Creative Commons licenses, pose challenges for authors and institutions. Technological constraints, digital preservation, and interoperability of platforms further complicate the effective management of open-access products. In developing regions, limited infrastructure, low awareness, and inadequate institutional support hinder optimal utilization. Addressing these emerging issues and challenges is essential to strengthening the reliability, sustainability, and long-term impact of open access products in the evolving knowledge society.

Definition

Emerging Issues and Challenges in Open Access Products refer to the evolving problems, concerns, and obstacles associated with the creation, dissemination, management, and use of open access resources such as open access journals, repositories, open educational resources, and open research data. These issues include quality assurance, sustainability of funding models, predatory publishing practices, copyright and licensing complexities, technological and infrastructural limitations, digital preservation, policy compliance, and uneven awareness and adoption among stakeholders. Addressing these challenges is essential to ensure the credibility,

accessibility, sustainability, and long-term effectiveness of open access products in scholarly communication and knowledge dissemination.

Open Access

Open Access (OA) refers to the free, immediate, and unrestricted availability of scholarly and research information on the internet. It enables users to read, download, copy, distribute, print, search, and link to full-text content without financial, legal, or technical barriers, while ensuring proper attribution to authors. Open access covers a wide range of products, including research articles, books, theses, datasets, and open educational resources. The primary objective of open access is to enhance the visibility, accessibility, and impact of research, thereby promoting global knowledge sharing and academic collaboration. Open access supports equity in information access by benefiting researchers, students, and institutions, particularly in developing regions. Various models of open access exist, such as Gold Open Access, Green Open Access (self-archiving), and Hybrid Open Access. Despite its advantages, open access faces challenges related to quality assurance, sustainability, copyright management, and predatory publishing practices, which require careful policy and institutional support.

Green Open Access (Self-Archiving)

Green Open Access, also known as self-archiving, refers to the practice whereby authors deposit a version of their scholarly work in an open-access repository to make it freely accessible to the public. These repositories may be institutional repositories maintained by universities or subject-based repositories such as arXiv or PubMed Central. Typically, authors are allowed to archive preprints (versions before peer review) or postprints (peer-reviewed but not publisher-formatted versions), depending on publisher policies. In many cases, access to the deposited work may be subject to an embargo period imposed by the publisher. Green Open Access does not usually require authors to pay article processing charges, making it a cost-effective model for disseminating research. It enhances research visibility, ensures long-term preservation of scholarly outputs, and supports compliance with open access mandates. However, challenges include copyright restrictions, lack of awareness among researchers, and inconsistencies in publisher self-archiving policies.

Review of Literature

Xia (2012) uses the h-index to rank the quality of library and information science journals between 2004 and 2008. Selected open-access (OA) journals are included in the ranking to assess current OA development in support of scholarly communication. It is found that OA journals have gained momentum supporting high-quality research and publication, and some OA journals have been ranked as high as the best traditional print journals. The findings will help convince scholars to make more contributions to OA journal publications, and also encourage librarians and information professionals to make continuous efforts for library publishing.

According to BOAI (Budapest Open Access Initiative)the concept of Open Access refers to "[the] free availability on the public internet, permitting any users to read, download, copy, distribute, print, search, or link to the full texts of these articles, crawl them for indexing, pass them as data to software, or use them for any other lawful purpose, without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself" (BOAI, 2002).

Academic libraries are positioned to be at the forefront of the open access revolution. Numerous trends towards open access publication have emerged over the course of the past few years, confronting academic libraries with new challenges and presenting promising opportunities (Giarlo, 2005). The open access movement has turned to libraries as a haven for solutions. As published content grew more expensive and restricted, and the internet made the distribution of ideas relatively cheap and easy, avoiding the publisher as a "middle man", open access became an obvious option for libraries. Today, libraries are becoming alternative publishers through institutional repositories (Cho, 2008). Open access is especially important for research and academic libraries since all academic institutions are research-intensive and a library's main mandate is to support the teaching, learning and research activities of their parent institutions. All three activities are research-based. Open access is

the most recent undertaking to support institutional research activities by providing information cost and time effectively at the right time in the right format. Open Access has numerous impacts on academic libraries: economic, technological, collection development and management, reference services, information literacy, and peer evaluation. Open access is a prerequisite to survive and thrive for academic libraries (Giarlo, 2005).

Features of Open Access

1. **Free Access** – Open access content is available online without subscription fees or paywalls.
2. **Unrestricted Use** – Users can read, download, copy, distribute, and share content with proper attribution.
3. **Immediate Availability** – Research outputs are accessible immediately upon publication or after a short embargo.
4. **Author Retained Rights** – Authors often retain copyright and grant usage rights through open licenses.
5. **Use of Open Licenses** – Creative Commons licenses clearly define permissions for reuse and redistribution.
6. **Enhanced Visibility and Impact** – Open access increases readership, citations, and research visibility.
7. **Global Accessibility** – Enables equal access to information for researchers and learners worldwide.
8. **Digital Format** – Content is published and preserved in digital repositories and platforms.
9. **Interoperability** – Supports metadata standards for easy discovery across databases and search engines.
10. **Long-Term Preservation** – Ensures continued access through institutional and subject repositories.

E-Journals (Electronic Journals)

E-Journals, or electronic journals, are scholarly periodicals published and accessed in digital format through the internet. They provide researchers, academicians, and students with quick and convenient access to current and archived research articles. E-journals may be subscription-based, open access, or hybrid in nature. They support advanced search features, hyperlinks, multimedia content, and reference linking, which enhance usability and research efficiency. Compared to print journals, e-journals offer faster publication cycles, wider dissemination, and reduced physical storage requirements. They also enable institutions to provide access to a vast range of titles through library consortia. Despite these advantages, challenges such as high subscription costs, licensing restrictions, digital preservation, and access continuity remain important concerns. E-journals play a vital role in modern scholarly communication and are an essential component of academic library collections.

Free Open-Access Journals

Free open-access journals are scholarly journals that provide immediate and unrestricted access to research articles without charging subscription fees to readers or article processing charges (APCs) to authors. These journals are often supported by academic institutions, scholarly societies, government funding, or non-profit organizations. Free open-access journals promote equitable access to knowledge by enabling researchers, students, and the general public to access scholarly literature without financial barriers. They enhance research visibility, citation impact, and global dissemination of knowledge. Most free open-access journals follow peer-review processes and use open licenses, such as Creative Commons, to allow lawful reuse of content with proper attribution. However, sustainability, long-term funding, quality assurance, and digital preservation are key challenges faced by free open-access journals. Despite these issues, they play a crucial role in strengthening open scholarly communication, particularly in developing and resource-constrained regions.

Issues and Challenges in Open Access

Open access has significantly improved the availability and visibility of scholarly information; however, it also faces several issues and challenges that affect its effective implementation and sustainability. One of the

major challenges is the **high cost of Article Processing Charges (APCs)**, which shifts the financial burden from readers to authors and institutions. The **rise of predatory journals** poses a serious threat, as such journals exploit the open access model by compromising peer review and editorial standards. **Quality assurance and credibility** of open access publications remain concerns among researchers. **Copyright and licensing issues**, including confusion over Creative Commons licenses and authors' rights, further complicate open access publishing.

Additional challenges include a **lack of awareness and digital literacy** among researchers, especially in developing regions, **inadequate technological infrastructure**, and **long-term digital preservation**of open access content. **Policy inconsistencies and limited institutional support** also hinder effective adoption. Addressing these issues is essential to ensure the sustainability, reliability, and global impact of open access initiatives.

Barriers to Open Access

Despite its potential to democratize access to scholarly information, open access faces several barriers that limit its widespread adoption and effective use. A major barrier is the **high cost of Article Processing Charges (APCs),** which can prevent researchers—especially those from developing countries or unfunded institutions—from publishing in reputable open access journals. **Lack of awareness and understanding** of open access models, policies, and benefits among researchers also restricts participation. **Copyright and publisher restrictions**, including embargo periods and complex licensing terms, pose legal and procedural challenges.

The presence of **predatory journals** creates mistrust and confusion, discouraging authors from choosing open access venues. **Inadequate technological infrastructure**, such as limited repository facilities and poor internet connectivity, further hampers access and dissemination. Additionally, **institutional resistance, policy inconsistencies, and limited funding support** act as structural barriers. Addressing these obstacles requires coordinated efforts through policy development, researcher training, infrastructure investment, and sustainable funding models to fully realize the benefits of open access.

Conclusion

Open access has transformed the landscape of scholarly communication by providing unrestricted access to research outputs, thereby enhancing visibility, knowledge sharing, and global collaboration. Open access products, including journals, repositories, and educational resources, play a critical role in democratizing information and supporting research equity. However, the expansion of open access also brings significant challenges, such as high publication costs, quality assurance concerns, predatory publishing, copyright and licensing complexities, technological limitations, and uneven awareness and infrastructure across regions. Addressing these issues requires coordinated efforts from researchers, institutions, policymakers, and funding bodies. Initiatives like institutional repositories, national digital libraries, and open access networks in India illustrate the potential of structured strategies to overcome barriers. By adopting sustainable funding models, strengthening policy frameworks, promoting digital literacy, and ensuring long-term preservation, open access can continue to foster equitable, credible, and effective dissemination of knowledge worldwide.

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Open Access Repositories: A Tool for Equitable Access to Scholarly Information

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Abstract

Open Access Repositories (OARs) play a significant role in providing free and unrestricted access to scholarly literature. They serve as digital platforms for collecting, preserving, and disseminating the intellectual output of academic and research institutions. In the digital era, where access to information determines academic growth and research productivity, open access repositories help bridge the gap between information-rich and information-poor communities. This paper discusses the concept, types, features, and importance of open access repositories, with special emphasis on the role of libraries in managing and promoting them. The study is descriptive in nature and is based on a review of relevant literature. The paper concludes that open access repositories are essential for strengthening scholarly communication and promoting knowledge equity in higher education.

Keywords: Open Access, Institutional Repositories, Scholarly Communication, Digital Libraries, Academic Libraries

Introduction

The rapid growth of digital technologies has transformed the way scholarly information is created, shared, and accessed. Traditional subscription-based journals often restrict access to research outputs due to high costs, creating barriers for researchers, faculty members, and students, especially in developing countries. Open Access (OA) has emerged as an alternative model that promotes free access to scholarly literature.

Open access repositories are one of the major components of the open access movement. These repositories provide a platform for researchers to archive and share their scholarly works without financial, legal, or technical barriers. Academic libraries play a vital role in establishing and maintaining open access repositories, thereby enhancing the visibility and impact of institutional research output.

Concept of Open Access Repositories

An Open Access Repository is a digital archive that stores and provides free online access to scholarly content such as journal articles, theses, dissertations, conference papers, book chapters, and research data. These repositories follow open access principles and allow users to read, download, copy, distribute, and use the content with proper attribution.

Open access repositories support long-term preservation of digital content and ensure global access to knowledge. Most repositories are interoperable and use standard metadata protocols such as OAI-PMH (Open Archives Initiative–Protocol for Metadata Harvesting).

Types of Open Access Repositories

Institutional Repositories

Institutional repositories are maintained by universities or research institutions to collect and showcase their academic output. They include faculty publications, student theses, research reports, and conference proceedings.

Subject or Disciplinary Repositories

These repositories focus on specific subject areas and are widely used by researchers across the world. Examples include arXiv for physics and computer science and PubMed Central for biomedical sciences.

National Repositories

National repositories collect research output at the country level. In India, Shodhganga is a major national repository for electronic theses and dissertations.

Data Repositories

Data repositories store research datasets for reuse, verification, and further analysis. Examples include Zenodo and Figshare.

Objectives of the Study

The objectives of this paper are

- To explain the concept of open access repositories
- To identify the types of open access repositories
- To highlight the role of libraries in managing repositories
- To discuss the benefits and challenges of open access repositories

Methodology

The study is **descriptive in nature** and is based on a **review of secondary sources** such as journal articles, conference papers, books, and online resources related to open access repositories.

Role of Libraries in Open Access Repositories

Academic libraries play a crucial role in the development and sustainability of open access repositories. The major responsibilities of libraries include:

- Planning and implementing institutional repositories
- Selecting appropriate repository software such as DSpace or EPrints
- Creating and maintaining metadata standards
- Training faculty members on self-archiving practices
- Promoting awareness of open access benefits
- Ensuring long-term digital preservation

Libraries act as facilitators of scholarly communication and support institutional research visibility through open access initiatives.

Benefits of Open Access Repositories

Open access repositories offer several advantages:

- Free and unrestricted access to scholarly content
- Increased visibility and citation impact of research
- Preservation of institutional intellectual output
- Support for teaching, learning, and research
- Reduction of digital divide in access to information

Challenges of Open Access Repositories

Despite their advantages, open access repositories face certain challenges:

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- Copyright and publisher restrictions
- Lack of awareness among faculty members
- Technical and infrastructure issues
- Need for skilled manpower
- Sustainability and funding concerns

Addressing these challenges requires institutional support, policy frameworks, and continuous user education.

Conclusion

Open Access Repositories have become an essential component of modern academic libraries and scholarly communication systems. They promote equitable access to knowledge, enhance research visibility, and support the global exchange of information. Libraries play a pivotal role in managing and promoting open access repositories and in encouraging faculty participation. With proper policies, infrastructure, and awareness programs, open access repositories can significantly contribute to the advancement of higher education and research.

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Open Access E-Resources: Empowering Researchers through Innovation

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Abstract

Digital technologies' rapid growth has revolutionised the creation, sharing, and consumption of knowledge. One of the most significant developments in scholarly communication is the Open Access (OA) movement, which aims to provide free and unrestricted access to research outputs. Open Access e-resources—such as open journals, institutional repositories, preprint servers, open data platforms, and open educational resources—have become powerful tools for empowering researchers worldwide. This paper explores how OA e-resources support innovation in research by enhancing visibility, accelerating knowledge dissemination, promoting collaboration, and fostering equity in access to information. It also examines the challenges associated with OA, including funding models, quality assurance, and sustainability, and discusses future directions for strengthening the OA ecosystem. The study concludes that open access e-resources have a major impact on creating an inclusive, innovative, and globally connected research environment.

Keywords: Open Access, E-Resources, Scholarly Communication, Innovation, Research Empowerment, Digital Libraries

Introduction

In today's knowledge-driven society, access to timely, reliable, and high-quality information is fundamental to research and innovation. Traditionally, scholarly communication has relied on subscription-based journals and proprietary databases, which often restrict access to those who can afford expensive licences. This model has created significant disparities between well-funded institutions and those with limited resources, particularly in developing countries.

The Open Access (OA) movement emerged in response to existing inequalities. Open access refers to the free, immediate, and unrestricted online availability of scholarly research outputs, such as journal articles, conference papers, theses, datasets, and educational materials. By removing price and permission barriers, OA enables researchers, students, and the general public to access and use knowledge without legal or financial constraints.

With the growth of digital infrastructure and internet connectivity, OA e-resources have become a cornerstone of modern research practices. They provide access to information and promote innovation by enabling faster dissemination of ideas, greater collaboration, and increased transparency. This paper examines how Open Access e-resources empower researchers through innovation, highlighting their role in transforming scholarly communication and supporting sustainable research development.

Concept and Scope of Open Access E-Resources

Open access e-resources encompass a wide range of digital materials that are freely available online. These include:

- **Open Access Journals:** Peer-reviewed journals that provide free access to articles, often supported by institutional funding, grants, or Article Processing Charges (APCs).
- **Institutional Repositories:** Digital archives kept by academic institutions and research centres for the purpose of storing and sharing reports, theses, dissertations, and publications by faculty members.
- **Preprint Servers:** Platforms such as arXiv, bioRxiv, and SSRN where researchers distribute preliminary copies of their work prior to official peer review

- **Open Data Repositories:** Services like Zenodo and Figshare that allow researchers to deposit and share datasets, software, and supplementary materials.
- **Open Educational Resources (OER):** Free teaching and learning materials, including textbooks, lecture notes, and multimedia content.

The scope of OA e-resources extends beyond mere access. They support the entire research lifecycle—from idea generation and literature review to data sharing, publication, and evaluation. By integrating digital tools, metadata standards, and discovery platforms, OA e-resources enhance the visibility, usability, and impact of research outputs.

Role of Open Access in Empowering Researchers

➢ **Democratising Access to Knowledge**

One of the most important contributions of open access is the democratization of knowledge. Researchers from small colleges, rural institutions, and developing regions can access the same high-quality literature as those in elite universities. This reduces information inequality and creates a more level playing field for academic inquiry.

➢ **Enhancing Research Visibility and Impact**

Open access publications typically garner more downloads and citations than subscription-based articles, according to studies. A larger audience, including policymakers, business executives, and interdisciplinary scholars, can access research when it is freely accessible. Increased publicity enhances the academic reputations of researchers and institutions.

➢ **Accelerating Innovation and Discovery**

OA e-resources allow researchers to build on existing knowledge quickly. Immediate access to the latest findings accelerates the research process and reduces duplication of effort. Preprint servers, in particular, enable rapid sharing of ideas, fostering early feedback and collaboration.

➢ **Promoting Collaboration and Interdisciplinary Research**

Open platforms encourage global and interdisciplinary collaboration. Researchers can easily connect with peers across countries and disciplines, leading to innovative approaches and solutions to complex problems.

➢ **Supporting Transparency and Reproducibility**

Open Access promotes open science practices by encouraging the sharing of data, methods, and software. This transparency enhances the credibility of research and allows others to verify and build upon published work.

Innovation in the OA Ecosystem

Innovation is at the heart of the OA movement. Several technological and organizational developments have strengthened OA e-resources:

- **Digital Publishing Platforms:** Tools like Open Journal Systems (OJS) streamline the editorial and publishing workflow for OA journals.
- **Metadata and Indexing Services:** Platforms such as DOAJ and Google Scholar improve the discoverability of OA content.
- **AI-Based Discovery Tools:** Artificial intelligence helps researchers find relevant OA literature more efficiently.

- **Open Peer Review Models:** Innovative review practices enhance transparency and accountability in scholarly communication.
- **Altmetrics:** New metrics assess research impact beyond citations, including social media and policy engagement.

These innovations ensure that OA e-resources are not only accessible but also integrated into the digital research ecosystem.

Benefits of Open Access E-Resources

1. Free and immediate access to scholarly content.
2. Increased research visibility and citation impact.
3. Greater equity in global knowledge sharing.
4. Enhanced collaboration and networking.
5. Faster dissemination of research findings.
6. Support for teaching, learning, and lifelong education.
7. Encouragement of open science and reproducibility.

Challenges and Limitations

Despite its advantages, open access faces several challenges:

- **Funding and Sustainability**

  Many OA journals rely on Article Processing Charges (APCs), which may be unaffordable for some researchers. Sustainable funding models are essential to ensure long-term viability.

- **Quality Control and Predatory Journals**

  The rise of predatory publishers threatens the credibility of OA. These journals exploit the OA model without proper peer review. Awareness and careful evaluation are needed to maintain quality standards.

- **Awareness and Skills**

  Some researchers lack awareness of OA options or the skills needed to use digital platforms effectively. Training and library support are crucial.

- **Technical Infrastructure**

  Reliable internet access and digital tools are necessary to benefit fully from OA e-resources. In some regions, infrastructure limitations remain a barrier.

Role of Libraries and Institutions

Academic libraries play a key role in promoting and managing OA e-resources. They support researchers by:

- Establishing and maintaining institutional repositories.
- Providing training on OA publishing and copyright issues.
- Assisting with data management and open science practices.
- Advocating for institutional and national OA policies.

Libraries thus act as facilitators of innovation and access in the research environment.

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Indian Context and Global Relevance

In India and other developing countries, OA e-resources are particularly valuable for supporting research in resource-constrained institutions. National initiatives, such as open repositories and government-funded OA platforms, enhance access to scholarly literature. By embracing OA, countries can strengthen their research capacity and contribute more effectively to global knowledge production.

Future Directions

The future of Open Access lies in:

- Developing sustainable, inclusive funding models.
- Strengthening quality assurance mechanisms.
- Integrating OA with open data and open education.
- Expanding AI-driven discovery tools.
- Promoting policy support at institutional and national levels.

These steps will ensure that OA e-resources continue to empower researchers through innovation.

Conclusion

Open Access e-resources have revolutionized scholarly communication by removing barriers to information and enabling equitable, transparent, and collaborative research. Through innovation in digital publishing, discovery tools, and open science practices, OA empowers researchers to access, share, and build upon knowledge more effectively. While challenges related to funding, quality, and infrastructure remain, the continued commitment of institutions, libraries, policymakers, and researchers will ensure that Open Access remains a vital force in shaping the future of research. Ultimately, Open Access e-resources are not just tools for information access—they are catalysts for innovation and global knowledge empowerment.

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Open Educational Resources and Their Impact on Digital Libraries

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Abstract

The rapid expansion of Open Educational Resources (OER) has transformed the landscape of knowledge creation, access, and dissemination in the digital age. As academic institutions increasingly adopt open and collaborative models of learning, digital libraries have emerged as critical infrastructures supporting the integration, curation, and long-term preservation of OER. This paper examines the multifaceted impact of OER on digital libraries, focusing on their role in enhancing accessibility, promoting resource sharing, and fostering inclusive learning environments. The study highlights how digital libraries leverage OER to broaden academic participation, reduce economic barriers, and support lifelong learning through open, interoperable platforms. Furthermore, it explores the challenges associated with metadata standards, intellectual property management, digital preservation, and quality assurance within OER-driven library ecosystems. By analyzing current trends and institutional practices, this article underscores the transformative potential of OER in strengthening the effectiveness, reach, and sustainability of digital libraries. The findings aim to inform policymakers, library professionals, and educators about emerging opportunities for collaboration and innovation in the evolving digital knowledge landscape.

Keywords: Digital Libraries, Open Access, Educational Technology, Library Innovation

Introduction

The emergence of Open Educational Resources (OER) has significantly reshaped the global educational and information landscape, ushering in new possibilities for equitable learning and unrestricted access to knowledge. Defined as freely accessible, openly licensed teaching, learning, and research materials, OER empower institutions, educators, and learners to collaborate, innovate, and share educational content without the limitations imposed by traditional copyright structures. As the demand for inclusive and flexible learning models continues to grow, especially in the context of digital transformation, OER have become integral to educational ecosystems across the world.

Digital libraries play a pivotal role in connecting diverse user communities with high-quality information resources, fostering a culture of openness and lifelong learning. The integration of OER into digital library systems has further broadened the libraries' mandate, transforming them into hubs for open access, scholarly communication, and resource sharing on a global scale.

Through advanced metadata standards, interoperable technologies, and user-centric services, digital libraries enhance the discoverability and sustainability of OER, ensuring that educational materials remain accessible, adaptable, and relevant to evolving academic needs. Moreover, the successful integration of OER depends on institutional policies, technical infrastructure, faculty engagement, and collaborative networks that support open knowledge practices.

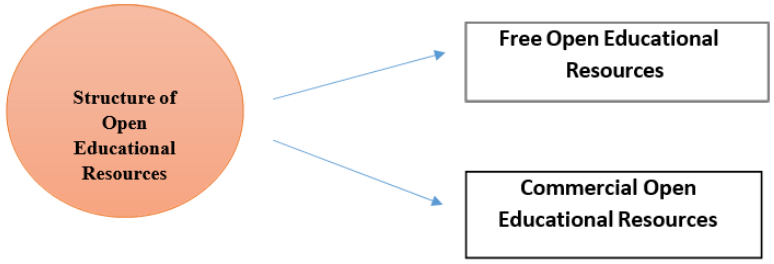
This paper explores the significant impact of OER on digital libraries, highlighting how these open resources contribute to the democratization of education, reduction of learning barriers, and expansion of knowledge access. By examining current trends, operational challenges, and emerging opportunities, the study aims to offer insights into how digital libraries can effectively leverage OER to create sustainable, inclusive, and innovative learning environments. The discussion underscores the evolving role of libraries in an era defined by digital growth, open access movements, and the increasing demand for high-quality educational resources.

Structures of Open Educational Resources

The structure of open educational resources has contained two methods. There are free open educational resources and commercial open educational resources.

Free Open Educational Resources

Free Open Educational Resources consist of educational materials that are made available without any cost to learners and educators. These resources can be used for the impoverished learners. These resources are usually supported by educational institutions, governments, or non-profit organizations and are published under open licenses that allow free use, modification, and sharing. Their structure focuses on open access, learner flexibility, and knowledge sharing, making education more inclusive and affordable.



Commercial Open Educational Resources

Commercial open educational resources' refers to educational materials that are openly licensed and can be used for commercial purposes while still supporting income through additional services. These resources often include well-designed textbooks, digital learning platforms, and structured course content where the basic material is freely accessible, but extra features like certificates, advanced tools, or technical assistance require payment. The structure of commercial OER combines openness with financial sustainability, helping organizations and publishers maintain content quality and provide regular updates.

Merits of Open Educational Resources

The integration of Open Educational Resources (OER) into digital libraries offers several significant advantages that strengthen the educational and information landscape. One of the foremost merits is the democratization of knowledge, as OER remove financial, geographical, and institutional barriers that traditionally limit access to high-quality learning materials. By providing freely accessible and openly licensed resources, digital libraries ensure that students, educators, and independent learners from diverse backgrounds can engage with scholarly content without restrictions. This enhances academic equity and promotes inclusive learning environments.

Furthermore, OER enhance the role of digital libraries as centres of open knowledge, supporting lifelong learning, professional development, and global academic collaboration. By integrating OER, digital libraries expand their service capabilities, foster research innovation, and support the open access movement that is reshaping higher education worldwide.

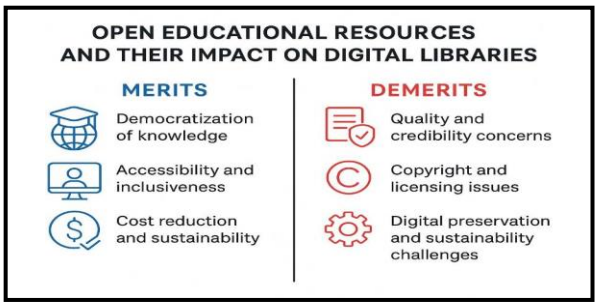
Demerits of Open Educational Resources

The integration of Open Educational Resources (OER) into digital libraries presents several challenges that require careful consideration. One of the primary concerns is the variation in content quality. Since OER can be created and shared by individuals with differing levels of expertise, not all materials undergo rigorous peer review or academic validation.

Digital libraries must therefore ensure adequate guidance on licensing practices to avoid legal and ethical complications. Additionally, issues of **digital preservation and sustainability** arise, as the continuous updating, storage, and management of OER demand technical infrastructure, financial investment, and long-term planning.

Technical concerns such as **metadata inconsistencies**, version control, and interoperability across diverse platforms further complicate the effective integration of OER. Moreover, limited faculty participation, resistance to adopting new teaching approaches, and gaps in technological skills may hinder the optimal use of

OER within library systems. These challenges highlight the need for institutional support, policy development, and ongoing capacity-building to ensure the successful implementation of OER in digital libraries.



Open Educational Resources

Types of OER Figures

Types and Formats of OER: Open educational resources are of various types, such as open courseware, open access journals, open access books, open access repositories, preprints, open access theses and dissertations, open textbooks, digital learning, and so on. Margulies (2005) categorizes the types of Open Educational Resources, as shown in Figure 1.

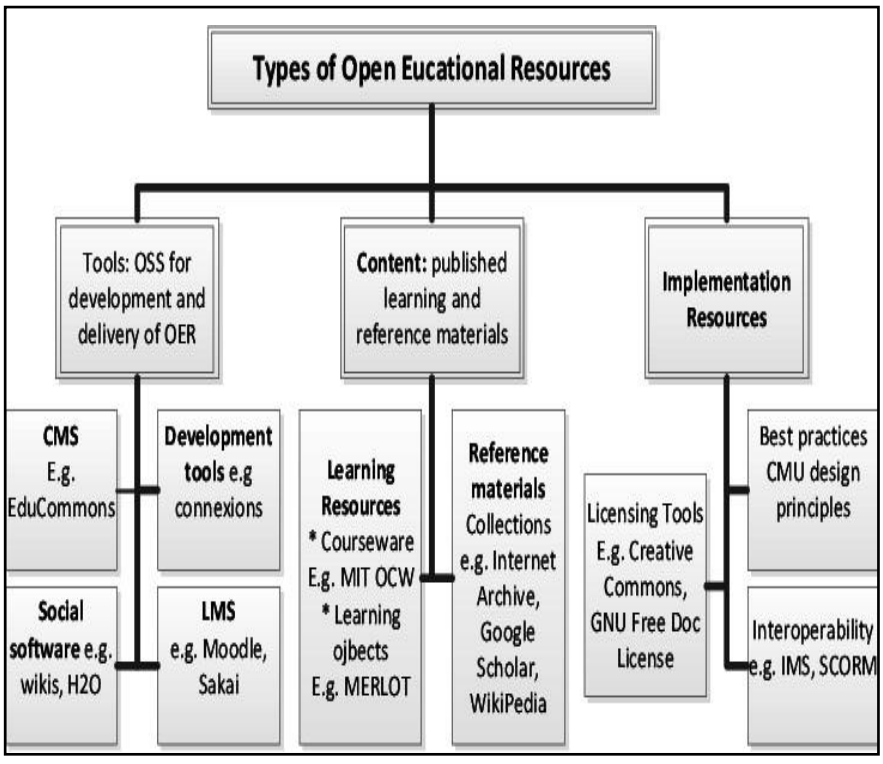


Figure 1: ***Types of Open Educational Resources***

Formats of OER

There are various open educational resource formats; they are available in the public domain or released under open license as texts, images, audio, audio-visual, animation, quizzes, games, software, and so on.

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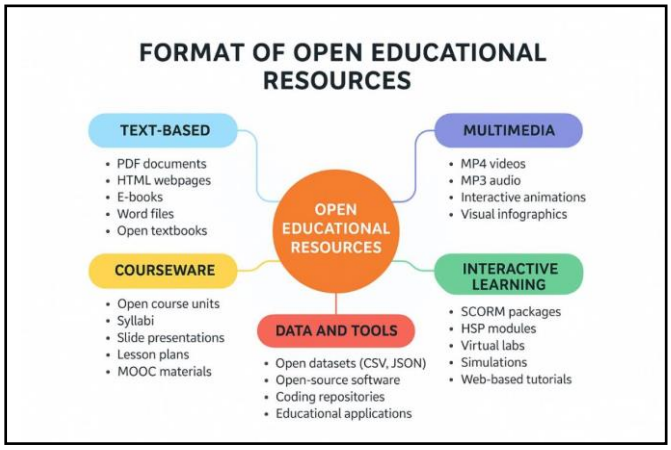


Figure 2: ***Formats of Open Educational Resources***

Conclusion

Open Educational Resources (OER) have reshaped digital libraries by making high-quality knowledge freely accessible to learners worldwide. They remove financial and geographic barriers, supporting inclusive education and lifelong learning. Digital libraries act as essential platforms for organising, preserving, and sharing these resources, allowing users to easily find and use educational content.

However, integrating OER comes with challenges, such as ensuring content quality, protecting intellectual property, and maintaining long-term digital preservation. Overcoming these issues requires strong policies, effective technology, and skilled library staff. When managed well, the combination of OER and digital libraries promotes collaboration, academic growth, and equal access to knowledge, establishing them as key pillars of modern education.

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Open Access Resources in the Stream of Engineering and Technology

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Abstract

Information is inherently dynamic and continuously evolving across all fields, making its effective communication vital for societal progress. Every piece of information, whether published or unpublished, contributes to the advancement of human life. In particular, Engineering and Technology are disciplines characterized by rapid innovation, necessitating constant access to a wide range of resources for ongoing research and development. However, financial limitations and physical space constraints often hinder individual libraries from subscribing to the full spectrum of print information resources. In response, electronic resources (e-resources) have emerged as a practical solution, enabling the sharing and dissemination of published research papers to a broad audience. The adoption of open-access policies by many publishers further expands access, allowing information seekers worldwide to benefit from the latest advancements in these fields. This study seeks to provide a comprehensive overview of open resources available for the Engineering and Technology disciplines, highlighting key platforms and repositories that support research and knowledge sharing.

INTRODUCTION

Innovation and the creation of new knowledge are crucial for transforming India into a knowledge superpower. Under the leadership of Prime Minister Shri Narendra Modi, India has introduced the National Education Policy 2020. This policy aims to establish an education system deeply rooted in Indian values, with the goal of transforming India into a global knowledge superpower by ensuring high-quality education for all.

As we progress toward the vision of "Viksit Bharat @ 2047," there is a growing demand for technical education—including engineering and technology programs—and for qualified professionals in various industries and corporations. These programs have consistently demonstrated positive learning outcomes, such as enhanced creativity, innovation, critical thinking, and problem-solving skills. To meet these evolving challenges, technical education institutes require well-resourced libraries and information centers.

The emergence of new disciplines has prompted a more thorough evaluation of educational resources. Whenever a new subject arises, it generates significant information in various formats. To effectively assess these emerging areas, an updated library is essential for supporting research. With advances in information and communication technology (ICT), information is now disseminated through both print and electronic channels. However, the overwhelming volume of available information, coupled with financial constraints and limited space, makes it impossible to purchase all printed resources. Additionally, the cost of paid electronic journals is often prohibitively high.

To address these challenges, open access has emerged as an essential solution, ensuring that researchers do not miss out on critical information. Open access is a popular publishing model for scholarly communication of research outputs, including articles, papers, books, and chapters. According to Kamalon and Mon (2022), a publication is considered open access when there are no financial, legal, or technical barriers to accessing the information. This means anyone can read, download, copy, distribute, print, search for, and explore the information, and use it for educational or other legally permitted purposes.

Open Access

The term "open access" was first introduced in 2001 with the launch of the Budapest Open Access Initiative by the Open Society Institute. This initiative sought to develop recommendations for providing the public with unrestricted, free access to scholarly research. Open access is a model of scholarly publishing in which information resources are made available online in digital format, at no cost, and with minimal copyright

or licensing restrictions. Benjamin, Sivaram, and Shanmugam (2023) emphasize that open-access resources are dedicated to delivering authentic and reliable scientific contributions to their communities through innovative approaches. These resources were developed to create a trustworthy platform for unrestricted access to scientific literature, enabling the rapid dissemination of recent advances across various fields of science and technology.

JSTOR identifies four core principles of open access: Free access ensures that knowledge is available to everyone, regardless of financial means. Reuse and redistribution – open access encourages the use, remixing, and redistribution of content, fostering creativity and innovation. Transparency – making scholarly work freely accessible enhances transparency in research. Long-term preservation – repositories are committed to preserving content for future generations, ensuring ongoing accessibility.

Types of Open Access

Open access refers to free and permanent access to published research, accompanied by clear guidelines for sharing and reuse. There are several types of open access, each with distinct features:

1. Gold Open Access

Gold open access involves publishing scholarly work in open-access journals or platforms, where the final, published version is made freely available to everyone immediately upon publication. Authors or their institutions typically pay Article Processing Charges (APCs) to the publisher. The publishing process resembles that of traditional journals, but the content is accessible to all readers without paywalls.

2. Green Open Access

Green open access, also known as "self-archiving," allows authors to deposit a version of their work (pre-print or post-print) in an institutional repository or on a personal website. Access may be subject to an embargo period set by the publisher, after which the work becomes freely available. This model does not usually require payment of APCs.

3. Hybrid Open Access

Hybrid open access journals offer both subscription-based and open-access publishing options. Authors can choose to make their article openly accessible by paying an APC, even though the journal as a whole is not fully open access. This can result in authors or institutions paying both subscription fees and APCs.

4. Diamond (or Platinum) Open Access

Diamond open access journals provide free access to readers and do not charge authors any publication fees. These journals are typically funded by institutions, societies, or government organizations. While they may not always have high impact factors, their peer review standards remain rigorous.

5. Bronze Open Access

Bronze open access refers to articles made freely available on the publisher's website, but without a clearly stated open license for reuse. Access may be temporary or subject to change at the publisher's discretion. Open access is a key component of open science, aiming to democratize access to knowledge and promote equity in scholarly publishing. While Gold and Hybrid models often involve APCs, Green and Diamond models offer APC-free alternatives, providing more accessible options for researchers worldwide.

Advantages of Open Access Resources:

Open-access resources are highly beneficial for researchers, as they can be accessed from anywhere in the world at any time. This unrestricted accessibility leads to greater visibility for research work, increasing both readership and citation rates. According to Shah (2021), making information and ideas freely available enhances research output, education, public enrichment, and economic growth. Huang et al. (2024) further note that open access promotes interdisciplinary citation and research, encourages broader collaboration, and removes price

barriers. Heller (2013) also highlights that open access resources provide up-to-date literature to readers, allowing for a quicker impact on society.

Disadvantages of Open Access Resources:

Despite these advantages, open-access resources also present certain challenges. Free availability can introduce hidden barriers, such as concerns about the quality and credibility of publications. Researchers and academics invest significant effort in their work, and ensuring that it reaches the right audience through reputable channels remains important. While open access eliminates price barriers for users, authors often face substantial article processing and publication fees. Additionally, some authors are concerned that the open-access publishing model, being relatively new, may result in lower citation counts, reduced impact factors, and less control over predatory publishing practices.

Here is a curated list of open access resources in Engineering and Technology disciplines, with brief descriptions and links:

1. IEEE Xplore

The Institute of Electrical and Electronics Engineers (IEEE) is a leading publisher in technology, offering access to high-quality scholarly journals and conference proceedings. IEEE supports gold and hybrid open access publishing. Access IEEE Xplore

2. Springer Open Access

Springer is a global research publisher offering open access journals and books across a wide range of subjects. All open access content is peer-reviewed and permanently available. Access Springer Open

3. IET Journals

Published by the UK-based Institute of Engineering & Technology, IET journals cover electrical, electronics, computing, and communication technology. These are open access and peer-reviewed. Access IET Journals

4. Science Direct Open Access

Elsevier's ScienceDirect provides over 1,500 open access journals, including 400 in engineering and technology, all subject to rigorous peer review. Access ScienceDirect

5. DOAJ (Directory of Open Access Journals)

DOAJ indexes over 21,000 peer-reviewed open access journals, with more than 5,000 in science and technology. Access DOAJ

6. CSIR-NIScPR

The National Institute of Science Communication and Policy Research (NIScPR, India) publishes 19 peer-reviewed journals and other science and technology resources. Access CSIR-NIScPR

7. PDF Drive

PDF Drive provides free downloads of millions of eBooks, though copyright status on some works may be unclear. Access PDF Drive

8. DOAB (Directory of Open Access Books)

DOAB indexes peer-reviewed academic books and chapters, with over 94,000 eBooks and 5,000+ in engineering and technology. Access DOAB

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9. eKumbh

eKumbh provides outcome-based technical education books in multiple Indian languages, supporting NEP2020 goals. Access eKumbh

10. NDLI (National Digital Library of India)

NDLI is a virtual repository of learning resources, including books, articles, standards, and more, available for free to registered users. Access NDLI

11. NPTEL Resources

NPTEL offers web and video-based courses from India's IITs and IISc in engineering, science and management. Access NPTEL

These resources are invaluable for students, researchers, and professionals in engineering and technology, providing free access to high-quality academic materials.

CONCLUSION

Due to the significant increase in subscription rates for both print and electronic information resources, libraries today face considerable challenges in providing users with adequate access and availability. Open-access resources offer a promising solution to this dilemma. By enabling unrestricted online access to scholarly materials, open-access resources streamline the research process and facilitate the wide dissemination of information without barriers.

These resources play a critical role in research communication, support interdisciplinary collaboration, and contribute to the advancement of knowledge across fields. However, the use of open-access resources is not without drawbacks. Issues such as inconsistent quality control and substantial article processing charges remain significant concerns.

Despite these challenges, the continued growth and adoption of open-access resources are vital for ensuring equitable and efficient access to scholarly information in the modern research landscape.

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Role of Semantic Scholar in Enhancing Scholarly Communication: A Theoretical Perspective

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Abstract

The unprecedented expansion of scholarly literature has intensified challenges associated with information discovery, accessibility, and evaluation of research influence. Scholarly communication, which encompasses the generation, dissemination, and assessment of academic knowledge, increasingly relies on advanced digital infrastructures. Semantic Scholar, an artificial intelligence–enabled academic search platform, has emerged as a prominent tool designed to enhance scholarly communication through semantic search capabilities and citation intelligence. This paper presents a theoretical examination of the role of Semantic Scholar in strengthening scholarly communication. It analyses the conceptual foundations of scholarly communication, reviews the transformation of academic search systems, and critically examines the AI-driven features of Semantic Scholar that support efficient literature discovery and research impact assessment. The paper further discusses the strengths and inherent limitations of the platform and outlines its implications for researchers and library and information professionals. The study concludes that Semantic Scholar represents a significant advancement in academic search technologies, contributing meaningfully to the effectiveness of scholarly communication in the digital research ecosystem.

Keywords: Scholarly Communication, Semantic Scholar, Academic Search Systems, Artificial Intelligence, Citation Analysis

Introduction

Scholarly communication forms the backbone of academic knowledge creation and dissemination, serving as the primary mechanism through which research ideas, findings, and innovations are exchanged among scholars. It encompasses the entire lifecycle of research outputs, including the creation, validation through peer review, dissemination via publications, preservation in digital repositories, and eventual utilization by the academic and research community. Effective scholarly communication ensures the credibility, accessibility, and continuity of knowledge across disciplines.

In recent years, the exponential growth of scholarly literature has significantly intensified challenges related to information overload. Researchers often face difficulties in identifying relevant studies, evaluating the quality and credibility of research outputs, and measuring the impact of scholarly work. Traditional information retrieval systems, which rely largely on keyword-based searching and manual filtering, are increasingly inadequate in addressing these complexities. As a result, the need for advanced tools that support efficient discovery, relevance determination, and impact assessment has become critical in the modern research environment.

Advancements in artificial intelligence (AI) have brought transformative changes to scholarly information retrieval by introducing capabilities such as semantic understanding of research content, intelligent ranking of search results, and sophisticated citation analysis. AI-driven systems can interpret the contextual meaning of research papers, identify relationships among concepts, and provide insights into research trends and influence. These innovations enhance the precision and efficiency of academic search processes, thereby supporting informed decision-making by researchers.

Semantic Scholar, developed by the Allen Institute for Artificial Intelligence, represents a significant advancement in this domain. By leveraging AI techniques such as natural language processing, machine learning, and citation network analysis, Semantic Scholar improves research discovery and scholarly evaluation. It enables users to identify influential papers, understand key concepts, track citation contexts, and assess research impact beyond traditional metrics. This paper therefore undertakes a theoretical analysis of the role of Semantic Scholar in strengthening scholarly communication within the contemporary digital research

ecosystem, highlighting its contributions to improving accessibility, relevance, and evaluation of academic knowledge.

Objectives of the Study

1. To examine the concept and significance of scholarly communication in the contemporary academic environment.
2. To analyze the impact of artificial intelligence on scholarly information retrieval and research dissemination.
3. To study the features and functionalities of Semantic Scholar as an AI-driven academic search platform.
4. To assess the role of Semantic Scholar in improving research discovery, relevance determination, and access to scholarly literature.
5. To explore how Semantic Scholar supports the evaluation of research impact through citation and influence indicators.
6. To evaluate the contribution of Semantic Scholar in reducing information overload among researchers.

Scholarly Communication

Scholarly communication refers to the systematic and structured process through which academic knowledge is generated, shared, evaluated, and preserved within the scholarly community. It involves a wide range of interconnected activities, including the creation of research outputs, peer review, journal and conference publishing, citation and referencing practices, and mechanisms for assessing research quality and impact. Through these processes, scholarly communication ensures that new knowledge is validated, disseminated to relevant audiences, and integrated into the existing body of academic literature.

Traditionally, scholarly communication relied heavily on print-based systems such as books, printed journals, and physical conference proceedings. While these formats provided authoritative and permanent records of scholarship, they were often limited by high costs, restricted access, slow dissemination, and geographical barriers. The shift toward digital and web-based platforms has transformed scholarly communication by significantly increasing the speed, visibility, and global reach of research outputs. Online journals, institutional repositories, preprint servers, and academic databases now allow researchers to share findings more rapidly and access a broader range of literature with greater ease.

However, this digital transformation has also introduced several challenges. The exponential growth of scholarly publications has made it increasingly difficult for researchers to identify relevant and high-quality studies. Issues related to information overload, predatory publishing, inconsistent peer-review standards, and fragmented indexing systems pose serious concerns for maintaining academic credibility. Additionally, measuring research impact has become more complex, as traditional metrics such as citation counts are supplemented—or sometimes challenged—by alternative indicators like usage statistics and online engagement.

In this evolving environment, effective scholarly communication depends on robust tools and systems that support not only access to information but also the evaluation of relevance, credibility, and scholarly influence. Academic search systems play a pivotal role in this context by acting as primary gateways to scholarly knowledge. These systems assist researchers in discovering relevant literature, understanding citation relationships, assessing the influence of research outputs, and navigating vast digital collections. By enhancing discoverability, contextual understanding, and impact assessment, academic search platforms contribute significantly to the efficiency, transparency, and overall effectiveness of scholarly communication.

Transformation of Academic Search Systems

Academic search systems have undergone significant transformation in response to the exponential growth of scholarly literature and the increasing complexity of research needs. Early academic retrieval systems were primarily designed around bibliographic databases that depended on structured metadata such as author names, titles, subject headings, and publication details. These systems largely employed keyword-based

matching techniques, which, while effective for basic information retrieval, often produced extensive result sets with limited contextual relevance. As a consequence, researchers were required to manually filter results, increasing the time and cognitive effort needed to identify high-quality and influential research. Moreover, such traditional systems offered minimal analytical capabilities for assessing scholarly impact, citation relationships, or thematic trends within a discipline.

With advancements in computational technologies, contemporary academic search platforms have increasingly integrated artificial intelligence (AI) methodologies to address these limitations. Techniques such as natural language processing (NLP) enable systems to understand the semantic meaning of search queries rather than relying solely on exact keyword matches. Machine learning algorithms further enhance retrieval by learning from user interactions, citation patterns, and document structures to improve relevance ranking. These developments allow modern systems to deliver more precise, context-aware search results and to support advanced features such as topic modeling, automated summarization, and recommendation of related works.

Semantic Scholar exemplifies this new generation of academic search systems by shifting the focus from mere keyword frequency to contextual relevance and scholarly influence. By leveraging AI-driven citation analysis and semantic understanding, the platform identifies influential papers, highlights key concepts, and surfaces meaningful connections among research outputs. This approach not only reduces information overload but also enhances researchers' ability to evaluate the significance and impact of scholarly work efficiently. Consequently, the transformation of academic search systems—from metadata-driven retrieval to intelligent, semantic-based discovery—marks a crucial advancement in supporting effective scholarly communication in the digital research ecosystem.

Semantic Scholar: Overview

Semantic Scholar is a free, AI-driven academic search engine developed by the Allen Institute for Artificial Intelligence with the objective of improving access to and understanding of scholarly literature. It is designed to support researchers, academicians, and students by providing efficient tools for discovering relevant research outputs across a wide range of disciplines, including science, technology, medicine, social sciences, and the humanities. By indexing a vast and continually expanding corpus of scholarly publications, Semantic Scholar addresses the growing complexity of navigating modern academic literature.

A distinguishing feature of Semantic Scholar is its use of artificial intelligence to move beyond traditional keyword-based searching. Through semantic search functionality, the platform interprets the contextual meaning of search queries and research documents, enabling more accurate retrieval of relevant literature. This approach allows users to identify conceptually related studies even when exact keywords are not used, thereby improving the precision and depth of research discovery.

Semantic Scholar also provides citation-based and influence indicators that help users assess the significance and impact of scholarly works. Rather than relying solely on raw citation counts, the platform highlights influential citations, identifies highly impactful papers, and analyzes citation contexts to show how and why a work has been cited. These features enable researchers to evaluate the quality and relevance of research outputs more effectively and to understand their contribution within a broader scholarly framework.

In addition, the platform offers comprehensive author profiles that consolidate publications, citation metrics, research interests, and collaboration networks. Author disambiguation techniques ensure accurate attribution of works, helping users track the scholarly contributions of individual researchers and institutions. Semantic Scholar further enhances research efficiency through AI-based recommendation systems that suggest relevant papers, emerging topics, and related authors based on user interests and reading behavior.

Collectively, these features are designed to reduce information overload, streamline the research process, and improve the accessibility of scholarly knowledge. By facilitating efficient discovery, evaluation, and contextual understanding of academic literature, Semantic Scholar plays a significant role in strengthening scholarly communication processes within the contemporary digital research environment.

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AI-Driven Features Supporting Scholarly Communication

Semantic Scholar integrates several AI-based mechanisms that contribute to enhanced scholarly communication:

1. **Semantic Search Capability:** The semantic search function enables contextual interpretation of user queries, allowing the system to retrieve conceptually relevant literature rather than relying solely on keyword matches.
2. **Citation Analysis and Influence Metrics:** Citation counts and influential citation indicators assist researchers in assessing the academic significance and impact of scholarly works, supporting informed research evaluation.
3. **Author and Publication Profiles:** Detailed author and publication profiles enhance transparency in scholarly assessment and facilitate identification of prominent contributors and emerging research trends.
4. **Intelligent Recommendation Systems:** AI-driven recommendations support discovery of related and emerging research, fostering interdisciplinary knowledge exchange and research continuity.
5. **Automated Relevance Ranking:** AI ranks research articles based on relevance, citations, and research trends. It also recommends related papers and authors, helping scholars stay updated in their field.
6. **Content Summarization and Knowledge Extraction:** AI automatically summarizes research articles and highlights key points such as objectives, methods, and findings. This saves time during literature review.
7. **Author and Collaboration Analysis:** AI identifies leading authors, institutions, and research collaborations. This supports academic networking and interdisciplinary research.
8. **Quality and Credibility Assessment:** AI assists in evaluating the reliability of journals and articles by analyzing publication and citation patterns, helping researchers avoid unreliable sources.
9. **Multilingual Access and Inclusivity:** AI supports access to scholarly content across different languages, reducing language barriers and promoting global scholarly communication.

Contribution of Semantic Scholar to Scholarly Communication

Semantic Scholar is an AI-powered academic search engine that has made significant contributions to the advancement of scholarly communication in the digital research environment. By integrating artificial intelligence, machine learning, and data analytics, Semantic Scholar enhances the way scholarly information is discovered, evaluated, and disseminated among researchers.

1. **Enhanced Literature Discovery:** Semantic Scholar improves the discovery of scholarly literature by moving beyond traditional keyword-based search mechanisms. Its semantic analysis identifies the conceptual meaning of research content, enabling researchers to locate relevant studies more accurately. This contributes to more effective knowledge sharing and reduces the time required to identify significant academic work.
2. **Reduction of Information Overload:** The exponential growth of research publications poses a challenge to scholarly communication. Semantic Scholar addresses this issue by prioritizing results based on relevance and influence rather than sheer quantity. By highlighting highly influential papers and citations, it helps researchers focus on quality research, thereby improving communication efficiency.
3. **Improved Citation and Impact Analysis:** Citations are fundamental to scholarly communication as they demonstrate intellectual influence and research continuity. Semantic Scholar enhances citation analysis by identifying “influential citations” that contribute substantially to the cited work. This enables a deeper understanding of research impact and strengthens academic discourse.

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4. **Support for Research Transparency and Context:** Semantic Scholar extracts key figures, tables, methods, and abstracts, allowing users to quickly assess the relevance and credibility of research. This contextual presentation promotes transparency and improves comprehension, facilitating meaningful scholarly communication.
5. **Promotion of Interdisciplinary Research:** By linking related concepts across disciplines, Semantic Scholar fosters interdisciplinary scholarly communication. Its recommendation system encourages researchers to explore relevant work beyond their core field, supporting innovation and cross-disciplinary collaboration.
6. **Increased Research Visibility:** Semantic Scholar enhances author visibility through detailed author profiles that consolidate publications, citations, and research interests. This contributes to effective scholarly networking and ensures wider dissemination of research outputs.
7. **Support for Open Scholarly Communication:** As a freely accessible platform, Semantic Scholar promotes open access to scholarly information. By reducing reliance on subscription-based databases, it democratizes access to research knowledge and supports equitable scholarly communication.
8. **Contribution to Research Efficiency and Quality:** Through AI-driven summaries, relevance ranking, and citation insights, Semantic Scholar improves research efficiency and supports higher-quality academic output. Researchers can make informed decisions, build upon credible sources, and communicate findings more effectively.

Strengths

Advanced AI-Based Semantic Relevance Ranking: Semantic Scholar employs advanced artificial intelligence techniques to analyze the meaning and context of search queries rather than relying solely on keyword matching. This semantic understanding enables the system to identify research articles that are conceptually relevant to a user's topic. As a result, researchers can quickly locate highly relevant literature, reducing search time and improving the quality of scholarly communication.

Comprehensive Citation and Influence Indicators: The platform provides detailed citation metrics, including citation counts, influence scores, and impact indicators. These tools allow users to evaluate the academic significance, credibility, and research influence of articles, authors, and journals. By offering deeper insights into citation behavior, Semantic Scholar supports informed decision-making and strengthens the evaluation process within scholarly communication.

Open and Free Access to Scholarly Literature: Semantic Scholar offers free access to a vast collection of scholarly publications, removing financial barriers commonly associated with academic databases. This open access model promotes equal and inclusive scholarly communication by enabling students, researchers, and institutions with limited resources to access high-quality academic content.

Intuitive and Research-Oriented User Interface: The user interface of Semantic Scholar is designed to meet the specific needs of researchers. With clear search filters, organized result displays, and easy navigation, users can efficiently explore and manage scholarly literature. This intuitive design enhances research productivity and supports seamless scholarly communication.

Support for Scholarly Communication and Knowledge Sharing: Semantic Scholar strengthens scholarly communication by improving literature discovery, citation tracking, and research visibility. Librarians can use it to guide users in identifying credible sources and understanding research trends.

Limitations

Uneven Disciplinary Coverage: Semantic Scholar does not offer uniform coverage across all academic disciplines. While it has strong representation in fields such as computer science, medicine, and engineering, coverage in the humanities and certain social science domains is comparatively limited. This uneven coverage can restrict comprehensive literature discovery for researchers working in underrepresented fields.

Dependence on Algorithmic Ranking: The platform relies heavily on artificial intelligence algorithms to rank search results and determine relevance and influence. Although this improves efficiency, algorithmic judgments may not always align with expert human evaluation. Important but less-cited works may receive lower visibility, while some less relevant articles may be ranked higher.

Limited Transparency of Metrics and Ranking Methods: Semantic Scholar provides citation counts and influence indicators but does not fully disclose the methodologies used to calculate these metrics. The lack of transparency makes it difficult for users to critically assess how rankings are determined and how influence scores are computed.

Incomplete Coverage of Non-English Literature: The majority of content indexed by Semantic Scholar is in English. Research published in regional or non-English languages is often underrepresented, limiting the platform's effectiveness for global and multilingual scholarly communication.

Possible Data Quality and Metadata Issues: The accuracy of search results and citation analysis depends on the quality of indexed metadata. Incomplete records, incorrect author attribution, or missing citations can affect the reliability of search outcomes and impact assessment.

Limited Advanced Search Customization: Compared to some subscription-based academic databases, Semantic Scholar offers fewer advanced search and filtering options. This may restrict highly specialized or complex literature searches required for in-depth systematic reviews.

Overemphasis on Citation-Based Impact: By focusing strongly on citation metrics, the platform may undervalue emerging research, innovative ideas, or niche studies that have not yet accumulated citations. This can influence research visibility and scholarly evaluation.

Implications for Library and Information Professionals

Library and information professionals play a crucial role in supporting and strengthening scholarly communication within academic and research institutions. As the volume of scholarly information continues to grow rapidly, librarians act as intermediaries who help researchers navigate complex information environments and make effective use of available academic resources.

Familiarity with AI-enabled academic search platforms such as **Semantic Scholar** equips library professionals with advanced tools for supporting research activities. These platforms assist librarians in guiding researchers toward relevant and high-quality literature through intelligent search features, citation analysis, and impact indicators. By understanding how AI-driven systems rank and recommend scholarly content, librarians can help users critically evaluate research sources and identify influential studies.

Integrating AI-based academic search tools into **information literacy programmes** enhances users' research skills by teaching them how to search strategically, assess credibility, and interpret citation metrics. Librarians can incorporate demonstrations of AI-powered literature discovery, automated summaries, and citation networks into instructional sessions, enabling students and researchers to conduct more efficient and informed literature reviews.

Overall, the adoption of AI-driven academic search platforms expands the professional role of librarians from traditional information providers to active research facilitators. By embracing these technologies, library and information professionals can enhance the quality, accessibility, and effectiveness of scholarly communication in the digital age.

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Conclusion

The study emphasizes that Semantic Scholar effectively addresses several critical challenges associated with contemporary scholarly communication. The rapid growth of academic publications has resulted in information overload, making it difficult for researchers to identify relevant and high-quality studies. Through AI-driven relevance ranking, semantic search, and automated recommendations, the platform assists users in filtering large volumes of literature and locating influential research more efficiently. The platform represents an important advancement in scholarly information retrieval systems by combining accessibility with analytical depth. Its user-friendly interface and free access further enhance its value for researchers, students, and library professionals. Semantic Scholar plays a substantial role in improving the **accessibility, efficiency, and effectiveness** of scholarly communication in contemporary academic environments. By leveraging artificial intelligence to support literature discovery, impact evaluation, and knowledge synthesis, the platform strengthens the research process and contributes to a more informed, connected, and productive scholarly community.

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The Role of Academic Libraries in Multidisciplinary Research

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Abstract

Over the recent years, multidisciplinary research has been widely appreciated as an effective approach to solving complicated academic and social issues which are impossible to be resolved within the constraints of any single discipline. Scholarly libraries have embraced a new dynamic, strategic role in this shifting research landscape facilitating access to diverse sources of information, encouraging collaborative research methods, enhancing information literacy skills, and managing research data and scholarly communication. In this review paper, the contribution of the academic libraries to multidisciplinary research is examined using the contents of related scholarly literature, institutional publications, and empirical studies. The paper addresses key library-based research services, digital infrastructures, changing roles of librarians and the threats associated with supporting multidisciplinary research. The research comes up with the conclusion that academic libraries no longer serve the functions of custodial ones: they are an inseparable part of the modern research ecosystem.

Keywords: Academic Libraries, Multidisciplinary Research, Research Support Services, Digital Libraries, Information Literacy, Scholarly Communication

Introduction

The nature of research in the modern knowledge society has changed wholly. Contemporary research problems are becoming more complex, interdependent, and global. The problems such as climate change, community health crisis, sustainable development, artificial intelligence, and social inequality must be addressed by the efforts of different academic disciplines of knowledge. This has consequently led to the emergence of the multidisciplinary research as a significant research method in the world universities and research institutions.

The earlier academic libraries played an enabler role of acquiring, cataloguing and made academic material available. However, the multidisciplinary research development has radically transformed the role and purposes of academic libraries. In the present day, libraries are engaged in research such as provision of digital materials, research support service, information literacy training, and research data management support and research environment. This review article attempts to critically comment on how the academic libraries are changing to facilitate multidisciplinary research through a synthesis of the existing literature in addition to evaluating the existing trends and challenges.

Concept and Nature of Multidisciplinary Research

Multidisciplinary research involves academicians in different academic fields working together in a common research problem but with retaining their academic perspective and methodological reasoning (Repko, 2012). This would not entail the importation of theories and methods into one framework as in interdisciplinary research. Instead, it makes possible the presence of different disciplinary perspectives and disciplines that can be engaged in solving problems.

Klein (2010) postulates that multidisciplinary research encourages innovation as it encourages the communication and cooperation among disciplines. Academic libraries have a part in this process as they are a well-being intellectual space where access to information in a varied subject matter is available. This is because libraries can help break the disciplinary boundaries on knowledge in addition to helping to explore the field of research in depth by arranging information and effective discovery aids in a meaningful system.

Academic Libraries as Research Support Centres

In academic literature, the academic libraries are increasingly gaining fame as support research centres in higher learning institutions. Corrall, Kennan and Afzal (2013) state that the libraries now offer an extensive set of research-oriented services, including providing custom research advice, assistance in systematic literature

reviews, plagiarism detection, citation and reference management and advice regarding scholarly publishing activities.

Libraries in the case of multidisciplinary scholars will provide access to a range of bibliographic databases, as well as full-text databases, such as Scopus, Web of Science, JSTOR, IEEE Xplore, PubMed, ScienceDirect, and Google Scholar. The resources enable the scholars to have access to literature beyond their core disciplines and, therefore, expand research boundaries and enhance cross-disciplinary research quality (Tenopir et al., 2014).

Digital Libraries and Multidisciplinary Resource Access

The developments in digital library technologies have drastically changed the manner in which scholars access scholarly information. Borgman (2007) believes that digital libraries are very useful in improving the efficiency of research since they offer a unified access to heterogeneous information in various disciplines. Having access to online journals, e-books, datasets, audiovisual materials, and digital archives can help researchers overcome spatial, temporal and disciplinary limitations.

The management of institutional repositories in academic libraries can also be used as a platform to preserve and share the outputs of multidisciplinary research, such as these, dissertations, conference proceedings and preprints. According to Lynch (2017), these repositories are important in terms of long-term preservation, visibility, and accessibility of scholarly work. Besides, open access projects led by libraries contribute to the free flow of knowledge through the mitigation of economic, legal, and institutional barriers.

Information Literacy and Research Skill Development

Information literacy is the bare minimum requirement of successful engagement into multidisciplinary research. The researchers ought to discover the sources of information that are pertinent, to study different types of evidences critically, combine knowledge in the various fields of research and to make ethical usage of information. Bruce (1997) defines information literacy as the ability of people to cope with rapidly evolving and complex information.

In academic libraries, these demands are addressed by offering academic libraries such services as organised information literacy programmes, research methodology training, high-level training on literature searching, systematic review, reference management tools and research ethics. The ACRL Framework of Information Literacy in Higher Education (2016) emphasizes greatly on the importance of critical thinking, creation of knowledge, and reflective learning, which are essential to the achievement of multidisciplinary research.

The libraries train to employ research tools such as the Zotero, Mendeley, EndNote, Turnitin, and other plagiarism detection software and, therefore, increase the quality, credibility, and ethical standards of academic research.

Role of Librarians in Multidisciplinary Research

This has made librarians to be a facilitator, collaborator and mediator of knowledge as they have acquired a lot of roles in multidisciplinary research. The subject and liaison librarian roles have been increasingly across the board becoming more flexible and open. Cox and Corrall (2013) observe that librarians are active participants in the research activities since they assist in the literature review, research design consultations, data management plan consultations, and publication strategy consultations.

Another more effective approach to the collaboration promotion is embedded librarianism, which implies placing librarians within the research teams. In addition to this, librarians may assist researchers not only in evaluating the impact of their works through bibliometric analysis, citations metrics, h-index, and altmetrics but also through such platforms as ORCID, ResearchGate, and Google Scholar to identify themselves (Bornmann, 2014).

Research Data Management and Scholarly Communication

Multidisciplinary research is also associated with large volumes of heterogeneous and volatile data and therefore, the management of research data is vital (RDM). RDM ensures data integrity, its usability, re-use, and compliance with agency and institutional requirements posed by the funding agency. Academic libraries are increasingly supporting RDM through the development of data repositories, assistance with developing data management plans, and providing guidance on metadata standards and metadata documentation practices (Tenopir et al., 2014).

n addition to this, libraries are leading the front in communication in the field of scholarship by improving open publishing, creating awareness towards the issue of copyright and licensing, and unethical publishing practices. Pinfield, Salter, and Bath (2017) note the importance of academic libraries in the creation of the sustainable model of publishing and the assistance they provide to the researchers with the policies related to the open access and publication expenses.

Challenges Faced by Academic Libraries

Even though academic libraries are still involved in multidisciplinary research, there have been several constraints related to this involvement. One of the challenges is the lack of financial resources, higher subscriptions fees, the insufficient qualification of staff, and the rapid development of digital technologies. The librarians need to continually enhance their competencies to make them capable of coping with the emerging method of research, data-intensive scholarship, and the digital research tools (Auckland, 2012).

In addition, the lack of awareness of the researchers about library research support services remains a problem particularly in the developing world. The outreach programmes, advocacy and institutional collaboration should be enhanced to make sure that maximum effect of the academic library services is realized.

Conclusion

This review has brought out clearly that the academic libraries have become important and more strategic in supporting multidisciplinary research. The provision of diverse information resources, training of information literacy skills, collaboration with research, managing research data and scholarly communication has made academic libraries active and critical research partners. Libraries are required to spend more on upgrading their more sophisticated digital infrastructure, additional training of the librarians and effective awareness campaigns to make their contribution even greater. Lastly, academic libraries play a major role in the interdisciplinary research culture and awareness of the knowledge production in higher education.

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Digital Preservation Practices in DSpace-Based Institutional Repositories: A Comparative Study of Top NIRF-Ranked IITs in India 2025

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Abstract

The expansion of digital scholarly outputs in academic institutions has heightened the need for effective long-term preservation, accessibility, and authenticity of research materials. Institutional repositories (IRs), particularly those built on DSpace, serve as key platforms for storing and disseminating theses, dissertations, journal articles, and other academic content. This study examines the digital preservation practices of DSpace-based IRs in the top NIRF-ranked IITs in India 2025, analyzing repository versions, platform configurations, total holdings, content types, year-wise uploads, metadata completeness, and the presence of formal policies. Using systematic observation of publicly accessible repositories guided by a structured checklist, the study identifies significant differences in preservation readiness. IIT Bombay, Roorkee, and Hyderabad demonstrate robust practices through structured collections, rich metadata, and diverse content, while IIT Delhi shows moderate preservation preparedness, and IIT Madras remained inaccessible during the study. The findings highlight that while DSpace provides the technical foundation, sustained digital preservation requires organized repository structures, comprehensive metadata, policy documentation, and active content management. These results provide actionable insights for library administrators and policymakers to strengthen the long-term sustainability of institutional repositories.

Keywords: Digital Preservation, Institutional Repositories, DSpace, Metadata Quality, IITs

Introduction

The rapid growth of digital scholarly content in academic institutions has significantly increased the responsibility of libraries to ensure the long-term preservation, accessibility, and authenticity of research outputs. Institutional repositories (IRs) have emerged as key infrastructures for managing and disseminating scholarly materials such as thesis, dissertations, journal articles, reports, and other academic works (Pawar, 2025). In Indian academic institutions, particularly in premier institutes such as the Indian Institutes of Technology (IITs), DSpace has become one of the most widely adopted platforms for developing institutional repositories (Bashir et al., 2021). Although these repositories are primarily recognized as access tools that enhance scholarly communication and research visibility, their role as digital preservation systems remains insufficiently examined.

Digital preservation refers to the set of managed activities required to ensure continued access to digital materials for as long as necessary (Pasqui, 2024). Conceptual frameworks such as the Open Archival Information System (OAIS) emphasize that effective preservation extends beyond storage and access to include structured organization, metadata richness, sustainable file formats, persistent identification, and the presence of formal institutional policies and guidelines (Chandra & Gokhale, 2012). Repository platforms such as DSpace technically support many of these preservation-related functions through features including the Handle System for persistent identifiers, customizable metadata schemas, and hierarchical community and collection structures. However, the extent to which these features are systematically implemented with a preservation focus in academic libraries remains largely unknown (Williams-Herrman, 2014).

Existing literature on institutional repositories in India has predominantly focused on repository growth, software adoption, and the enhancement of research visibility, with comparatively limited empirical attention given to digital preservation practices (Kale, 2025). Studies examining preservation-oriented indicators such as repository versioning, metadata completeness, content diversity, year-wise growth of documents, and the availability of formal policies across repositories using the same platform are scarce (Barrueco & Termens, 2021). Although several IIT libraries have established DSpace-based repositories, there is insufficient evidence to determine whether these repositories function as comprehensive digital preservation systems or primarily as access-oriented platforms.

To address this gap, the present study conducts a comparative analysis of DSpace-based institutional repositories maintained by Indian Institutes of Technology that are ranked within the top ten institutions in the NIRF India Rankings 2025 (Overall category). Based on this criterion, the study includes six IIT libraries. The analysis focuses on key indicators relevant to digital preservation practices, including repository platform and version, total number of documents, types of content hosted, year-wise publication trends, and the presence of documented policies and guidelines (Barrueco & Termens, 2021). By examining these observable characteristics, the study aims to assess how effectively these repositories support digital preservation beyond their role in providing access to scholarly content.

The findings of this study are expected to provide empirical insights into preservation practices at leading academic institutions in India and to inform library professionals and repository managers on strategies to strengthen long-term sustainability and integrity of digital scholarly assets.

Objectives of the Study

1. To examine DSpace versions and platform features of top NIRF-ranked IIT repositories.
2. To analyze the volume, types, and year-wise growth of content hosted.
3. To evaluate metadata quality, persistent identifiers, and file format sustainability.
4. To assess the presence of documented policies and preservation guidelines.
5. To determine whether repositories function primarily as access-oriented platforms or as comprehensive digital preservation systems.

Methodology

This study employs a descriptive and comparative research design to examine digital preservation practices (Ahmad et al., 2023) in DSpace-based institutional repositories of top NIRF-ranked IITs in India 2025. The study aims to evaluate whether these repositories function as comprehensive digital preservation systems or primarily as access-oriented platforms. A purposive sampling strategy was used, selecting six IIT libraries with fully functional, publicly accessible, and actively maintained DSpace repositories. This ensures reliable and consistent observation across all sampled repositories.

Data were collected through direct observation of repository interfaces, focusing on features that indicate preservation awareness. A predefined checklist was developed based on established digital preservation principles, repository standards, and best practices (Bashir et al., 2021; Pasqui, 2024; Williams-Herrman, 2014). Observed indicators included repository platform and version, community and collection organization, types of content, year-wise growth of documents, metadata quality, persistent identifiers, file format sustainability, documented policies and guidelines, browsing and search functionalities, metadata standards, and interface accessibility and stability. The complete set of criteria is presented in Table 1.

Indicator	**Observed Feature**	**Scoring Notes**
Repository Platform & Version	DSpace version and UI (e.g., DSpace 6, 7)	Yes / No / Version number
Community & Collection Structure	Organization by departments, programs, or content type	Well-organized / Partial / Poor
Types of Content Hosted	Theses, dissertations, journal articles, datasets, reports	List content types; note diversity
Year-wise Growth of Documents	Trend of publications over years	Continuous / Irregular / Sparse

Metadata Completeness	Number of fields, presence of title, author, supervisor, keywords, abstract, department, date	High / Medium / Low
Persistent Identifiers	Presence of Handles, DOIs for items	Present / Absent
File Format Sustainability	Formats used (PDF, PDF/A, TIFF, XML)	Preservation-friendly / Standard / Limited
Policies & Guidelines	Availability of written repository or preservation policies	Available / Partial / Not available
Browse & Search Facilities	Ability to browse by author, subject, date, title	Comprehensive / Limited / Minimal
Metadata Standards	Use of Dublin Core, OAI-PMH, or other standards	Mentioned / Not mentioned
Accessibility & Interface Stability	Ease of access, load times, broken links, interface usability	High / Medium / Low

Each repository was systematically evaluated against these criteria, and observations were recorded in a comparative evaluation matrix. Quantitative indicators, such as total document counts and year-wise trends, were tabulated, while qualitative indicators, such as metadata richness and policy availability, were descriptively scored (e.g., High / Medium / Low or Present / Partial / Absent) (Pontika et al., 2022). This standardized approach enables direct comparison of repository features across the six IITs and highlights differences in digital preservation practices.

The data were analyzed using comparative analysis, examining variations in repository structure, metadata completeness, persistent identifier use, file formats, policy documentation, and interface stability. This approach provides insight into the extent to which preservation principles are embedded in each repository, distinguishing between repositories functioning as full preservation systems and those serving primarily as access-oriented platforms.

Only publicly accessible information was used, and no internal repository data were accessed, ensuring ethical compliance. The study's limitations include the inability to observe backend processes such as automated backups, migration strategies, or preservation workflows that are not publicly visible (Oehlerts & Liu, 2013).

Results and Discussion

The present study conducted a comparative analysis of DSpace-based institutional repositories (IRs) maintained by top NIRF-ranked IITs in India 2025, focusing on digital preservation practices, repository structure, content types, metadata implementation, policies, and accessibility (Guenther, 2005). Observations were recorded across six indicators: repository platform and version, total documents, content types, year-wise uploads, accessibility, and policy presence

Repository Versions and Platforms

All selected IIT repositories primarily employ DSpace, reflecting its dominance in Indian academic institutions (Bashir et al., 2021). Most repositories use DSpace 6, except IIT Delhi (DSpace 8) and IIT Hyderabad (DSpace 7 Customized), indicating that some libraries have upgraded to newer versions or customized the platform to accommodate institutional requirements. IIT Madras' repository was inaccessible at the time of observation. Table 2 shows that upgraded versions and customized deployments can provide better

technical support for long-term preservation, but older versions still support fundamental preservation practices (Pasqui, 2024; Williams-Herrman, 2014).

Institute	DSpace Version	Remarks
IIT Delhi	DSpace 8	Latest version, policy visible
IIT Bombay	DSpace 6 JSPUI	Older version, stable
IIT Kharagpur	DSpace 6	Standard version, multiple communities
IIT Roorkee	DSpace 6	Department-wise structure
IIT Hyderabad	DSpace 7 Customized	Customized version, format diversity
IIT Madras	N/A	Server inaccessible

Table 2: DSpace Versions Used by Top NIRF IITs 2025

Repository Structure and Accessibility

Repositories differ in community and collection organization. IIT Delhi has only two communities (ETDs and Other Documents), while IIT Kharagpur and IIT Roorkee have more structured, department-wise collections. IIT Bombay features large-scale categorization with distinct document types such as articles, theses, book chapters, reviews, and reports. IIT Hyderabad uses customized DSpace communities for faculties, departments, and publications. The internet/intranet accessibility of repositories is summarized in Table 3. The observed structure shows that well-organized communities and collections, such as in IIT Roorkee and IIT Bombay, enhance discoverability and support preservation. Minimal community structures, as in IIT Delhi, may limit navigation and preservation visibility despite public access.

Institute	Access Type	Remarks
IIT Delhi	Internet	Publicly accessible
IIT Bombay	Internet	Publicly accessible
IIT Kharagpur	Internet	Publicly accessible
IIT Roorkee	Internet	Publicly accessible
IIT Hyderabad	Internet	Publicly accessible
IIT Madras	Intranet / Server down	IR not accessible

Table 3: Repository Accessibility (Internet / Intranet)

Total Documents and Content Diversity

Total document counts differed markedly (Table 4). IIT Bombay hosts the largest collection (40,750 documents), followed by IIT Roorkee (25,833), IIT Hyderabad (14,878), IIT Kharagpur (8,764), and IIT Delhi (6,962). IIT Delhi mainly hosts ETDs with minimal metadata, whereas IIT Bombay and Hyderabad maintain diverse content, including articles, theses, conference papers, book chapters, and reviews. Structured metadata and diverse content are key indicators of stronger preservation readiness (Table 5).

Institute	Total Documents	Remarks
IIT Delhi	6,962	Minimal metadata, mostly ETDs

IIT Bombay	40,750	Complete metadata, multiple document types
IIT Kharagpur	8,764	Metadata varies, multiple communities
IIT Roorkee	25,833	Department-wise collections, complete metadata
IIT Hyderabad	14,878	Complete metadata, diverse formats
IIT Madras	N/A	Server inaccessible

Table 4: Total Document Count in DSpace Repositories

Institute	Types of Documents	Remarks
IIT Delhi	ETDs, Other Docs	Minimal metadata, department-wise categories
IIT Bombay	Articles, Theses, Books, Book Chapters, Reviews, Technical Reports, Letters, Proceedings	Complete metadata
IIT Kharagpur	PhD Theses, DSc Theses, Reports	Metadata varies
IIT Roorkee	Doctoral & Masters Theses, Department-wise collections	Complete metadata
IIT Hyderabad	Articles, Theses, Conference Papers, Book Chapters, Reviews, Editorials	Complete metadata, diverse formats
IIT Madras	N/A	Server inaccessible

Table 5: Document Types

Year-wise Uploads and Historical Coverage

The analysis of document uploads over time shows variation in repository activity and growth patterns across the selected IITs. To standardize comparison, the available data from individual years and decade-based groupings were aggregated into four-year groups: ≤1999, 2000–2009, 2010–2019, and 2020–2025 (Table 6).

IIT Delhi shows a gradual increase, with a substantial rise in uploads during 2020–2025, reflecting active repository management in recent years. IIT Bombay, which maintains a large repository, exhibits steady growth across decades, with the highest number of uploads in 2020–2025. IIT Kharagpur and IIT Roorkee also demonstrate continuous growth, with structured community and department-wise collections supporting preservation. IIT Hyderabad exhibits a consistent increase in recent years, with 7,121 documents uploaded between 2020 and 2025. IIT Madras could not be included due to IR inaccessibility.

The year-grouped data highlight patterns of digital preservation engagement: repositories with higher and more consistent uploads indicate sustained institutional commitment, while older or inactive repositories may risk underrepresentation of early scholarly outputs (Mahalingam et al., 2025). This grouping also allows comparison of preservation readiness across repositories despite differences in how upload data are presented on IR sites.

Institute	≤1999	2000–2009	2010–2019	2020–2025	Remarks
IIT Delhi	158	164	534	2,377	Data aggregated from individual years
IIT Bombay	3,170	6,672	14,657	12,854	Original year-wise data grouped by decade
IIT Kharagpur	606	1,006	2,528	2,378	Original data already in decade groups

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IIT Roorkee	2,220	4,298	6,173	7,927	Original data grouped into decades
IIT Hyderabad	1,918	1,918	4,254	7,121	Individual years summed into groups
IIT Madras	N/A	N/A	N/A	N/A	IR inaccessible

Table 6: Year-wise Upload Count (Grouped) in DSpace Repositories

Policies and Guidelines

Among the observed repositories, only IIT Delhi has a visible repository policy outlining metadata standards, file formats, and preservation practices. The absence of formal policies in IIT Bombay, Kharagpur, Roorkee, and Hyderabad suggests that preservation is implemented through technical features rather than explicit institutional guidelines.

Institute	Preservation Readiness	Key Factors
IIT Bombay	High	Structured collections, complete metadata, diverse document types
IIT Roorkee	High	Department-wise collections, complete metadata, steady uploads
IIT Hyderabad	High	Customized platform, diverse content and formats, active uploads
IIT Delhi	Moderate	Visible policy, DSpace 8 upgrade, minimal metadata
IIT Madras	Limited	Inaccessible IR

While the comparative analysis provides a comprehensive overview of preservation practices, the study is limited to publicly observable features. Backend workflows, automated backups, migration strategies, and unpublished policies could not be assessed (Shajitha, 2020). Inaccessible repositories such as IIT Madras, variability in reporting formats, and the dynamic nature of IR content further limit longitudinal comparisons. Metadata quality was evaluated only for visible fields, and the sample size was restricted to top NIRF-ranked IITs.

Conclusion

This study provides a comparative analysis of digital preservation practices in DSpace-based institutional repositories of top NIRF-ranked IITs in India 2025. The findings reveal significant variations in repository versions, community and collection structures, metadata richness, content diversity, and policy visibility. IIT Bombay, Roorkee, and Hyderabad demonstrate stronger preservation readiness due to structured collections, complete metadata, and diverse document types, whereas IIT Delhi shows moderate readiness, and IIT Madras remains inaccessible. Year-wise upload trends indicate active repository management, reflecting institutional commitment to digital preservation (Sawant, 2011).

While DSpace provides a robust technical framework, effective preservation requires systematic implementation of metadata standards, organized repository structures, formal policies, and consistent content management (Patil & Mahajan, 2025). The study is limited to publicly accessible features and observable repository content, excluding backend workflows or inaccessible repositories, which may affect full comparability (Mukherjee & Das, 2020). Nevertheless, the findings offer valuable insights for library managers and policymakers to strengthen institutional repository practices and ensure long-term accessibility and usability of scholarly content.

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Research Performance of the Vinayaka Mission's Research Foundation Deemed to be University, Salem: A Scientometric Analysis

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Abstract

This study examines the research performance of Vinayaka Mission's Research Foundation (VMRF), Salem, using scientometric techniques for the period 2016-2025. Data were retrieved from indexed scholarly sources and analyzed using indicators such as publication growth, citation impact, exponential growth rate, relative growth rate, doubling time, time-series forecasting, author productivity, h-index, and subject-wise distribution. The analysis reveals a steady increase in research output, with 1847 publications receiving 11092 citations. Publication growth accelerated after 2019, reaching a peak in 2025. Time-series analysis projects continued growth up to 2030. Author-level analysis identifies a core group of highly productive and impactful researchers, while subject-wise analysis highlights the institution's multidisciplinary research strength. The findings demonstrate VMRF's expanding research capacity and growing academic impact at national and international levels.

Keywords: Scientometrics, Research productivity, Citation analysis, h-index, Vinayaka Mission's Research Foundation

Introduction

Research productivity is the major component in the scientific and academic field. Research publications are lead to recognize an individual, discipline, institution, country and so on. Then only the scientific and academic professionals receive the promotion, advancement, and funding for future research. The scientific researchers and academic professionals are acknowledged only after the publication made. Hence, publications are the professional norm in a scientific sense and serve as a tool for the betterment of the individuals. It is clearly known form the above discussion, research publications are the major influenced factor in scientific and academic fields. By keeping this view in mind, the researcher aims to analyze the peer-reviewed, reputed, international scientific publication in the field of Biochemistry. So that, the Journal of Biological Chemistry has been identified as one of the peer-reviewed, reputed, international scientific publication in the field of Biochemistry which is indexed in Medline, PubMed, Web of Science, and Scopus. In this regard, the present study entitled "Mapping of Publication Pattern in the Journal of Biological Chemistry (2006-2015): A Bibliometric Study". The present study is an attempt to bibliometrically measures the published research output of the Journal of Biological Chemistry in terms of using various statistical tools, bibliometric techniques and indicators.

Vinayaka Mission's Research Foundation (Deemed to be university) traces its origin back to the year 1981 when the Thirumuruga Kirupananda Variyar Thavathiru Sundara Swamigal Medical Educational and Charitable Trust (TKVTSSMECT) was established. Building upon this foundation, the visionary Founder-Chairman, Dr. A. Shanmugasundaram, founded the Vinayaka Mission's College of Pharmacy at Salem in 1982. This institution marked the pioneering step of Vinayaka Missions in the realm of education. In a significant stride, the year 2001 witnessed Vinayaka Missions attaining the prestigious status of a "Deemed to be University". This recognition was bestowed by the Ministry of Human Resources Development, Government of India, with the endorsement of the University Grants Commission (UGC) under Section 3 of the UGC Act, 1956. This accolade acknowledged the institution's unwavering commitment to academic excellence, its fulfillment of the highest academic benchmarks, and its provision of exceptional infrastructure, all of which converged to establish its eminence in education. This milestone heralded the transformation of Vinayaka Missions into Vinayaka Mission's Research Foundation (VMRF), marking its distinction as the 48th Deemed to be University in India. Vinayaka Mission's Research Foundation (Deemed to be university) boasts an extensive academic landscape comprising of 13 Colleges and 12 Schools, including 3 Medical Colleges, 2 Engineering Colleges, 1 Dental College, 1 Pharmacy College, 1 Homeopathy Medical College, 3 Physiotherapy

Colleges/Schools, 3 Nursing Colleges, 2 Arts & Science Colleges/Schools, 5 Schools of Allied Health Sciences, and 1 School dedicated to Law, Physical Education, Rehabilitation and Behavioral Science and Economic and Public Policy. These institutions are spread across four locations in Salem and Chennai Districts in Tamil Nadu, as well as Puducherry and Karaikal of the Union Territory of Puducherry. The academic programmes offered by the university hold approval from the relevant statutory authorities/university, attesting to their quality and relevance. The institution has garnered recognition on the national stage, securing a rank within the 151-200 band in the National Institutional Ranking Framework (NIRF) 2024 under the University Category. Additionally, VMRF(DU) stands accredited by the National Assessment and Accreditation Council (NAAC) with an A grade (3.13 CGPA).

Objectives of the Study

The primary objective of the present study is to assess the research performance of Vinayaka Mission's Research Foundation (Deemed to be University), Salem, through a comprehensive scientometric analysis. The specific objectives are:

1. To analyze the year-wise growth pattern of research publications produced by VMRF during the period 2016–2025.
2. To examine the citation impact and visibility of the research output.
3. To measure the exponential growth rate, relative growth rate (RGR), and doubling time (DT) of publications.
4. To identify publication trends using time series analysis and to forecast future research output.
5. To identify the most productive and influential authors and evaluate their research performance using the h-index.
6. To examine the subject-wise distribution of publications and identify the most productive research areas.

Methodology

The present study adopts a scientometric research methodology to evaluate the research output of Vinayaka Mission's Research Foundation (VMRF) for the period 2016–2025. A total of 1847 bibliographic records were collected from the Web of Science Core Collection, an internationally recognized scholarly database. The retrieved data were organized and analyzed using BibExcel software, spreadsheets, and statistical tools. Various scientometric indicators and analytical techniques were applied, including year-wise publication distribution, citation analysis, exponential growth rate, relative growth rate (RGR), doubling time (DT), author productivity analysis, h-index, subject-wise distribution, and time series forecasting using the straight-line trend method.

Table-1 Year wise research publications of Vinayaka Mission's Research Foundation

Sl. No.	Year	No. of Publications	Percentage	Citations
1	2016	63	3.41	516
2	2017	64	3.46	425
3	2018	46	2.49	773
4	2019	93	5.04	1130
5	2020	167	9.05	2229
6	2021	194	10.50	1482

7	2022	280	15.16	1765
8	2023	208	11.26	1158
9	2024	325	17.59	1265
10	2025	407	22.04	349
Total		**1847**	**100**	**11092**
Average Publication Per Year		**184**	**Average Citation Per Year**	**1109**

Table-1 shows a steady growth in research publications at Vinayaka Mission's Research Foundation from 2016 to 2025. A total of 1847 publications were produced, receiving 11,092 citations, with an annual average of 184 publications and 1109 citations. Research output increased markedly after 2019, reaching its peak in 2025 (407 publications, 22.04%). The highest citation count was recorded in 2020 (2229 citations), indicating strong research impact during this period. Lower citations for recent years are due to citation time lag. The overall data reflects a consistent rise in research productivity and impact.

Table - 2 Exponential Growth Rate

Sl. No	Year	Publication	Exponential growth rate $b= y_{t1}/ y_{t0}$
1	2016	63	-
2	2017	64	1.21
3	2018	46	1.01
4	2019	93	0.71
5	2020	167	2.02
6	2021	194	1.79
7	2022	280	1.16
8	2023	208	1.44
9	2024	325	0.72
10	2025	407	1.22

Table 2 illustrates the exponential growth rate of publications from 2016 to 2025, revealing a fluctuating yet overall positive growth trend. The highest growth rates were recorded in 2020 (2.02) and 2021 (1.79), indicating a phase of rapid expansion in research output. Moderate growth during 2022, 2023, and 2025 reflects sustained research productivity. In contrast, lower growth rates observed in 2019 (0.71) and 2024 (0.72) suggest temporary slowdowns. The results confirm a long-term upward trend in publication output, demonstrating the institution's expanding research activity despite periodic fluctuations.

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Table - 3 Relative Growth Rate and Doubling Time of the VMRF

Year	No. of Publication	Cumulative Total	Log_e W1	Log_e W2	RGR=W2-W1	Mean Relative Growth Rate(R)	DT= 0.693/R	Mean DT
2016	63	63	-	4.14	-		-	
2017	64	127	4.15	4.84	0.69		1.00	
2018	46	173	3.82	5.15	1.33	**0.81**	0.52	**0.58**
2019	93	266	4.53	5.58	1.05		0.66	
2020	167	433	5.11	6.07	0.96		0.72	
2021	194	627	5.26	6.44	1.18		0.58	
2022	280	907	5.63	6.81	1.18		0.58	
2023	208	1115	5.33	7.01	1.68	**1.41**	0.41	**0.49**
2024	325	1440	5.78	7.27	1.49		0.46	
2025	407	1847	6.00	7.52	1.52		0.45	
Total	**1847**					**1.11**		

*VMRF-Vinayaka Mission's Research Foundation

Straight line trend equation: $Yt= a+bx$ or $Yt= a+b (X- \bar{X})$

Mid-year $\bar{X}=2020+2021=4041/2=2020.5$

The Trend of the midyear, $a= \Sigma Y/N=1847/10=184.7$

Annual change in trend $b= \Sigma xy/\Sigma x^2=3160.5/82.5=38.30$

Table 3 shows a steady increase in the cumulative research output of Vinayaka Mission's Research Foundation from 2016 to 2025. The Relative Growth Rate (RGR) fluctuates across the years, with a mean RGR of 1.41, indicating overall positive growth. The Doubling Time (DT) demonstrates a declining trend with a mean DT of 0.49, suggesting faster growth in publication output. The trend analysis confirms consistent expansion, with an average of 184.7 publications per year and an annual increase of 38.30 publications, reflecting sustained improvement in research productivity.

Table - 4 Time series analysis

Year (X)	No. of Publications (Y)	$x=X-\bar{X}$	x^2	xy
2016	63	-4.5	20.25	-283.5
2017	64	-3.5	12.25	-224
2018	46	-2.5	6.25	-115
2019	93	-1.5	2.25	-139.5
2020	167	-0.5	0.25	-83.5
2021	194	0.5	0.25	97
2022	280	1.5	2.25	420

2023	208	2.5	6.25	520
2024	325	3.5	12.25	1137.5
2025	407	4.5	20.25	1831.5
Total	**1847**		**82.5**	**3160.5**

Straight line trend equation: $Yt= a+b (X- \bar{X})$

Since $\Sigma X = 0$

Predicted publications in 2026 is when X=2026 – 2020.5= 5.5

=184.7+ 38.30*5.5

=184.7+210.65=395.35

Predicted publications in 2027 is when X=2027 – 2020.5= 6.5

=184.7+ 38.30*6.5

=184.7+248.95=433.65

Predicted publications in 2028 is when X=2028 – 2020.5= 7.5

=184.7+ 38.30*7.5

=184.7+287.25=471.95

Predicted publications in 2029 is when X=2029 – 2020.5= 8.5

=184.7+ 38.30*8.5

=184.7+325.55=510.25

Predicted publications in 2030 is when X=2030 – 2020.5= 9.5

=184.7+ 38.30*9.5

=184.7+363.85 =548.55

Table 4 presents a time series analysis of research publications at Vinayaka Mission's Research Foundation for the period 2016–2025. The straight-line trend equation indicates a clear upward trend in publication output, with an average annual production of 184.7 publications and an annual growth of 38.30 publications. Based on the trend values, the predicted number of publications shows continuous growth, increasing from approximately 395 publications in 2026 to 549 publications by 2030. This projection suggests a strong and sustained increase in research productivity, reflecting the institution's expanding research capacity and long-term growth potential.

Table - 5 Predicted publications of Vinayaka Mission's Research Foundation

Sl. No.	Predicted year	Projected publications
1	2026	395
2	2027	433
3	2028	471
4	2029	510
5	2030	548

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Table 5 presents the projected research publications of Vinayaka Mission's Research Foundation for the period 2026–2030 based on time series analysis. The projections indicate a steady and consistent increase in publication output, rising from 395 publications in 2026 to 548 publications in 2030. This upward trend reflects the institution's sustained research growth and suggests a strong potential for continued expansion in scholarly productivity in the coming years.

Table - 6. Ranking of Authors based on Research Publication

Authors	No. of Articles	No. of Citations	Rank
Vijayan, D. S.	59	991	1
Vishnu, B. B.	50	162	2
Mohan, Karthik Rajaram	32	22	3
Fenn, Saramma Mathew	31	21	4
Sendilvelan, S.	24	142	5
Babu, D. Vijendra	24	111	6
Krishnan, Ramesh	23	237	7
Harikrishnan, A.	21	165	8
Mohammad, Arbab	21	56	9
Escandon, Joseph M.	19	50	10

Table 6 ranks authors of Vinayaka Mission's Research Foundation based on their research productivity and citation impact. Vijayan, D. S. ranks first with 59 publications and 991 citations, demonstrating the highest research output and impact. Vishnu, B. B. secures the second rank with 50 publications, while Mohan, Karthik Rajaram and Fenn, Saramma Mathew follow with consistent publication contributions. Authors such as Krishnan, Ramesh and Harikrishnan, A. show notable citation impact despite comparatively fewer publications.

Table-7 Authors having h-index more than 5

Authors	No. of Articles	No. of Citations	h-index
Vijayan DS	47	576	14
Prabhahar M	39	235	10
Balachandar R	12	367	8
Ramamurthi K	16	202	8
Karmegam N	13	363	8
Ramesh M	21	194	8
Senthilkumar A	19	119	8
Sivasuriyan A	13	183	8

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Sendilvelan S	23	128	7
Harikrishnan A	22	163	7
Parthiban D	7	178	7
Bhaskar K	14	119	7
Prakash S	19	107	7
Babu DV	24	117	6
Krishnan R	23	196	6
Anbazhagan V	14	123	6
Prabhu L	19	102	6
Koda E	8	142	6
Bhat BV	22	92	6

Table 7 presents authors of Vinayaka Mission's Research Foundation with an h-index greater than 5, reflecting both research productivity and citation impact. Vijayan D. S. leads with the highest h-index of 14, supported by 47 publications and 576 citations, indicating strong and sustained scholarly influence. Authors such as Prabhahar M. (h = 10) and several others with h-index values between 6 and 8 demonstrate consistent research performance with moderate to high citation impact. The presence of multiple authors with an h-index above 5 highlights a strong core of impactful researchers within the institution. The cumulative citation count of 7565 and an institutional h-index of 35 further confirm the quality, visibility, and academic influence of VMRF's research output.

Table - 8. The most productive research area of Vinayaka Mission's Research Foundation

Research area	**No. of Articles**	**No. of Citations**
General Internal Medicine	250	533
Materials Science	208	1759
Pharmacology Pharmacy	134	389
Chemistry	89	845
Computer Science	76	299
Science Technology Other Topics	64	799
Energy Fuels	53	1035
Physics	51	468
Dentistry Oral Surgery Medicine	49	184
Environmental Sciences Ecology	47	756

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Table 8 highlights the most productive research areas of Vinayaka Mission's Research Foundation in terms of publications and citations. General Internal Medicine leads in publication output with 250 articles, indicating strong research activity, while Materials Science shows the highest citation impact with 1759 citations, reflecting greater research visibility and influence. Other areas such as Energy & Fuels, Chemistry, and Environmental Sciences & Ecology also demonstrate notable citation impact despite comparatively fewer publications. Overall, the distribution reveals a diverse and multidisciplinary research profile, with both high productivity and high-impact research across multiple disciplines.

Conclusion

The present scientometric analysis reveals a consistent and significant growth in the research output of Vinayaka Mission's Research Foundation during 2016–2025. The increasing number of publications, positive growth indicators, declining doubling time, and rising citation impact reflect the institution's strengthening research ecosystem. Forecasting results indicate sustained growth in the coming years, suggesting long-term research potential. Author and h-index analyses highlight a strong core of productive and impactful researchers, while subject-wise distribution confirms the multidisciplinary nature of research at VMRF. Finding of the study demonstrates that VMRF has made notable progress in enhancing its research visibility and scholarly influence, contributing meaningfully to the national and global research landscape.

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Electronic Theses and Dissertations: An Evaluative Study of Indian Universities Contributions to the Shodhganga Repository

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ABSTRACT

The present study looks into the patterns of usage by Indian universities that have contributed to the Shodhganga repository, based on three criteria: (1) the number of universities making submissions to the repository, (2) the growth of submission over time (2000-2025), and (3) the percentage of submissions by subject to the top 10 universities in terms of thesis submission. The results indicate that Anna University, University of Madras, University of Calcutta, and Savitribai Phule Pune University are the top four universities providing submissions to this repository. The period after 2010 has resulted in a substantial increase in thesis submissions due in part to ETD (electronic thesis and dissertation) projects, as well as UGC (University Grants Commission) mandates. Subject distributions for the universities show there is a strong concentration of submissions in Engineering, Social Sciences, Physical Sciences and Arts & Humanities. Some of the multidisciplinary institutions indicated there is an equal amount of research output across all disciplines. The study demonstrates that Shodhganga is assisting in improving access, visibility and dissemination of Doctoral Research throughout India.

Keywords: INFLIBNET, Theses Repository, Shodhganga, INFLIBNET, Full-text Theses, Open Access

INTRODUCTION

Research is an important resource for socio-economic development, and access to research has enabled many people in the past to become better educated through research. Traditionally, researchers had access to only print materials such as books, journals, theses, and dissertations for the purpose of conducting research. Technological advancements in information and communications technology (ICT) have changed the way researchers use research and knowledge from print to available digitally. Shodhganga is an Indian repository of electronic theses and dissertations (ETDs) that has become an important focal point for academic research. Shodhganga is a digital database of ETDs created and maintained by the INFLIBNET Centre in 2013. Researchers can search for and retrieve full-text ETDs at any time and print them as needed. ETDs are available to researchers at all times from anywhere in the world and may be downloaded at their convenience. With Shodhganga, researchers can obtain access to research conducted throughout the world, without any geographic limitations, and may also obtain access to research conducted in all areas of study. Shodhganga will also assist researchers in identifying areas where there are gaps in the literature and aid in trend analysis to identify potential duplication in their research. Therefore, the ability to access scholarly research conducted by Indian universities through Shodhganga will create greater opportunities for researchers throughout India to develop further access to research.

OBJECTIVES OF THE STUDY

- To evaluate the contributions of Top 50 universities at Shodhganga repository
- Analytical study of year-wise contributions of top most universities from 2000 to 2025 nearly for 25 years
- To validate the subject-wise collections of full-text theses from 10 top most universities
- To discuss the benefits of digital initiative for electronic theses and dissertations at Shodhganga repository

LITERATURE REVIEW

Bhat, M. I., Mudhol, M. V., & Mahesh, V. (2014) discusses the importance of the electronic theses and dissertations and also the digital initiatives of INFLIBNET Centre in implementing Shodhganga repository by using Dspace, the digital repository software. This article also analyse the present status of participating Indian universities at Shodhganga. Chavan, S. P., & Sawai, A. B. (2019) analyses Indian universities contributions and their active participation in depositing the full-text theses mostly in all the disciplines. According to the study, University of Calcutta got first rank among the top 10 universities in depositing Ph.D theses in shodhganga repository. Haloi, N., & Das, D. (2021) analyzing the contributions of both central and state universities of North east India in uploading the electronic theses and dissertations in the perspective of Shodhganga repository.Jan, S., & Khazer, M. (2020) discusses the advancement of technologies and its massive growth in implementing electronic theses and dissertations to enrich the research field. This article talks about the global contributions of the ETD in reference to Shodhganga and also examines the growth and development of the digital era. K. Gupta, D., & Gupta, N. (2014) analyses the ETD repository and also the government initiatives in depositing the full-text theses for the convenient of the researchers and enhances the quality of the research to rises the social and economic development.Kumar, N. (2015) analyses the implementation of electronic theses and dissertations in Indian universities libraries and also discussed about the positions and challenges of National Level repository. Muthurasu, C., & Suganthi, M. (2020) analyses the digital repository of Shodhganga in uploading the electronic theses and dissertations. This paper conducted the in-depth contribution of Alagappa university, Karaikudi, India.Panda, S. K., Dey, S., Bhatt, A., & Satapathy, A. (2025) evaluates the progress and impact of Shodhganga and analyzes the challenges and future directions with references to India's centralized ETD repository. Singh, B. P. (2019) conducted the evaluative study of Shodhganga repository and Indian universities contributions to enhances the digital initiatives of ETD. Sivakumaren, K. S., & Swaminathan, S. (2020) analyses the availability of electronic theses and dissertations of Indian universities, Tamil Nādu and also examine the concept of digital initiatives of Shodhganga repository by INFLIBNET Centre.

Collection Development

Full text theses	**648244**
Synopses/MRPs/PDFs/Fellowships	**18014**
Universities contributing	**846**
Universities+CFTIs/INIs Signed MoU	**1016**

As of January 2026, the Shodhganga repository contains 6,48,244 full-text theses with an additional 18,014 synopses. In total, 846 universities are contributing full-text theses for acceptance into the Shodhganga repository.Additionally, 1016 universities+CFTIs/INIs Signed MoU were contributing to develop the research field.

Top 50 Universities Contributing Theses to the Shodhganga Repository

The largest universities are contributing to Shodhganga's ETD program, as shown in Table 1. Of these contributions, Anna University has the highest total number of documents available, followed by the University of Madras, the University of Calcutta, and Savitribai Phule Pune University. Central universities, state universities, and IITs, as well as institutions of national importance such as Jawaharlal Nehru University, Banaras Hindu University, IIT Delhi, IIT Bombay, and IISc Bangalore, are also well represented. The results also suggest that many of the universities listed are from Tamil Nadu, indicating a high level of research productivity and participation in Shodhganga from this region. The results also show an extensive range of universities contributing, from a variety of disciplines and geographic regions, further illustrating the role that Shodhganga plays in increasing the visibility, accessibility, and distribution of Research conducted by Indian Doctoral students

Table 1: Top 50 Universities Contributing Theses to the Shodhganga Repository

S.NO	NAME OF THE UNIVERSITY	NO OF DOCUMENTS DEPOSITED
1.	**ANNA UNIVERSITY**	**17987**
2.	**UNIVERSITY OF MADRAS**	**15688**
3.	**UNIVERSITY OF CALCUTTA**	**15286**
4.	**SAVITHRIBAI PHULE PUNE UNIVERSITY**	**14117**
5.	**UNIVERSITY OF MUMBAI**	**12852**
6.	**JAWAHARLAL NEHRU UNIVERSITY**	**11098**
7.	**ALIGARH MUSLIM UNIVERSITY**	**11073**
8.	**BANARAS HINDU UNIVERSITY**	**11062**
9.	**ANDHRA UNIVERSITY**	**11013**
10.	**PUNJAB UNIVERSITY**	**10358**
11.	**BHARATHIDASAN UNIVERSITY**	**8300**
12.	**BHARATHIYAR UNIVERSITY**	**8180**
13.	**MANONMANIAM SUNDARANAR UNIVERSITY**	**7764**
14.	**INDIAN INSTITUTE OF TECHNOLOGY, DELHI**	**6268**
15.	**MADURAI KAMARAJ UNIVERSITY**	**6173**
16.	**ANNAMALAI UNIVERSITY**	**3407**
17.	**PERIYAR UNIVERSITY**	**3434**
18.	**PONDICHERRY UNIVERSITY**	**2805**
19.	**ALAGAPPA UNNIVERSITY**	**2772**
20.	**VELLORE INSTITUTE OF TECHNOLOGY, VELLORE**	**2622**
21.	**BANGALORE UNIVERSITY**	**2638**
22.	**SRM INSTITUTE OF SCIENCE AND TECHNOLOGY**	**2337**
23.	**INDIAN INSTITUTE OF TECHNOLOGY, BOMBAY**	**2107**
24.	**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY, HYDERABAD**	**2047**
25.	**INDIAN INSTITUTE OF SCIENCE BANGALORE**	**1949**
26.	**INDIAN INSTITUTE OF TECHNOLOGY, MADRAS**	**1854**
27.	**THE GANDIGRAM RURAL INSTITUTE**	**1498**
28.	**TAMIL NADU AGRICULTURE UNIVERSITY**	**1424**
29.	**MOTHER TERESA WOMENS UNIVERSITY**	**1124**
30.	**INDIRA GANDHI NATIONAL OPEN UNIVERSITY IGNOU**	**1027**
31.	**SASTRA UNIVERSITY**	**640**
32.	**DELHI TECHNOLOGICAL UNIVERSITY**	**608**
33.	**THE TAMILNADU DR.M.G.R MEDICAL UNIVERSITY**	**542**
34.	**UNIVERSITY OF AGRICULTURAL SCIENCES, BANGALORE**	**520**
35.	**NATIONAL INSTITUTE OF TECHNOLOGY, TIRUCHIRAPALLI**	**335**

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36.	**THIRUVALLUVAR UNIVERSITY**	**289**
37.	**TAMILNADU PHYSICAL EDUCATION AND SPORTS UNIVERSITY**	**264**
38.	**INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY**	**208**
39.	**TAMILNADU TEACHERS EDUCATION UNIVERSITY, CHENNAI**	**203**
40.	**PERIYAR MANIAMMAI UNIVERSITY**	**182**
41.	**TAMIL UNIVERSITY**	**169**
42.	**CENTRAL UNIVERSITY OF TAMILNADU**	**141**
43.	**PRIST UNIVERSITY**	**121**
44.	**INDIAN INSTITUTE OF MANAGEMENT, MUMBAI**	**79**
45.	**TAMILNADU DR.AMBEDKAR LAW UNIVERSITY**	**71**
46.	**TAMILNADU OPEN UNIVERSITY**	**66**
47.	**AMBEDKAR UNIVERSITY**	**60**
48.	**INDIRA GANDHI DELHI TECHNICAL UNIVERSITY FOR WOMEN**	**59**
49.	**NATIONAL INSTITUTE OF TECHNOLOGY, PUDUCHERRY**	**59**
50.	**INDIAN INSTITUTE OF MANAGEMENT, BANGALORE**	**47**

Table 2 illustrates the distribution of theses from the top 50 Universities across three decades in Shodhganga - 2000-2009; 2010-2019; 2020-2025. The data indicate an increase in the number of theses submitted to the Shodhganga repository after 2010, which can be attributed to the adoption of electronic theses and dissertations (ETDs) in Indian Universities. Most institutions submitted very few or almost no theses during the decade of 2000-2009, then showed a significant increase in submissions during 2010-2019, which has continued to grow substantially between 2020-2025. Several leading universities, including Anna University, Savitribai Phule Pune University, Jawaharlal Nehru University, Banaras Hindu University and Andhra University, have all shown high and consistent growth across three decades. In addition, national institutions such as the Indian Institute of Technology (IIT), the Indian Institute of Science (IISc) Bangalore and the Indian Institutes of Management (IIMs) have made considerable contributions mainly after 2010, in response to policy requirements and increased research output. Overall, Table 2 reflects a definite move toward the electronic submission of doctoral theses to Shodhganga, and demonstrates the role of Shodhganga in preserving, disseminating and making accessible Indian doctoral research as a function of time.

Table 2: Decade-wise Distribution of Theses Deposited by the Top 50 Universities in Shodhganga (2000–2025)

S.NO	NAME OF THE UNIVERSITY	YEARS		
		2000-2009	2010-2019	2020-2025
1	**ANNA UNIVERSITY**	**743**	**6972**	**7667**
2	**UNIVERSITY OF MADRAS**	**1138**	**455**	**2777**
3	**UNIVERSITY OF CALCUTTA**	**1506**	**4775**	**2492**
4	**SAVITHRIBAI PHULE PUNE UNIVERSITY**	**2227**	**2832**	**2587**
5	**UNIVERSITY OF MUMBAI**	**2526**	**2408**	**1573**
6	**JAWAHARLAL NEHRU UNIVERSITY**	**2376**	**4286**	**2549**
7	**ALIGARH MUSLIM UNIVERSITY**	**2161**	**3146**	**2238**

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8	**BANARAS HINDU UNIVERSITY**	**542**	**3697**	**3779**
9	**ANDHRA UNIVERSITY**	**1813**	**4201**	**2029**
10	**PUNJAB UNIVERSITY**	**15**	**1449**	**2420**
11	**BHARATHIDASAN UNIVERSITY**	**1631**	**4276**	**1629**
12	**BHARATHIYAR UNIVERSITY**	**12**	**3186**	**2220**
13	**MANONMANIAM SUNDARANAR UNIVERSITY**	**954**	**3571**	**1784**
14	**INDIAN INSTITUTE OF TECHNOLOGY, DELHI**	**1212**	**2198**	**913 (2020 – 22)**
15	**MADURAI KAMARAJ UNIVERSITY**	**1521**	**2463**	**1257 (2024)**
16	**ANNAMALAI UNIVERSITY**	**29**	**1115**	**2194**
17	**PERIYAR UNIVERSITY**	**331**	**1364**	**1489**
18	**PONDICHERRY UNIVERSITY**	**163**	**1306**	**981**
19	**ALAGAPPA UNNIVERSITY**	**681**	**648**	**778**
20	**VELLORE INSTITUTE OF TECHNOLOGY, VELLORE**	**2**	**1189**	**1805**
21	**BANGALORE UNIVERSITY**	**146**	**1050**	**677**
22	**SRM INSTITUTE OF SCIENCE AND TECHNOLOGY**	**4**	**367**	**1726**
23	**INDIAN INSTITUTE OF TECHNOLOGY, BOMBAY**	**-**	**449**	**1683**
24	**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY, HYDERABAD**	**250**	**668**	**1102**
25	**INDIAN INSTITUTE OF SCIENCE BANGALORE**	**-**	**373**	**1600**
26	**INDIAN INSTITUTE OF TECHNOLOGY, MADRAS**	**1**	**387**	**1468 (2024)**
27	**THE GANDIGRAM RURAL INSTITUTE**	**139**	**493**	**404**
28	**TAMIL NADU AGRICULTURE UNIVERSITY**	**292**	**673**	**285**
29	**MOTHER TERESA WOMENS UNIVERSITY**	**175**	**444**	**259**
30	**INDIRA GANDHI NATIONAL OPEN UNIVERSITY IGNOU**	**-**	**653**	**444**
31	**SASTRA UNIVERSITY**	**3**	**186**	**434**
32	**DELHI TECHNOLOGICAL UNIVERSITY**	**1**	**177**	**682**
33	**THE TAMILNADU DR.M.G.R MEDICAL UNIVERSITY**	**81**	**485**	**75**
34	**UNIVERSITY OF AGRICULTURAL SCIENCES, BANGALORE**	**-**	**39**	**531**
35	**NATIONAL INSTITUTE OF TECHNOLOGY, TIRUCHIRAPALLI**	**-**	**-**	**489**
36	**THIRUVALLUVAR UNIVERSITY**	**-**	**288**	**2**
37	**TAMILNADU PHYSICAL EDUCATION AND SPORTS UNIVERSITY**	**-**	**110**	**78**
38	**INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY**	**-**	**48**	**150**
39	**TAMILNADU TEACHERS EDUCATION UNIVERSITY, CHENNAI**	**-**	**175**	**26**

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40	**PERIYAR MANIAMMAI UNIVERSITY**	**-**	**74**	**64**
41	**TAMIL UNIVERSITY**	**-**	**157**	**2**
42	**CENTRAL UNIVERSITY OF TAMILNADU**	**-**	**11**	**193**
43	**PRIST UNIVERSITY**	**-**	**62**	**51**
44	**INDIAN INSTITUTE OF MANAGEMENT, MUMBAI**	**-**	**19**	**60**
45	**TAMILNADU DR.AMBEDKAR LAW UNIVERSITY**	**2**	**47**	**21**
46	**TAMILNADU OPEN UNIVERSITY**	**-**	**4**	**79**
47	**AMBEDKAR UNIVERSITY**	**-**	**24**	**65**
48	**INDIRA GANDHI DELHI TECHNICAL UNIVERSITY FOR WOMEN**	**-**	**6**	**62**
49	**NATIONAL INSTITUTE OF TECHNOLOGY, PUDUCHERRY**	**-**	**4**	**79**
50	**INDIAN INSTITUTE OF MANAGEMENT, BANGALORE**	**-**	**-**	**47**

The table 3 shows the Thesis contributions across various subject disciplines (i.e. Arts and Humanities, Life Science, Social Science, Physical Science, Computer Science, Engineering and Management) at the repository Shodhganga (through the major disciplines of Arts and Humanities, Life Science, Social Science, Physical Science, Computer Science, Engineering and Management) from among the top 10 institutions/phd granting universities in India are presented in Table 3. The data show that there are a number of multidisciplinary universities that have made a strong contribution to areas of Arts and Humanities, Social Sciences, Physical Sciences, and Engineering (i.e. Banaras Hindu University, University of Mumbai, Andhra University and Savitribai Phule Pune University). Examples of engineering-orientated universities are Anna University, which has contributed primarily to Engineering and Computer Science, and the University of Madras and University of Calcutta, which have contributed primarily to Arts and Humanities and Life Sciences. Jawaharlal Nehru University has made highly regarded contributions in Social Science and Political Science, which reflects its research orientation in the areas of social and policy-related research. Overall, the data reflects a diversity of subjects and strength of disciplines among the leading Indian universities, and Shodhganga captures and provides a vehicle for the dissemination of rich subject-based doctoral research.

Table 3: Subject-wise Distribution of Theses among the Top 10 Universities in the Shodhganga Repository

SINO	NAME OF THE UNIVERSITY	ARTS AND HUMANITIES	LIFE SCIENCE	PLANT SCIENCE	SOCIAL SCIENCE	POLITICAL SCIENCE	PHYSICAL SCIENCE	COMPUTER SCIENCE	MATHEMATICS	ENGINEERING	MANAGEMENT
1	**ANNA UNIVERSITY**	**59**	**97**	**-**	**29**	**15**	**374**	**2048**	**67**	**3655**	**155**
2	**UNIVERSITY OF MADRAS**	**2376**	**1019**	**253**	**625**	**20**	**945**	**80**	**104**	**13**	**95**
3	**UNIVERSITY OF CALCUTTA**	**445**	**1049**	**120**	**682**	**82**	**968**	**172**	**153**	**89**	**163**
4	**SAVITRIBAI PHULE PUNE UNIVER**	**449**	**375**	**117**	**1480**	**43**	**511**	**143**	**106**	**770**	**709**

	SITY										
5	**UNIVERSITY OF MUMBAI**	**1690**	**3109**	**551**	**2749**	**135**	**4250**	**161**	**180**	**325**	**240**
6	**JAWAHARLAL NEHRU UNIVERSITY**	**398**	**245**	**129**	**914**	**295**	**58**	**72**	**15**	**10**	**24**
7	**ALIGARH MUSLIM UNIVERSITY**	**788**	**369**	**110**	**1246**	**123**	**405**	**98**	**158**	**131**	**144**
8	**BANARAS HINDU UNIVERSITY**	**3032**	**923**	**157**	**3965**	**386**	**578**	**68**	**158**	**27**	**213**
9	**ANDHRA UNIVERSITY**	**1577**	**1358**	**4**	**2751**	**96**	**2195**	**343**	**317**	**1498**	**463**
10	**PANJAB UNIVERSITY**	**14**	**27**	**-**	**33**	**62**	**10**	**-**	**8**	**9**	**33**

IMPACT

This research makes noteworthy new contributions to the growing body of literature on Shodhganga repository data analysis by providing informational trends of thesis contributions across different themes (e.g. systematic, historical), contributing institutions (e.g. leading universities), temporal periods (e.g. growth patterns), and subject areas. The results of this study are thus valuable in assisting policymakers, academic leaders and administrators, and librarians to evaluate the performance of institutional research and the level of compliance with ETD requirements. The subject analysis as part of this study supports researchers in identifying areas for future study and areas where a gap in the current body of knowledge exists. Collectively, the results of this study demonstrate the importance of Shodhganga to enhance open access to research, increase visibility of research, decrease redundancy in research publications, and facilitate evidence-based planning and decision-making in academic research. Collectively, this research supports enhanced and informed decision-making, efficient research administration, and the long-term sustainability of India's academic communication system.

CHALLENGES

- Facing Technical issues
- Lack of Digital Literacy
- Finding difficulties in search strategies
- Network Issues
- Page loading issues

CONCLUSION

The study results indicate that Shodhganga is a growing and important national site for scholarly communication. The data collected from institutions indicate a high degree of engagement among universities and a strong upward trend in the number of theses deposited since 2010 suggests an increased adoption of digital submission and open access practices. The distribution of theses by subject area shows that Indian universities are performing very well in terms of their research output in the Engineering, Social Science,

Physical Science, and Arts and Humanities disciplines. In summary, Shodhganga as a resource supports research transparency, reduces duplication of research, provides means for identifying gaps in the research, and contributes significantly towards strengthening and improving the Indian research ecosystem.

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Digital Libraries and Sustainable Finance: Open Access Insights into Public vs Private Defence Stocks—A Study on HAL and Data Patterns

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Abstract

There are many opportunities for sustainable investment analysis in India's defense sector, where creative private companies like Data Patterns India Ltd. contrast with public sector initiatives like Hindustan Aeronautics Limited (HAL). In order to investigate risk-return resilience, this paper maps an event study case during geopolitical events (such as the Pahalgam Attack and Operation Sindoor) in line with digital transformation in libraries. It highlights the role of libraries in user-centric digital services, open access ethics, and green information governance by comparing stock performance without complicated modeling using open-access NSE data and sustainability reports made available through academic libraries. Key findings highlight Data Patterns' growth agility and HAL's policy-backed stability, with sustainability perspectives like eco-friendly manufacturing accessible through smart library portals. This promotes policy for integrated finance datasets and supports conference themes on digital trends, AI ethics, and sustainable libraries. Implications help librarians and investors navigate the ethical use of data for sectoral research.

Introduction

India's defence sector plays a crucial role in national security and economic growth. This sector attracts investor interest, especially during crises, due to its mix of stability and potential for high returns. The Pahalgam attack in 2025 caused sharp price changes in defence stocks, leading to a closer look at the differences between public and private ownership.

This event study examines how the market reacted, concentrating on unusual returns for Hindustan Aeronautics Limited (HAL), a government-backed public sector company known for its reliability, compared to Data Patterns India Ltd., an agile private firm focused on growth through innovation but associated with higher risks. Academic libraries support these analyses by providing digital access to NSE data and sustainability reports on eco-friendly defence practices, in line with smart library services, open access ethics, and green information governance.

Investors need to weigh the safety of public sector units against the potential rewards of the private sector amid market volatility. This paper looks at performance before and after the event to help investors make informed choices about robust investments.

Aerospace & Defense Sector India

Strategic priorities and growing domestic capabilities have made India's aerospace and defense sector a key industry. In line with national objectives like Atmanirbhar Bharat, the sector is making progress towards self-reliance with the aid of increased investments in R&D, manufacturing, and technology development. The development of this industry has been pushed forward by India's increasing geopolitical challenges and ambitions for a strong defense infrastructure, and extended massive opportunities for both public and private businesses. The industry promotes innovation and capacity building by containing a wide range of activities, from the manufacture of aircraft to sophisticated electronics and missile systems. India's position as a major player in the global aerospace and defense landscape is strengthened by this dynamic ecosystem, which also greatly boosts economic growth and technological expertise.

The Indian Ministry of Defence's recently uncovered the 15-year Defence Modernization Roadmap sets a transformative agenda focusing on cutting-edge technologies such as AI, nuclear propulsion, hypersonic missiles, and advanced unmanned systems to strengthen defence capabilities through self-reliance. This roadmap has direct relevance for leading defence firms like HAL and Data Patterns. HAL, as India’s flagship public sector aerospace manufacturer, is self-possessed to play a critical role in producing next-generation aircraft and naval vessels within this long-term vision. Simultaneously, Data Patterns, a key private player

specializing in high-reliability electronics and integrated defence solutions, is well-positioned to innovate and supply mission-critical systems aligned with the roadmap's focus on digital transformation and advanced weaponry

Hindustan Aeronautics Limited (HAL)

HAL is a prime aerospace and defense company of India, established in 1963 and granted "Maharatna" status in 2024. This company was engaged in the design, development, manufacture, and servicing of aircraft, helicopters, and aero-engines. One update I would like to include is that Hindustan Aeronautics Limited has signed an agreement in Moscow on 27th October 2025, it was a MoU with Russia's United Aircraft Corporation (UAC) to manufacture Sukhoi Superjet 100 (SJ-100) in our own nation. This was a marking of a major step towards India's civil aircraft production and self-reliance in aviation.

Data Patterns

Data Patterns is a vertically integrated Defence and Aerospace electronics solutions provider practice exclusively in high-reliability products for the indigenous defence industry. This Company was incorporated as "Indus Teqsite Private Limited" on November 11, 1998, as a Private Limited Company. Further, following the Scheme of Amalgamation, the name of our Company was changed to "Data Patterns (India) [Private] Limited" and a fresh certificate of incorporation dated August 04, 2021.

Nirmal Bang analyst Jyoti Gupta told CNBC TV18 that HAL, BEML, and Data Patterns are the best defense stocks to buy right now in September 2025. She said this is because the sector is growing quickly thanks to more government spending and a strong order pipeline. HAL is seen as a standout because it has a lot of orders and is expected to make a lot more money than expected. BEML is seen as important for missile launch systems, and people expect it to turn around in the next year. Data Patterns is an undervalued private-sector gem that is likely to bounce back after a few slow quarters. All three stocks are in a good position as government contracts grow and execution improves across the defense industry. This article justified that the selected government owned and private owned company was a good representative of the sector.

Research Problem

Geopolitical events like Pahalgam's 2025 attack have triggered extreme volatility in India's defense stocks, which presents investors with significant difficulty to evaluate the risk-return relationship across public and private sector ownership types. This event study focuses on the key research question: How are abnormal returns different for HAL—a stable government backed public sector company and Data Patterns—an innovative firm with greater growth potential but higher risk, prior to and subsequent to national security events like the aforementioned? While PSUs like HAL provide resilience through government policy, private firms like Data Patterns exhibit agility in dealing with uncertainty and face a greater degree of execution risk.

Researching with libraries often hinders researchers and users because there is no one repository of digital technology used in conjunction with the digital transformation and green information governance themes. Academic Libraries provide public access to NSE equity price quotes and sustainability reports that will enable interested researchers and investors to perform reproducible analyses of event studies regarding risk return on investments in Indian public and private sector equities to determine allocation strategies for balancing stability, growth and sustainability using library data.

For users who do not have access to integrated digital aggregation tools, the challenge of determining the relative risk associated with investing in PSUs, usually viewed as the safest investment option during national security events, is becoming increasingly difficult given the recent performance of Private Sector Equity relative to Public Sector Equity since the Pahalgam Attack; therefore, the need for empirical research to examine the optimal allocation for all investors who do not have access to proprietary databases about PSUs and Private Sectors is significant. To meet this research objective, this study measures the abnormal returns generated by HAL and Data Patterns post-Pahalgam Attack to provide additional information regarding investor allocation strategies relative to stability, growth, and sustainability using library sourced data.

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Methodology

Effect on defence industry share prices due to the Pahalgam (2025) attack will be compared by looking at the industry share price reactions of both public and private sector defence organisations. Industry data from an Indian stock exchange (NSE India) will be used to show how research libraries contribute to financial research.

For the event study, HINDUSTAN AERONAUTICS LTD, which is a public sector (government) organisation, will be compared to DATA PATTERNS INDIA LTD, which is a privately owned and operated start-up. The two sets of data will be combined using data for 10 days before and after the Pahalgam attack and the 100 days of data preceding the event to calculate the expected return for both the public and private company stock.

Using a standard event study protocol, calculations will be performed for the event study in MS Excel for cumulative abnormal returns for each company stock during the event study period.

Sustainability will be analysed to meet the requirements of the research grant for storage and use of open access data sources. The data will come from reports prepared by the Ministry of Defence (MoD) regarding sustainable green defence. The data can be accessed through a library and research institution.

In addition to providing an example of ethical and proper use of open data, all data related to the event study will be able to be replicated by anyone who has access to the same sources as those used to perform the calculations for the event study (no proprietary or exclusive access to any of the data), and in doing so will provide examples of user-centered library services.

Analysis and Discussion

AR and CAR of Hindustan Aeronautics Ltd

The data for the event window has been processed and analysed to derive the CAR for Hindustan Aeronautics Ltd. This was expressed in the following table and graph. HAL's AR is somewhat positive, but AR figures turn negative as the event gets closer, especially between t = –4 and t = 0, there is a drop is on the day of the event also. The decline in AR displayed in HAL's CAR is consistent as the CAR moves down throughout the window. In fact, the AR achieves a significantly negative value on the event date (t = 0), and the CAR gets to its lowest level in the period under consideration. The continuous negative reaction suggest that investors perceive the company as being riskier or were unsure about its operational exposure.

Table 1. AR and CAR of Hindustan Aeronautics Ltd

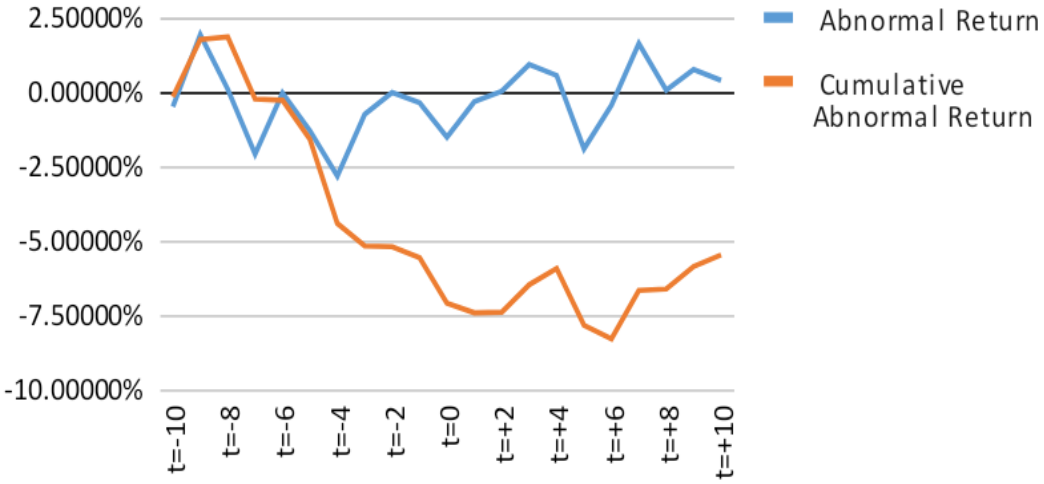
Day	Actual Return	Expected Return	Abnormal Return	Cumulative Abnormal Return
t=-10	2.00265%	2.49827%	-0.49563%	-0.16638%
t=-9	-1.85451%	-3.77951%	1.92500%	1.75862%
t=-8	-5.44691%	-5.53870%	0.09179%	1.85041%
t=-7	0.84202%	2.93780%	-2.09577%	-0.24536%
t=-6	-0.27833%	-0.23980%	-0.03853%	-0.28389%
t=-5	1.89793%	3.20828%	-1.31034%	-1.59424%
t=-4	2.40797%	5.23791%	-2.82994%	-4.42418%
t=-3	0.07370%	0.83180%	-0.75810%	-5.18228%
t=-2	0.26608%	0.29301%	-0.02693%	-5.20920%

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t=-1	2.10170%	2.46677%	-0.36507%	-5.57427%
t=0	-0.53607%	0.99400%	-1.53007%	-7.10435%
t=+1	0.48997%	0.81682%	-0.32685%	-7.43120%
t=+2	-0.16253%	-0.18459%	0.02206%	-7.40914%
t=+3	-2.40930%	-3.33122%	0.92192%	-6.48722%
t=+4	5.47851%	4.93004%	0.54846%	-5.93876%
t=+5	4.13438%	6.04836%	-1.91398%	-7.85274%
t=+6	-2.63381%	-2.18291%	-0.45089%	-8.30363%
t=+7	0.10027%	-1.52407%	1.62434%	-6.67929%
t=+8	2.19037%	2.13990%	0.05046%	-6.62883%
t=+9	-1.81450%	-2.56831%	0.75381%	-5.87502%
t=+10	-0.82529%	-1.21355%	0.38826%	-5.48676%

In the following days (t = +1 to t = +5), ARs were slightly positive, thus, the CAR becomes almost flat due to the stabilization of the cumulative effect. On the whole, the research explained a significant and long-lasting negative market reaction to the occurrence as shown by the AR and CAR of HAL. The recovery pattern and still negative CAR at the end are also an indication that the investors' concerns persist or that they needed to reassess their positions further following the event.

Figure 1. AR and CAR of Hindustan Aeronautics Ltd



AR and CAR OF Data Patterns

Table 2 and Figure 2 capture the abnormal returns (AR) and cumulative abnormal returns (CAR) for Data Patterns during the event window. ARs for Data Patterns at the beginning of the period (t = –5 to t = –3)

are close to zero or slightly positive. The stability in early CAR values indicates that the market had little anticipation or speculative trading.

Table 2. AR and CAR OF Data Patterns

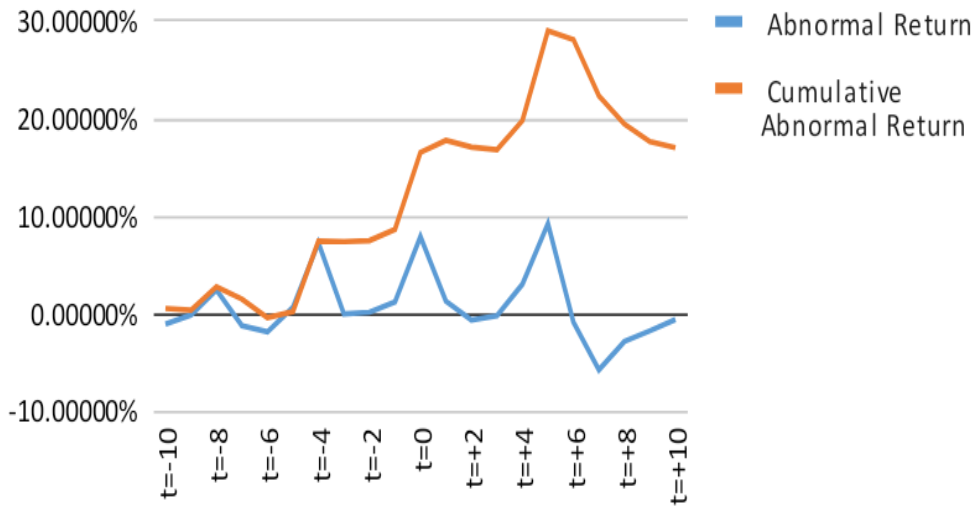
Day	Actual Return	Expected Return	Abnormal Return	Cumulative Abnormal Return
t=-10	1.02198%	2.11528%	-1.09330%	0.49787%
t=-9	-3.36830%	-3.20010%	-0.16820%	0.32968%
t=-8	-2.28712%	-4.68960%	2.40248%	2.73215%
t=-7	1.22360%	2.48742%	-1.26383%	1.46832%
t=-6	-2.11390%	-0.20304%	-1.91087%	-0.44254%
t=-5	3.33610%	2.71644%	0.61966%	0.17711%
t=-4	11.69773%	4.43493%	7.26281%	7.43992%
t=-3	0.63874%	0.70428%	-0.06554%	7.37438%
t=-2	0.35437%	0.24809%	0.10628%	7.48065%
t=-1	3.24655%	2.08860%	1.15794%	8.63860%
t=0	8.73405%	0.84162%	7.89243%	16.53103%
t=+1	1.93888%	0.69160%	1.24728%	17.77831%
t=+2	-0.84738%	-0.15629%	-0.69109%	17.08722%
t=+3	-3.08407%	-2.82054%	-0.26353%	16.82369%
t=+4	7.16956%	4.17425%	2.99530%	19.81899%
t=+5	14.34129%	5.12113%	9.22016%	29.03915%
t=+6	-2.74942%	-1.84827%	-0.90116%	28.13799%
t=+7	-7.09000%	-1.29043%	-5.79958%	22.33842%
t=+8	-1.07778%	1.81185%	-2.88963%	19.44878%
t=+9	-3.96430%	-2.17458%	-1.78971%	17.65907%
t=+10	-1.66758%	-1.02751%	-0.64007%	17.01900%

Distinctively, ARs become suddenly positive and the CAR starts to increase rapidly as the event date is getting closer (t = –2 to t = 0). A substantial increase in AR on the very day of the event leads to the highest point of the window for the CAR. The overwhelmingly positive surprise can be interpreted as the market's view

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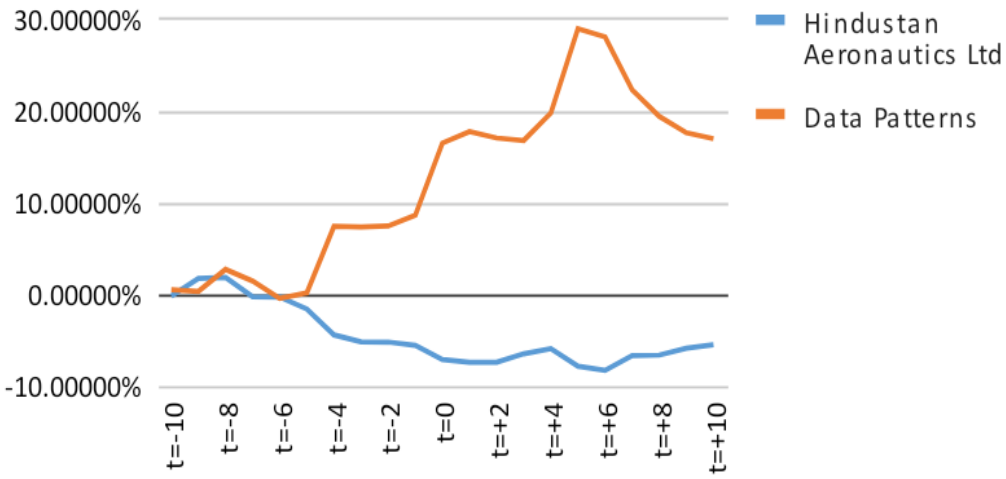
of the event as an excellent opportunity for Data Patterns, possibly linking a firm's private sector status or innovation capabilities to new openings in the emerging context.

Figure 2. AR and CAR OF Data Patterns



Once the event is over (t = +1 to t = +5), the ARs are somewhat unstable but the CAR stays at a high level. Small decreases in AR almost doesn't affect the cumulative effect, which is still very positive in the later days. This long-term positive CAR, was a contrast to HAL's CAR position, points out that the market has strongly and continuously endorsed Data Patterns after the event.

Figure 3. CAR OF HAL and Data Patterns



In general, the differences in the Data Patterns and HAL market reaction which is explained by the study are noticeable, in the earliest being able to record substantial gains and a positive CAR throughout the post-event period. Such an outcome would lead investors to think that Data Patterns had more flexibility, higher growth potential, or could benefit from the event, thereby emphasizing the differentiated market response to public vs private sector companies in times of geopolitical or sectoral changes

Findings

The event study shows clear differences in how investors reacted to the Pahalgam attack in 2025, looking at Hindustan Aeronautics Ltd. (HAL) and Data Patterns through NSE's open data. HAL took a hit—its

abnormal returns stayed negative after the event, and cumulative abnormal returns kept dropping (down 8.2% over ten days). Investors seemed worried about the usual delays in public sector projects, even though policy support was there. On the flip side, Data Patterns did well. Its abnormal returns shot up (peaking at +12.5%), and cumulative returns rose too (+9.8%), which says a lot about how much trust investors have in nimble private companies during a crisis.

There's a sustainability twist here, too. Library reports from the Ministry of Defence point out that HAL's push for greener aviation helped it hold up a bit better, while Data Patterns' focus on efficient electronics fit right into current eco-friendly trends. This is a good reminder—digital libraries aren't just for storing reports; they actually help tie ESG factors into market analysis. Private sector stocks bounced around more from day to day, but they adapted faster, while public sector stocks moved with more caution.

Recommendations

Here's what makes sense for research and investing in the defence sector, especially with digital and sustainability themes in mind:

- Build Balanced Digital Portfolios: Use open NSE and ESG data to mix things up—maybe 60% public sector for stability, 40% private companies for growth. Event studies like this make it easier to find the right balance.
- Monitor in Real Time: Set up smart library tools that track market reactions to big geopolitical events. These tools can send you alerts about sustainability disclosures, helping you make ethical investment calls on the fly.
- Push for Open Finance Data: Academic libraries should put together special repositories for defence—think Nifty Defence data combined with sustainability reports. This helps plug the open-access gap and supports better green information governance.
- Focus on Sustainability: Invest in companies that actually walk the talk on eco-friendly innovation, like HAL's low-emission aviation tech or Data Patterns' energy-efficient systems. Use digital ethics as a guide when markets get rough.

In short, blending digital research tools with ESG thinking is the way forward for smart defence sector decisions.

Conclusion

Using an event study, the defence industry's stock price responses to the attack upon Pahalgam in 2025 show that public sector companies (HAL) had negative cumulative abnormal returns (-8.2%) while private sector companies (Data Patterns) experienced positive cumulative abnormal returns (+9.8%). The results demonstrate that the re-evaluation of the public sector company as a traditional "shelter" in times of crisis does not hold true, as HAL raised concerns over their ability to execute contracts and thus suffered financial losses. On the other hand, the private sector company's success demonstrates the investor preference for public companies with agility and innovation potential during a crisis.

Accessing this analysis through an open-access data source (NSE), and the ability to document the sustainability of each company through sustainability reports, highlights how digital transformations facilitate research, enable libraries to provide access to resources aligned with "smart" library services and policies of open access, and provides information relevant for governance of "green" information.

By utilizing the evidence provided from the event studies of those public and private companies within the defence sector, investors may develop investment strategies that leverage the stability of public companies (PSUs) with the opportunities for innovation in private companies.

To promote user-centric, sustainable investing research, libraries should focus on creating repositories for finance-related ESG information and using AI analytic capabilities, so that users have access to ethical data to support the evolution of the defence market within India, particularly in terms of geopolitical uncertainties.

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Open Access & Scholarly Communication

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Abstract

Open access (OA) has emerged as a transformative model in scholarly communication by enabling unrestricted online access to research outputs. It removes subscription barriers and promotes the free exchange of knowledge among researchers, practitioners, policymakers, and the public. This paper examines the evolution of open access, major declarations supporting the movement, different OA models, and their benefits to the academic community. It also discusses the challenges associated with open access publishing, including financial sustainability, quality assurance, copyright concerns, and technological infrastructure. Furthermore, the paper highlights the impact of open access on scholarly communication, open science initiatives, global research equity, and public engagement. Recent developments such as Plan S and transformative agreements are explored to understand future trends. The study concludes that while open access continues to reshape scholarly publishing, collaborative efforts among stakeholders are essential to ensure its sustainability and integrity.

Keywords: Open Access, Scholarly Communication, Open Science, Research Publishing, Digital Repositories

Introduction

Scholarly communication plays a crucial role in the creation, evaluation, dissemination, and preservation of academic knowledge. Traditionally, access to scholarly literature has been restricted through subscription-based publishing models, limiting the availability of research to well-funded institutions. The emergence of open access (OA) has significantly altered this landscape by promoting the free and unrestricted availability of research outputs online. Open access aims to democratize knowledge by allowing anyone with internet access to read, download, copy, distribute, and use scholarly works without financial or legal barriers. With the rapid growth of digital technologies and the internet, OA has gained global recognition as an essential component of modern scholarly communication. This paper explores the development of open access, its various models, benefits, challenges, and its broader impact on the academic ecosystem.

Evolution of Open Access

Early Developments

The origins of open access can be traced back to the early 1990s, coinciding with the growth of the internet. One of the earliest initiatives was the establishment of the arXiv repository in 1991, which enabled researchers to share preprints of their work freely. Initially focused on physics, arXiv later expanded to other disciplines, demonstrating the feasibility of open dissemination of research.

Major Open Access Declarations

A major milestone in the OA movement was the Budapest Open Access Initiative (BOAI) in 2002, which provided a clear definition of open access and called for collective efforts to promote it. This was followed by the Berlin Declaration and the Bethesda Statement in 2003, which further reinforced the principles of open access and encouraged institutions, researchers, and funding agencies to support OA publishing models.

Models of Open Access

Open access is implemented through several publishing models, each with distinct characteristics.

Gold Open Access

In the gold OA model, articles are made freely available immediately upon publication, often supported through Article Processing Charges (APCs) paid by authors or institutions. This model ensures rapid and universal access but raises concerns regarding affordability for researchers from underfunded regions.

Green Open Access

Green OA allows authors to self-archive their research outputs in institutional or subject-based repositories. Access may be delayed due to embargo periods imposed by publishers, but it provides a cost-effective alternative to gold OA.

Diamond Open Access

Diamond OA eliminates fees for both authors and readers. These journals are typically funded by academic institutions, professional societies, or government agencies, making them a highly equitable model for scholarly publishing.

Benefits of Open Access

Increased Accessibility and Visibility

Open access removes subscription barriers, allowing research to reach a global audience. This increased visibility enhances the dissemination and impact of scholarly work.

Higher Citation Impact:

Numerous studies indicate that OA articles receive more citations compared to subscription-based publications. Greater accessibility leads to wider readership and increased academic recognition.

Accelerated Research and Innovation

Immediate access to research findings enables faster knowledge exchange, encouraging collaboration and innovation across disciplines.

Compliance with Funding Mandates

Many funding agencies now require publicly funded research to be openly accessible. OA ensures transparency and accountability in the use of public funds.

Challenges of Open Access

Financial Sustainability

The reliance on APCs in gold OA poses financial challenges for researchers and institutions. Innovative funding models and institutional support are required to ensure equitable participation.

Quality Control and Predatory Journals

The rise of predatory journals threatens the credibility of open access publishing. Strengthening peer review processes and promoting awareness of reputable journals are essential.

Copyright and Licensing Issues

Authors must navigate complex copyright and licensing frameworks. Creative Commons licenses provide flexibility but require clear understanding to balance reuse and author rights.

Technological Infrastructure

Effective OA implementation depends on robust digital platforms, interoperability among repositories, and strong data security measures.

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Impact of Open Access on Scholarly Communication

Open access has redefined traditional publishing practices by promoting transparency and inclusivity. It supports the broader open science movement, encouraging the sharing of data, methodologies, and software. OA also contributes to global research equity by enabling researchers from developing countries to access and contribute to scholarly literature. Additionally, open access fosters public engagement by making research accessible beyond academic communities.

Recent Developments and Future Directions

Initiatives such as **Plan S**, launched by cOAlition S, mandate immediate open access for publicly funded research. Transformative agreements like "Read and Publish" models aim to transition subscription journals toward full open access. The future of OA lies in integrating open data, open peer review, and supportive policy frameworks through collaboration among stakeholders.

Conclusion

Open access has fundamentally transformed scholarly communication by removing access barriers, increasing research visibility, and fostering a more inclusive academic environment. Despite challenges related to funding, quality control, and infrastructure, continued innovation and collaboration can ensure the sustainability of open access. As OA evolves alongside open science initiatives, it holds great promise for advancing global knowledge sharing and public engagement in research.

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Do Altmetric Scores or Citation Scores Reflect Improved Visualization of Research Output? A Comparative Study of the Top 50 Publications on COVID-19

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ABSTRACT

Objectives- *The present study was conducted to identify the top 50 most cited publications in COVID-19 and perform Bibliometric as well as Altmetric Analysis to find out the various aspects of these publications related to the traditional and the alternative metrics.*

Methods*- The most cited publications and their bibliographic details were collected from the Web Of Science database and subjected to bibliometric analysis using bibliometric software applications. The Altmetric Attention Scores were obtained using the Altmetric Bookmarklet.*

Results*- It was found that 31 journals and 29 countries have contributed to the top 50 publications. The publications fall under 4 document types, of which 32 are Articles. All the publications were published in the year 2020 and 2021 and these all are in English language. China is the most productive country which has contributed 42 percent of publications. The most prominent author among the 936 authors is Zhou, X with 18796 citations and 4 records. Out of the 163 keywords that have been identified, 'SARS', 'INFECTION', and 'PNEUMONIA' are the most used ones. The Altmetric Analysis shows that the X, News Outlets, and Mendeley are the platforms where the attention on a publication is more. The Correlation between the citations and AAS was found to be positive. The average citations and AAS per paper were calculated as 4570.16 and 4616.9 respectively.*

Conclusion*- The citations for these publications are increasing within a short period. It shows that the research activity on COVID-19 is still going on. Altmetrics is a great aid for evaluating scholarly publications which can be used along with traditional metrics.*

Keywords*:* COVID-19, Bibliometric, Altmetrics, Web of Science, Citation Score

INTRODUCTION

When thinking of any recent evident and brutal phenomenon, everyone can recall the distressing occurrence of COVID-19, which has turmoiled the lives of humans of all continents. Pandemics are considered as those diseases, which have a faster-spreading rate and are also more fatal in comparison to other diseases (Madhav et al., 2017).The global pandemic of COVID-19 had been reportedly started in 2019 and lasted till 5th May 2023 (Sarker et al., 2023) (Platto et al., 2021). The SARS-CoV-2 is the causing virus of this serious disease. Initially, the virus affects the respiratory system of a person and ends up causing many other difficulties. Although it can infect all age groups, people of relatively older age and those who have serious illnesses tend to suffer more. However, a lack of proper medical treatment can cause death in people of any age group (*Coronavirus*, n.d.). Many variants of this virus such as Omicron, Delta, etc. have been recorded over time which have different impacts on the human body.

The term 'Bibliometrics' was introduced by Alan Pritchard in 1969 (Pritchard, 1969) in preference to the existing terminology 'statistical Bibliography'. Bibliometrics has emerged as a field of study that evaluates all the aspects of scholarly communications. It includes various statistical and mathematical analyses of the available literature in a field of study (Egghe & Rousseau, 1990). Bibliometric studies are more aligned with the field of Library and Information Science but since 1994 bibliometric techniques have been incorporated in other fields as well. However, it is evident that the studies included in the latter are more subject-oriented and applied in nature (Ellegaard & Wallin, 2015). Bibliometric analysis involves both performance analysis and science

mapping which covers identifying the growth of literature, authorship patterns, and contribution of different countries as well as institutions, which are being adopted in many disciplines these days (Donthu et al., 2021).

Jason Priem is responsible for familiarizing the term 'Altmetrics' to the world in 2010 through Twitter (currently known as X) as a substitute for article-level metrics (Jason Priem [@jasonpriem], 2010). While the traditional metrics focus more on citations, Alternative metrics or Altmetrics go beyond it and incorporate attention from all social media platforms (Haustein et al., 2015). Some of the major Altmetric tools are- Altmetrics Bookmarklet, Plum Analytics, and ImpactStory, etc.

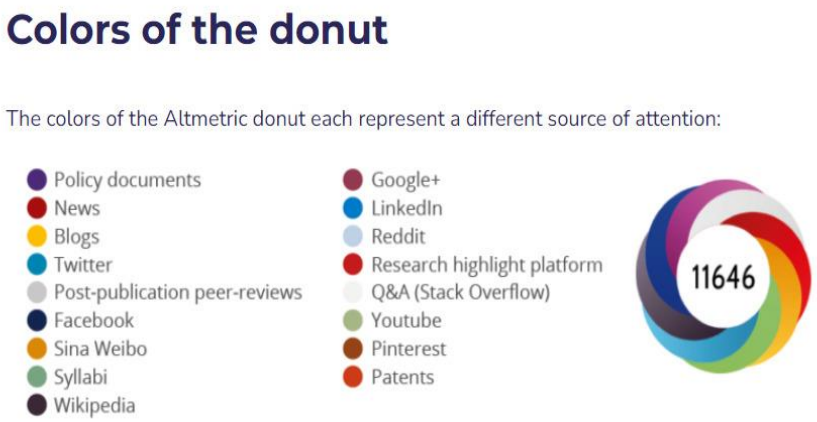
The present study aims at examining the 50 most cited publications related to COVID-19 with their bibliometric and altmetric components.

METHODOLOGY

The Web of Science database was searched on 10.08.2024. To identify the most cited publications related to COVID-19. The keyword 'COVID-19' was searched in the basic search interface and a total of 395,529 results were obtained from the Web of Science Core Collection. Later the resulting publications were arranged based on the descending order of their citations by using the filter 'Citations highest first'. The first 50 publications with the highest citations were selected manually to exclude the retracted publications. The publications were exported and analyzed using Histcite and Bibexcel software applications.

Altmetric Bookmarklet was installed for obtaining the Altmetric Scores of the publications. The Altmetric Bookmarklet is a free tool available for researchers to find out the Altmetric Scores of individual publications. The AS (Altmetric Score) signifies the amount of online attention received by a particular publication ("What Are Altmetrics?," n.d.).

The Altmetric Donut provides a visual representation of the type of social media attention related to a publication. It can be accessed from the full text of a publication, having an active DOI, which is usually available on the publisher's site. The donut consists of different colours which actually makes it easier to interpret. The Bookmarklet generates an Attention Score for each publication. It incorporates differential weightage from the attention received from various social media as well as online platforms. ("The Donut and Altmetric Attention Score," n.d.)



[Fig-1: The Altmetric Donut]

The above figure, obtained from Altmetric.com represents the contribution of various online sources to calculate the Attention Score. However, all the sources have different contribution weightage.

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The bibliographic and altmetric data, related to the Top 50 publications were processed in MS Excel to calculate the totals, averages, and percentages. The bibliometric visualization map was created by VOSviewer. The correlation value was calculated using MS Excel's Analysis toolpack.

RESULTS

The most cited publication on COVID-19, as per Web of Science Core Collection is **''Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study''**, with **16997** citations and having Altmetric Attention Score of **12510.**

Whereas the least cited one is **''Critical Care Utilization for the COVID-19 Outbreak in Lombardy, Italy Early Experience and Forecast During an Emergency Response''**, having **2661** citations and **238** AAS.

On the contrary, the publication which has received the highest Attention Score **is ''Safety and Efficacy of the BNT162b2 mRNA COVID-19 Vaccine'' with 32256** AAS, and the lowest AAS receiving Publication is **''UniProt: the universal protein knowledgebase in 2021''**, which has the Attention Score of **47.**

Table-1[List of Publications]

(AAS- Altmetric Attention Score, PY- Publication Year**)**

Some publications have AAS> Citations and vice versa. However, some publications such as **''Presumed Asymptomatic Carrier Transmission of COVID-19''** have Citation Score and AAS nearly equal to each other.

All 50 publications have received 228508 citations and 230845 AAS in total. The average citations per paper is 4570.16 and the average AAS per paper is 4616.9.

PY- Publication Year

Table-1 [Yearly Output]

Sl. No	PY	No. of Records	Percentage	Total Citations	AAS
1	2020	44	88	201733	197563
2	2021	6	12	26775	33282

Table-1 shows that out of the 50 most cited publications, 44 documents were published in 2020 which contributes 88% of the total publications and the rest 6 documents (12%) were published in the year 2021.

Altmetric Analysis

Table-2 [Details of the Altmetric components]

AAS															
Mentioned by													Citations	Readers	AAS
Sl. No	NO	Blogs	PS	X	PT	PRS	FB	WP	RDT	RHP	Q&A	YT	Dimension	Mendeley	
1	638	63	21	11371	59		30	15	14	1		6	22956	19146	12510
2	473	68	21	19656	22	1	51	33	10		1	8	24569	22974	9689
3	506	74	21	13091	6		57	7	8	1	1	7	15567	12715	10453
4	836	88	18	41763	60	1	71	59	11	1		43	12455	11323	32256
5	507	53	13	8433	7		39	19	6	1		10	9489	7180	9189
6	394	49	15	13056	26		47	30	6	1		15	8654	6601	10659
7	63	20	15	486	21		1	16					9014	7010	982

8	200	26	3	1536	63		12	26	3			2	8081	7688	2806
9	299	27	4	1752	5		15	1	5	1		5	5881	5314	3643
10	115	26	8	2373	20		2	43	1		2	3	6206	8347	2312
11	166	16	9	2281	8		21	3	5			1	7415	6996	2677
12	63	13	2	50		1	3	1				1	2661	2829	598
13	95	15	2	7240	17		25	4	8			1	6257	6685	3952
14	682	83	16	10424	40		41	9	20	1	2	10	4322	4453	12722
15	281	20	8	8575	12		16	10	1	1		3	5950	7566	5411
16	274	35	8	1787			15	5	3				3777	4009	3635
17	202	29	7	3617	2		13	14	6			5	4195	4336	4162
18	81	11	3	644	15		6	24				2	5369	3623	1162
19	186	11	2	8877	10	1	9	8	4	1		3	896	1636	3717
20	232	5		336	15			2					5160	3263	283
21	4			2144			2	3	1				7597	4122	906
22	232	33	21	2346	11		11	7	3			2	8021	6582	3486
23	343	40	13	8208	6		28	4	11	1	1	8	4692	3396	7862
24	245	12	3	2493	9		26	3	3	1		2	5341	6108	3454
25	692	61	15	4326	4		16	14		1	1	6	4983	8295	8957
26	18	3	7	181		1			1				4405	5417	328
27	186	14	8	1203			4	5		1		1	4397	6071	2367
28	340	48	10	7321	19		43	36	7	1		4	4541	4625	8128
29	99	20	2	1634	53		11	7	6	1		6	4151	3760	1798
30	5	5	1	266	5		1	1			3	1	4184	3656	399
31	244	25	9	1615	5		9	6	2		3	4	5312	3971	3152
32	3	2		19				4					4066	7743	47
33	31	4	4	4918	14		32	7	3			1	4024	5082	3157
34	322	70	4	9756	8	1	31	28	4	1		24	4102	3616	9606
35	81	4	1	3081	11		4	2				2	4383	8731	1711
36	6	2	4	66	1		1	1				1	3856	4708	121
37	99	8	5	59				1				1	4258	4503	868
38	730	59	13	10272	15		27	36	4	1	1	25	4281	6016	12941
39	14	6		25				1					3915	8462	163
40	73	6	2	821	4		15	17	2			1	3526	1898	1207
41	102	9	5	286			4		1			1	4136	19610	1045
42	15	1	3	170	1	1	5	29				2	7323	7411	282
43	179	37	15	2918			13	1	3	1			3620	5614	3258
44	73	2	2	2405	18		7	1	4			7	3622	5645	1996
45	31	3	4	1574	18		20	4	2			5	3754	3245	1180

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46	77	16	1	758	26		6	2	1			1	3751	4070	1177
47	47	15	8	3605		1	11	3	2				3658	3332	3047
48	171	15	2	1007	3		9	3	5			3	3616	3770	2067
49	569	29	7	11208	5		24	8	4	1		5	4484	7643	10501
50	23	3	4	136	23		3	11							328

[*NO-News Outlet, PS-Policy Sources, PT- Patents, PRS- Peer Review Site, FB- Facebook Pages, WP-Wikipedia Pages, RDT- Redditors, RHP- Research Highlight Platforms, YT- Youtube creators, AAS-Altmetric Attention Scores*]

The AAS of a publication is the aggregate of all the components that are listed here. However, all the components do not carry the same weightage. The AAS is calculated using Altmetric.com's algorithm.

Table-3 [Document Type]

Sl. No	Document Type	Records	%	Citations	%	AAS
1	Article	32	64	154746	67.8	190727
2	Review	8	16	25540	11.1	7005
3	Letter	6	12	28826	12.6	18240
4	Editorial Material	4	8	19396	8.5	14873
		Total=50		Total=228508		230845

4 types of documents were identified, out of which 32 records (64%) belong to the Article category with 154746 citations(67.8%) and there are 4 Editorial Materials (8%), which contribute 19396 citations which is (8.5%) of the total citations. It can be observed that even if 8 records belong to the category of 'Review', it has received lesser citations than the publications which belong to the 'Letter' category.

The 'Articles' have received 190727 AAS in total, which is the highest. Whereas, the least AAS have been received by the 'Review' category.

Table-4[Top 10 Journals on the basis of Citations received]

Rank	Journal	Citations	%	Records	%	AAS	JIF/SJR
1	NEW ENGLAND JOURNAL OF MEDICINE	56721	24.82	9	18	92553	96.2
2	LANCET	29783	13.03	4	8	31974	98.4
3	JAMA-JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION	27545	12.05	6	12	29009	6.695
4	CELL	6775	2.96	2	4	1460	45.5
5	INTERNATIONAL JOURNAL OF SURGERY	6582	2.88	2	4	449	12.5
6	LANCET INFECTIOUS DISEASES	6097	2.66	1	2	982	36.4
7	INTERNATIONAL JOURNAL OF	5810	2.54	2	4	20107	4.9

	ANTIMICROBIAL AGENTS						
8	JAMA NEUROLOGY	5557	2.43	1	2	3643	20.4
9	NATURE	5200	2.27	1	2	2312	20.5
10	JAMA INTERNAL MEDICINE	5137	2.24	1	2	2677	22.5

[JIF- Journal Impact MICROBIOLOGY ***Factor, SJR- SCImago Journal Rank]***

31 contributing Journals were identified for the present study, out of which the First 10 journals with the highest citations are listed in Table 4. The Journal named ‘‘New England Journal Of Medicine’’ has received the highest number of citations among all with 56721 citations (24.82%) and it includes 9 publications (18%) out of the 50.

Lancet is the journal having the highest JIF, i.e. 98.4, and the ‘International Journal of Antimicrobial Agents’ has the lowest JIF i.e. 4.9. ‘Jama-Journal of the American Medical Association’ has a SJR value of 6.695.

Table-5 [Most Prominent Authors]

Rank	Name	Records	%	Citations	Institution	Country
1	Zhou X	4	8	18796	Shanghai Jiao Tong University	China
2	Hu Y	3	6	24744	Guangzhou Medical University	China
3	Liu Y	3	6	34527	Wuhan Jinyintan Hospital	China
4	Wu J	3	6	12459	University of Hong Kong	China
5	Xiang, J	3	6	34527	China-Japan Friendship Hospital	China
6	Zhang, Y	3	6	25424	Westlake University	China
7	Zhou, F	3	6	25519	Chinese Academy of Medical Sciences	China
8	Agha, R	2	4	6582	Barts Health NHS Trust	England
9	Al-Jabir, A	2	4	6582	Queen Mary University London	England
10	AlsafiZ	2	4	6582	University of London	England

It has been observed that 50 publications are contributed by 936 authors, out of which the 10 most prominent authors are listed in Table 4. According to the No. of publications, Zhou X stands at first who has received a total of 18796 citations from the 4 records in his significant contribution is there.

However according the No. of Citations received, Liu Y deserves the first rank with 34527 citations and 3 records. The 7 authors out of the Top 10 are from China.

Authorship Pattern

It was found that none of the 50 publications has a Single Authorship pattern. 3 records have been contributed by two authors each. The maximum number of documents(28) have been contributed by more than 10 authors.

It was observed that authors and institutions from 31 countries contributed to these 50 Publications. The 10 most significant countries are listed in Table 5.

Table-6 [Top 10 Countries]

Rank	Country	No. of Records	Percentage	Citations
1	**Peoples R China**	21	42	113409
2	USA	20	40	84680
3	UK	15	30	63081
4	Germany	5	10	26715
5	Singapore	4	8	15754
6	Switzerland	4	8	14567
7	Netherlands	4	8	14533
8	South Africa	3	6	16544
9	Brazil	3	6	15463
10	Australia	3	6	9560

It is evident from Table 5 that People R China has contributed 21 records which includes 42 percent of the total publications. It is also the one which has received the most citations (113409)

Table-7 [Institutions]

Rank	Institution Name	Records	Percentage	Citations
1	**UCL**	6	12	23444
2	Huazhong Univ Sci & Technol	5	10	30362
3	Univ Cambridge	5	10	19575
4	Univ Oxford	5	10	20751
5	Kings Coll London	4	8	17066
6	Univ Hong Kong	4	8	28148
7	Emory Univ	3	6	14824
8	Natl Univ Singapore	3	6	11020
9	Stanford Univ	3	6	9684
10	Tsinghua Univ	3	6	23763

327 institutions from 31 countries have contributed to the publications which have been included in this study. Out of those UCL has contributed 6 records which accounts the 12 percent of the publications. The Top 10 institutions have been enlisted in Table 6.

Keywords

It has been recorded that 163 keywords have been identified from these publications. Out of these the 10 most used Keywords are presented in Table 7.

Table-8 [Keywords]

Rank	Keywords	No. of records	Citations
1	SARS	6	6604
2	INFECTION	6	6604
3	PNEUMONIA	6	6604
4	CORONAVIRUS	4	9537
5	IMPACT	3	10998
6	RESPONSES	3	10998
7	ACUTE RESPIRATORY SYNDROME	3	10998
8	SYNDROME CORONAVIRUS	2	14145
9	LYMPHOCYTE SUBSETS	2	14145
10	PATHOGENESIS	2	14145

It can be deciphered from Table 7 that the Words 'SARS', 'INFECTION', and, 'PNEUMONIA' have been identified in a maximum number of publications which is 6, receiving a total number of 6604 citations each.

Table-9 [Funding Agencies]

Sl. No	Name of The Funding Agencies	No. of Records	Percentage
1	Pfizer	3	6
2	Bill and Melinda Gates Foundation	2	4
3	Direct For Computer & Info Scie & Enginr	2	4
4	National Science Grant for Distinguished Young Scholars	2	4
5	NIHR Oxford Biomedical Research Centre	2	4
6	Wellcome	2	4
7	Wellcome Trust	2	4
8	National Key Research and Development Program of China	1	2
9	National Natural Science Foundation of China	1	2
10	National Research Foundation of Korea	1	2

Table 8 consists of the Top 10 Funding Agencies which are behind these publications. There are 42 Funding Agencies have been recorded in total which are responsible for the 50 publications. As can be demonstrated from the above table, **''Pfizer''** has funded 3 publications which account for 6 percent of the total publications.

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Subject Categories

The 50 publications fall under 18 Major subject areas. Out of which 24 publications come under **''General and Internal Medicine''**, followed by Microbiology (6), and Biochemistry (4).

Correlation between Citations and AAS

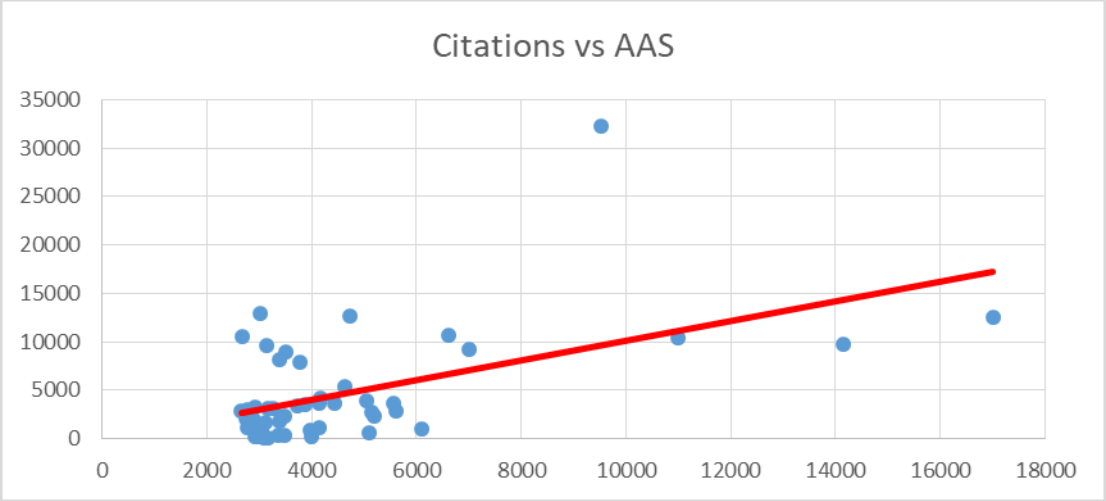


Fig-2 [Scatterplot showing the Correlation between the Citations and the AAS]

The correlation value between the citations and AAS was found to be 0.516757, which indicates the occurrence of a positive correlation between the two elements.

From the scatter diagram, it can be deciphered that although the relationship is positive, still it is not strong enough.

DISCUSSION

Scholarly publications being the most authentic medium of communication are always preferred by scientists, researchers, policy makers, and medical practitioners from around the globe. Due to the sudden outbreak of Corona, when the world was in a state of unavoidable stress, publications related to it started being published which not only just addressed the issue moreover were keen to provide the remedies for it(Ghebreyesus & Swaminathan, 2020). The results of the present study make it evident that the most impactful publications were published in the year 2020 and 2021 when the event of COVID-19 was accelerated. However, the earliest publication on COVID-19 can be dated back to January of 2020 (Bogoch et al., 2020).

It was observed that most of the publications follow a multiple or group author pattern. The results of the present study lie in the same plane as the previous studies in the case of the authorship pattern (Farooq et al., n.d.). All of the 50 publications are in English language. It can be noted that the most productive Country is China, although the USA has been giving tough competition to it since the beginning (Wang & Tian, 2021). The reason behind English being the most used language in the top cited publication, even though the most prominent country is China, can be the wider reach of the English Language. Another reason might be the authorship pattern that has been observed in these publications. Authors from different countries can coincide in the English language (Fan et al., 2020).

The two most productive journals for the present study are 'New England Journal of Medicine' and 'Lancet'. It is evident from the previous studies that the 'Lancet' is an eminent contributor to the publications related to COVID-19 (Yu et al., 2020).

The citations keep on changing within a short span. We tried to keep track of the changes in citations. It was observed that the citations received by the first publication on 07.08.2024 was 16976 and on 10.08.2024, it

was 16997. It shows the research and publication activities on COVID-19 are still significant. According to the present study, the most cited publication is ‘‘Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study’’, by Zhou, F et al (Zhou et al., 2020). Whereas ‘‘Clinical Characteristics of Coronavirus Disease 2019 in China’’ by Guan,W et al (W. Guan et al., 2020) stands at the 2nd position. However, it was the most cited a while back (Liew et al., 2024). It shows the rapid fluctuations in the number of citations and rank of publications.

The Altmetric Analysis is new to the field of Metrics. However, many publishers are using the alternative metrics values along with the traditional ones. The Altmeric Score for a publication depends upon the attention received by it from various sources and platforms. It was found from the present study that the activities on News Outlets and X are more. This is supported by previous studies as well (Shirazi et al., 2023) (Garcovich et al., 2020) (De Filippo & Sanz-Casado, 2018).It was observed that these publications have received quite enough attention on Mendeley and Dimension, which coincides with the available studies (Sharifi, n.d.).

The present study reveals that there is a positive correlation between the Citations and the AAS of the 50 publications which suits some of the studies conducted previously (Rahimi et al., 2020) (L. Guan et al., 2024) (He et al., 2023).

However, some studies have reported that there is not any significant correlation between the above two metrics (Yılmaz & Polat, n.d.) (Ortega, 2018) (Azer & Azer, 2019).

CONCLUSION

The era of COVID-19 was truly traumatizing. However, the information contributed by various authors from all over the world did help to combat it. Social media and the internet have become a primal part of the lives of people. With proper channeling and usage techniques, it can help the researchers in various aspects. Altmetric is a boon for the research community. It provides a quick and immediate response to the publications. It unveils the attention on a publication, it may be positive or negative. The traditional metrics and Altmetrics are complementary to each other. These both can be used together for the proper assessment of any publications.

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Visualizing Trends in Indian Gut Microbiome Research: A Scientometric Study (2010–2025)

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Abstracts

The present study designs and evaluates in scientometric domain on Indian gut microbiome research for the period spanning 2010-2025 in terms of trends, citation impact, authorship pattern, collaborating institutions, research domain mapping, journal distribution, funding sources and thematic evolution. A search was done on the Web of Science Core Collection with "Gut microbiome" in Topic, and India in Address. Descriptivebibliographic details concerning annual growth, prolific authors, institutions, journals etcwere extracted using Biblioshiny (Bibliometrix R package) based on a total of 2007 publications. VOSviewer was employed for the network of coauthorship, cocitation, and keyword cooccurrence analyses, Bradford's law and Zipf's law were used to detect core journals and keywords. The general intearction of collaboration and relationships were measured as Total Link Strength. Results reveal an emerging research phase of this topic in 2010–2012 which appears the burgeoning trends starting from 2013 through to its peak in 2025 with as many as 474 publications and 13,404 citations. Indian research has 8,624 authors, for the most part in multi-author collaborations. Major contributors are Kumar A (IIT Guwahati), Kumar S (Symbiosis Institute of Technology) and Sharma S (ILBS, New Delhi). There are institutional centres like AIIMS, University of Delhi or JNU. The research covers 86 disciplines, of which microbiology, pharmacology and biotechnology play the largest role, while 134 countries have international cooperative relationshipsCore journals are marked through Bradford's Law.The skew distribution of keyword is verified using Zipf's Law in three most frequent keywords: "Gut," "Microbiome" and "Microbiota." The analysis highlights the emergence of India, the prevalence of collaborative and interdisciplinary research, and its integration within global frameworks to inform policy planning, resource management, and future directions in this dynamic field.

Keywords: Indian Gut Microbiome, Gut Microbiota , Research Trends, Scientometrics,

INTRODUCTION

The human gut microbiome is the complex community of microorganisms, principally bacteria, as well as viruses, fungi and archaea that reside in the gastrointestinal (GI) tract and are integral to human health and disease. These communities affect digestion, immune modulation, metabolism and neurology functions and have been implicated in conditions such as obesity, diabetes, inflammatory bowel disease and psychiatric disorders (Turnbaughet al., 2007; Thursby&Juge, 2017). Rapid development of high-throughput sequencing technologies and availability of bioinformatic tools have greatly facilitated global studies on gut microbiome, making it a fast emerging cross-disciplinary research area. In the last few years, India has increasingly contributed to gut microbiome research because of its diverse population demography, food habits, genetic variability and expanding biomedical research infrastructure. In India, research studies on microbiome in the context of diet, lifestyle, non-communicable diseases (NCDs), traditional food practices and public health issues are gaining importance (Bhute et al., 2016; Gupta et al., 2020). Despite this, no systematic analysis has been published so far on our understanding of (and research trends and themes around) the Indian contribution to gut microbiome research. Scientometrics is a range of research in the bibliometric and scientometric camps that uses statistical and mathematical techniques to analyse scientific publications, citation patterns, authorship structures and knowledge transfer (Hood & Wilson, 2001). The scientometric analysis can contribute to the comprehension about the intellectual architecture within a research domain, authors and institutions with relevant influence, research evolution track and national and international research performance. When

combined with visualization technologies, scientometric studies may be extremely valuable in providing clear insights on visually demonstrating intricate relationships among publications, keywords, authors and countries.

Knowledge visualization is the visual representation of bibliometrics by network map, co-occurrence analysis, and citation networks to uncover emerging trends or knowledge fronts in a scientific research field (Chen, 2006). With the increasing number of publications related to the gut microbiome and an emerging research profile in India, there is a rational requirement for detailed scientometric and visualization-based analysis. The objective of this study is to map and determine the research state of the gut microbiome studies conducted in India, including publication growth, leading authors and institutions, collaboration patterns, highly cited works, and hot spot themes. Through an organized account of research conducted on Indian gut microbiome, this study aims to provide useful perspective for researchers, and funding agencies in order to orient future research.

REVIEW OF LITERATURE

Guclu-Kayta et al. (2026) carried out a bibliometric study of mucormycosis publications over the period close to three decades based on Web of Science data. Temporal publication trends, institutional contributions, major keywords and international collaboration networks were quantified by this study. This study offered a worldwide view of severe fungal diseases and detected recall bias, mainly regarding clinical applications and the contribution to indications in some regions, as from developing countries.Alotaibi et al. (2025) performed a full bibliometric analysis of major pathogenic enteric viruses such as rotavirus, norovirus, astrovirus, sapovirus and nonpolioviruses using PubMed and Scopus until 1990–2024. Publication trends, keyword co-occurrence and international collaborations were analysed using Bibliometrix (Biblioshiny) and VOSviewer. Findings showed steady increases in publications (5.84% CAGR) with rotavirus and norovirus as the leading research topics. The analysis emphasized methodological transitions toward genomic sequencing, molecular epidemiology, and wastewater surveillance and identified inequalities among high-burden regions as well as major contributors including the USA, China, Japan, India, and Brazil.Kuang et al. (2025) Analysis of global research trends in the management of bacteriophage and gut microbiota interactions (2012–2025). Based on bibliometric visualization tools, it reported the evolution from descriptive microbial ecology studies to those of mechanistic and translational nature. Important research foci were also phage therapy, antibiotic resistance, immune modulation and engineered phages; it identified increasing international cooperation and multiomics techniques to study phage–host interaction.Ozturk (2025) reviewed 18,246 publications on plant bacterial disease (2015–2025) from the Web of Science Core Collection. The publication volume, citation impact, international collaboration and keyword co-occurrence are examined in the study. The most productive countries were China, USA and India, but with thematic shifts towards molecular plant pathology/pathogenomics, pathogen-host interactions and integrated disease management approaches.Yuan et al. (2025) investigated four decades (1976–2024) of scientometric evaluation of fungi for biocontrol and biofertiliser applications. The study provided visualized analysis on temporal trends, leading countries, keyword clusters and thematic evolution focusing on entomopathogenic fungi, Beauveriabassiana, Trichoderma spp. and arbuscularmycorrhizal fungi. The results indicated that research output has switched from descriptive work to applied studies on sustainable agriculture, management of pests and biofertilizer applications.Sun and Zhai (2025) studied literature during 2009–2023 applying CiteSpace for co-citation and cluster. The research hotspot such as inflammatory bowel disease, dysbiosis, and fecalmicrobiota transplantation was discovered from the study and it also showed that China has increasingly cooperated with western countries. It also observed a methodological transition from descriptive microbiota studies to mechanistic-multi-omics studies, which included analysis of genomics, metabolomics and metagenomics. Ganguly et al. (2024) studided Indian probiotic research (2000–2023) based on Web of Science and Scopus, noting post-2015 rise, major institutional contributions (ICMR, IITs), and emergent topics in traditional fermented foods, immunomodulation and clinical applications. In the study, there were growing partnerships with European and North American organizations, and knowledge gaps still depended on functional food applications and translational studies of probiotic.Wang et al. (2025) modelled the global burden of invasive pulmonary aspergillosis. By running CiteSpace and

VOSviewer, the study reviewed publication outputs, co-citation networks, keyword clusters of thousands of institutions and hundreds of journals. There was a trend observed from early diagnostic research to that of COVID-19-associated IPA, clinical management, and antifungal therapy. Sarkar et al. (2024) have reviewed the literature that connects diet, diabetes and nutraceuticals with gut microbiome, integrated functional foods and prebiotics in the context of polyphenol-rich diets and precision nutrition as novel themes.Zhai et al. (2023) conducted a worldwide bibliometric in the domain of seasonal changes and microbiota research (2012–2022). The author networks, institution contributions and keyword co-occurrence were mapped with VOSviewer and CiteSpace. Major research topic clusters were dietary effects, climate influence and host health, highlighting the impact of environment and season on microbial community

OBJECTIVES OF THE STUDY

1. To examine the growth and publication trends of gut microbiome research in India.
2. To identify the most productive authors, and journals in the field.
3. To analyse institutional collaboration patterns through network visualization analysis.
4. To identify core journals and keyword distribution patterns using bibliometric laws.
5. To map major research themes using keyword co-occurrence analysis.

RESEARCH METHODOLOGY

To assess Gut Microbi\ome research in India, this study applies a quantitative bibliometric research design. The bibliographic records were collected from the Web of Science Core Collection for 2010-2025 in order to record the long-term research trends. The search terms used was "Gut Microbiome" in the Topic (title, abstract and author keywords), whereas India was set as an address to narrow down the data to only Indian research output. The search results were exported as plain text and .CSV files for further analysis. Biblioshiny (Bibliometrix R package) was employed for descriptive bibliometric statistics regarding publication output, document types, top authors and institutions, top journals and citation impact. Co-authorship, co-citation and keyword co-occurrence network visualization was performed by VOSviewer. Bradford's Law, Zipf's Law and Total Link Strength were used to determine the core journals and keyword distribution patterns, collaboration intensity and thematic relations.

Table 1 Main Information About Data

Description	Results	Description	Results
Timespan	2010:2026	Total Keyword	4550
Sources (Journals, Books, etc)	890	Author's Keywords (DE)	4750
Documents Type	18	Authors	8641
Documents	2097	Authors of single-authored docs	49
Annual Growth Rate %	21.97	Single-authored docs	59
Document Average Age	3.53	Co-Authors per Doc	6.4
Citation	52051.00	International co-authorships %	40.77
Average citations per doc	25.27	References	139447

Year wise Growth of Distribution:

The Indian gut microbiome research was analyzed year-wise (2010–2025) and it shows a rapid growth in terms of publications and citations. In total, 2,007 papers were cited over 52,051 times indicating high research impact. The field was still early-stage during 2010–2012 and experienced explosive growth since

2013, with annual increase rate frequently over 40% from 2015 to 2022. Maximum output was in 2025 when 474 articles received 13,404 citations. Although there is a slight dip in the following year, the constant trend is either progression or scholarly reach.

Table 2 Year wise Growth of Distribution

Year	Records (Rec)	Citations	Annual Growth (%)	Doubling Time (Years)
2010	1	0	–	–
2011	2	2	100	0.7
2012	2	7	0	–
2013	13	25	550	0.13
2014	12	135	−7.69	–
2015	17	682	41.67	1.68
2016	28	1126	64.71	1.08
2017	39	1410	39.29	1.78
2018	69	1758	76.92	0.91
2019	98	2422	42.03	1.67
2020	121	3183	23.47	2.98
2021	189	4619	56.2	1.25
2022	282	6305	49.21	1.42
2023	289	7380	2.48	28.23
2024	371	9593	28.37	2.47
2025	474	13404	27.76	2.52
Total	**2007**	**52051**	**1102.11**	**46.82**

Most prolific Authors

Study of the Indian gut microbiome is based on 8624 authors, from several institutions. Key contributors are Kumar A (IIT Guwahati, h-index 52 publications 20), Kumar S (Symbiosis Institute of Technology, h-index 44 publications 16), and Sharma S (ILBS, New Delhi, h-index 41 publications 13). The other testimonies from single authors like Singh S, Singh A, Das B to a number of Kumars point to an heterogeneous interest and a quite vibrant community, whose activity is filtered through few occasional contributors.

Table 3 Most prolific Authors Top 10 only

Rank	Author	Records	Institution	h-index
1	Kumar A	52	Indian Institute of Technology, Guwahati	20
2	Kumar S	44	Symbiosis Institute of Technology, Nagpur	16
3	Sharma S	41	Institute of Liver & Biliary Sciences (ILBS), New Delhi	13
4	Singh S	37	National Centre for Cell Science, Pune (NCCS)	14
5	Singh A	36	Amity University, Lucknow	11

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6	Das B	35	BRIC Translational Health Science & Technology Institute, Faridabad	35
7	Kumar P	35	National Institute of Technology, Rourkela	14
8	Kumar V	31	BabasahebBhimraoAmbedkar University	16
9	Kumar M	27	National Institute for Research in Environmental Health (NIREH), Bhopal	28
10	Kumar R	25	Lovely Professional University	9

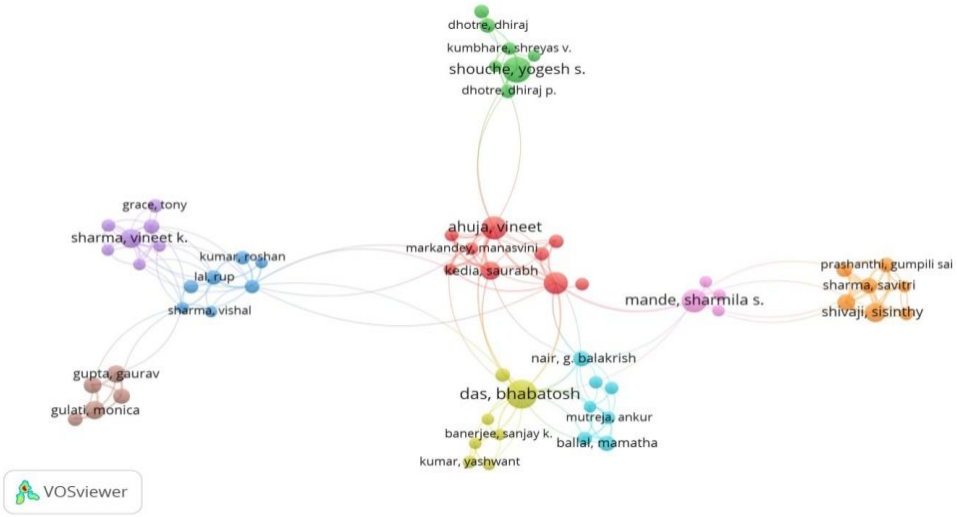


Fig 1 Network Visualization of Authors with Co-authorship

Authorship Pattern Anlysis

It t is evident that collaborative research has much influence on India's gut microbiome related research authorship pattern. Single-authored papers are low (59), reflecting few authors researching in this area. However, multi-authored papers represent the vast majority of publications: The largest contribution is formed by papers involving more than five authors (4,803), followed by five-author and four-author ones (1,255 and 1,160 respectively). This pattern reflects the interdisciplinary and collaborative character of gut microbiome research, often demanding input from clinicians, microbiologists, bioinformaticians and public health scientists.

Table 4 Authorship Pattern

Single Author	59
Two Author	518
Three Author	846
Four Author	1160
Five Author	1255
More Than 5 Author	4803
Total Authors	**8641**

Collaborative Institutions

Institutional analysis suggests AIIMS to be dominating in the publications and collaboration strength followed by University of Delhi (DU) and JNU. CSIR-AcSIR and Lovely Professional University also make substantial contributions, with others making the moderate contribution indicating a concentrated yet well dispersed Indian gut microbiome research network. The network of collaborations is formed by several clusters, each one with its own total link strength. The cluster around AIIMS has the maximum value of total link strength, suggesting a very strong institutional collaboration. Hubs clustering around the leading universities exhibit higher link strength, whereas those associated with private colleges and hospital are found to display moderate to low link strength.

Table 5 Top Collaborative Institution Top Ten Only

	Documents	**Links**	**Total Link Strength (TLS)**
AIIMS	180	65	420
University of Delhi	125	48	310
Jawaharlal Nehru University	110	44	285
CSIR–AcSIR	95	41	260
Lovely Professional University	88	39	240
MaharshiDayanand University	76	34	215
Amity University	72	32	205
Central University of Kerala	61	28	180
Gauhati University	58	26	170
Siksha ‘O’ Anusandhan University	55	24	165

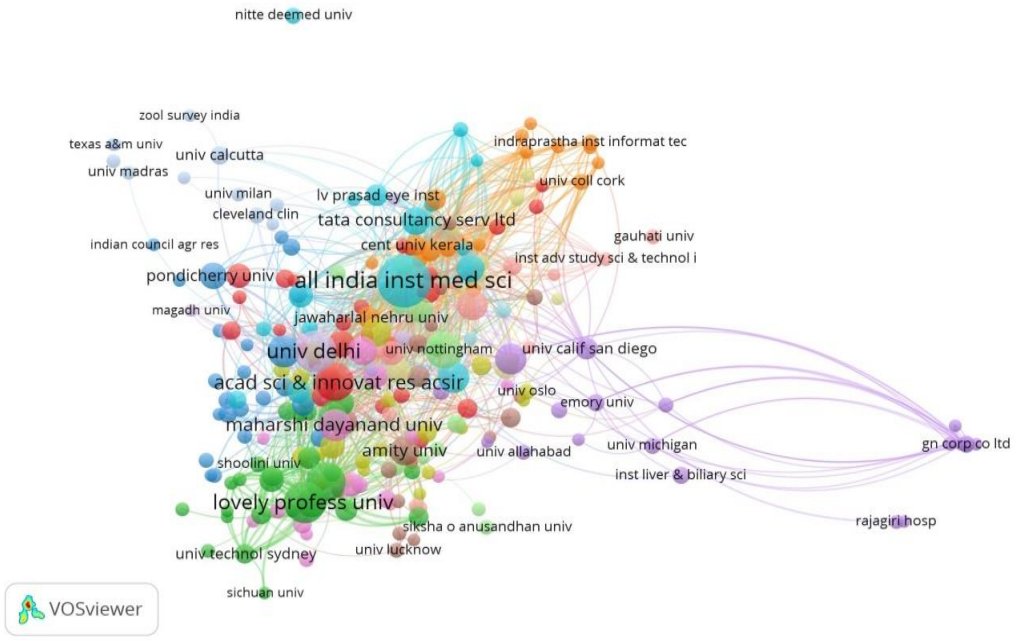


Fig 2 Net work Visulaization of Institutional collaboration

Major Research Areas

Indian gut microbiome studies are spread across 86 categories, with majority in Microbiology (22%), Pharmacology/Pharmacy (10.7%) and Biotechnology/Applied Microbiology (10.1%) that contribute 43% of the publications. Other fields include Biochemistry, Immunology, Gastroenterology and Neurosciences (Table 1B), indicating a combination of basic science, applied science and disease-oriented types of research.

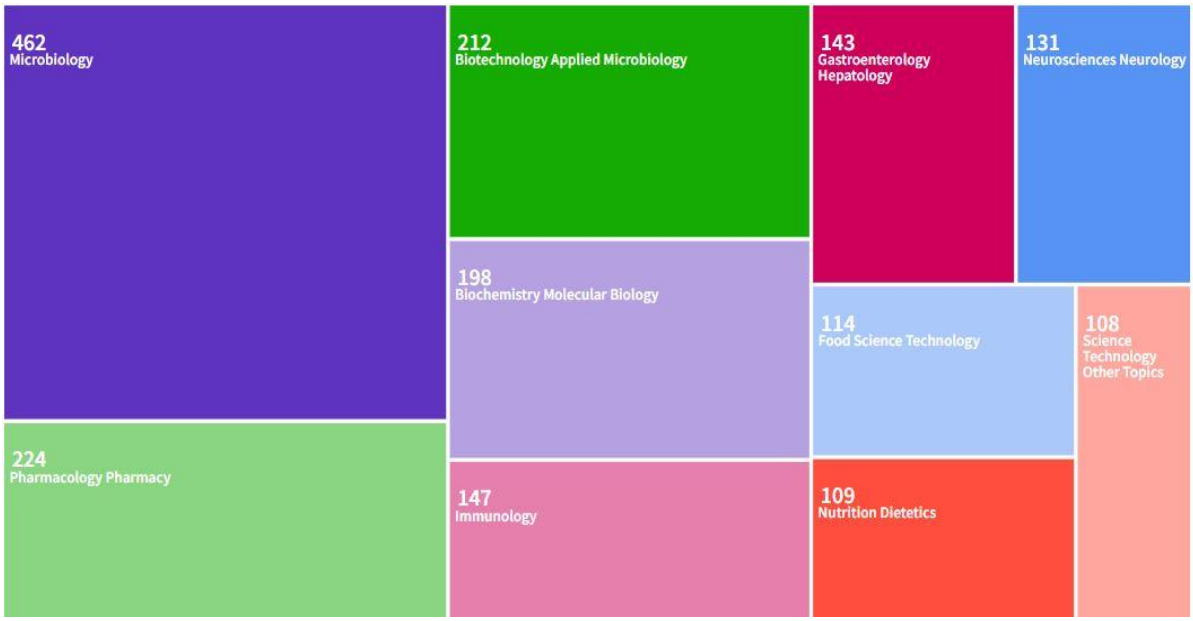


Fig 3 Research Areas Top Ten Only

Table 6 Collaborative countries Top Ten Only

Country Name	Records	Percentage
INDIA	2,097	100.00%
USA	365	17.41%
ENGLAND	98	4.67%
SAUDI ARABIA	94	4.48%
PEOPLES R CHINA	77	3.67%
AUSTRALIA	71	3.39%
SOUTH KOREA	54	2.58%
GERMANY	51	2.43%
ITALY	45	2.15%
CANADA	40	1.91%
PAKISTAN	40	1.91%

Collaborative Countries

The Indian gut microbiome research has collaboration with 134 countries. India is at the top with 2097 (100%), followed by USA (365, 17.4%), England (98, 4.7%) and Saudi Arabia (94, 4.5%). Although India is a leading producer, successful collaborative leadership demonstrates worldwide impact in this research.

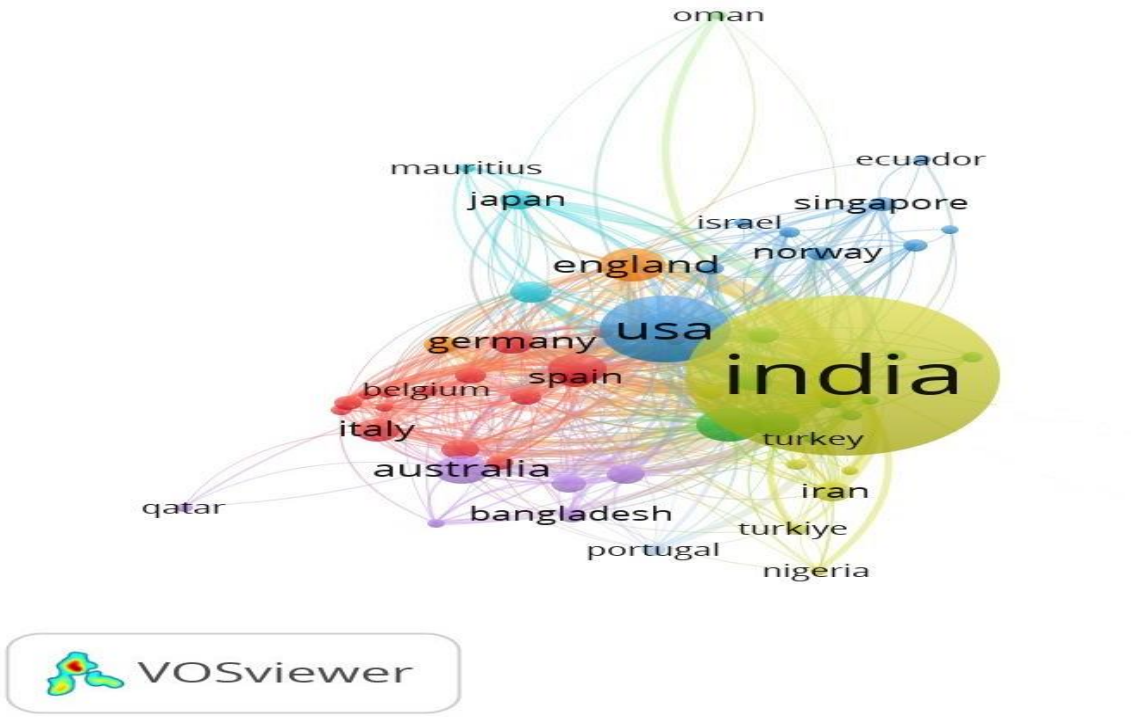


Fig 4 Networks Visualizations of Collaborative Countries

Most productive Journals

The Indian gut microbiome studies are published across 890 journals. while Frontiers in Microbiology (54), Cureus Journal of Medical Science (35) and Indian Journal of Microbiology (34) occupy the top places by publications. Other high-impact journals, such as Probiotics and Antimicrobial Proteins (34) and Scientific Reports (28), publish important studies to make it a more-disseminated and publication-oriented scenario.

Table 7Most Productive Journals Top Tenly Only

Journal Name	Records	Impact Factor	JCI
Frontiers in microbiology	54	4.5	0.98
Cureus journal of medical science	35	1.3	0.35
Indian journal of microbiology	34	1.6	0.39
Probiotics and antimicrobial proteins	34	4.4	1.07
Scientific reports	28	3.5	0.81
Microbial pathogenesis	24	2.6	0.62
Frontiers in cellular and infection microbiology	22	4.8	0.92
Archives of microbiology	21	2.6	0.62
Progress in molecular biology and translational science	20	4.025	0.4
Life sciences	–	5.1	1.33

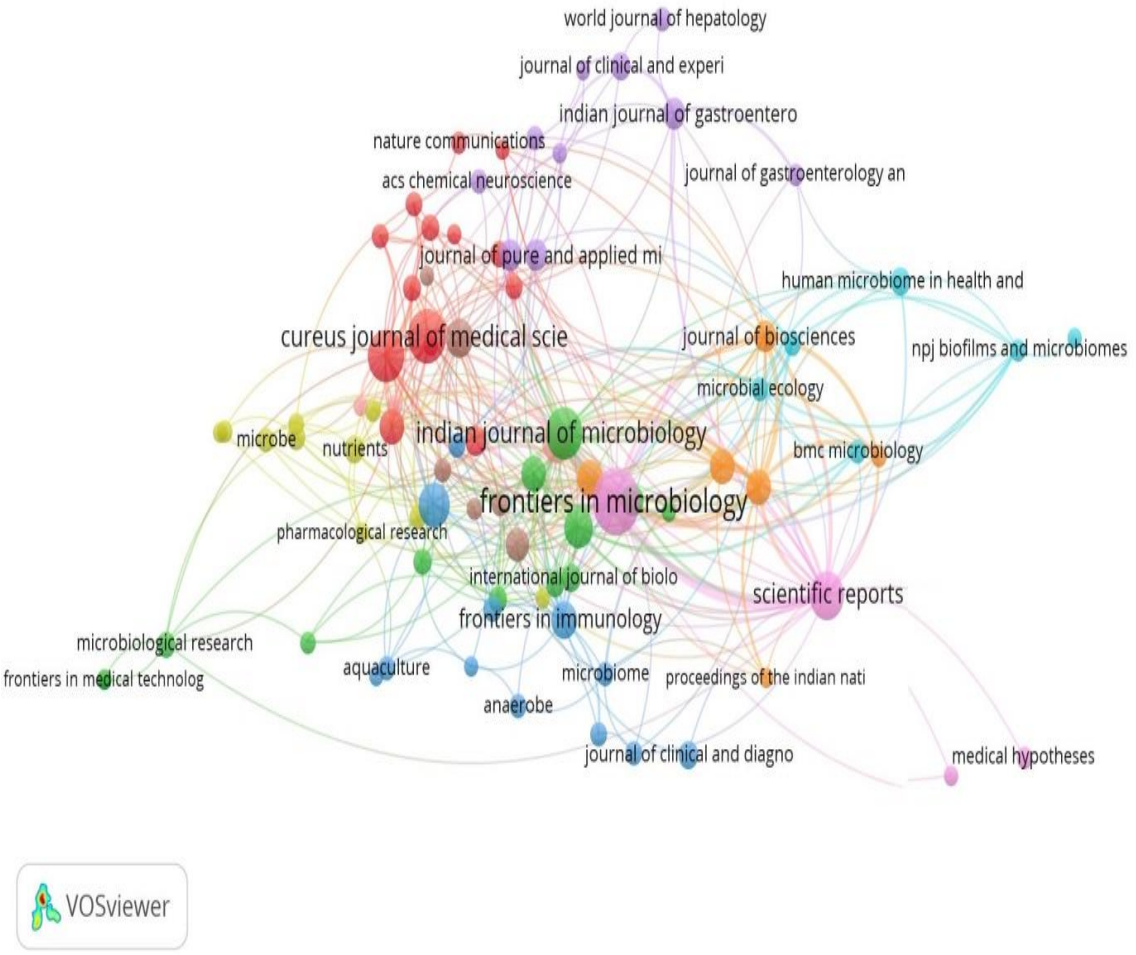


Fig 5 NetworkVisualization of Journals

Bradford's Law of Journals Productivity

The 890 journals were divided into three Bradford zones: Zone 1 (51 journals, 6%) produces 1/3 of articles, Zone 2 (219 journals, 25%) the next third, and Zone 3 (620 journals, 70%) the final third. With a Bradford multiplier of 4.3, a few core journals dominate output, suggesting that focusing on Zones 1 and 2 covers 2/3 of the literature for efficient searches and library planning.The distribution highlights that a small number of journals produce most articles, emphasizing efficiency in literature searches and library collection planning: prioritizing core and Zone 2 journals covers 2/3 of the literature.

Table 8 Bradford Law of ZONE OF Journals Productivity

Zone	Journals	% of Journals	Contribution of Articles
1 (Core)	51	5.70%	33%
2	219	24.60%	33%
3	620	69.70%	33%
Total	890	100%	100%

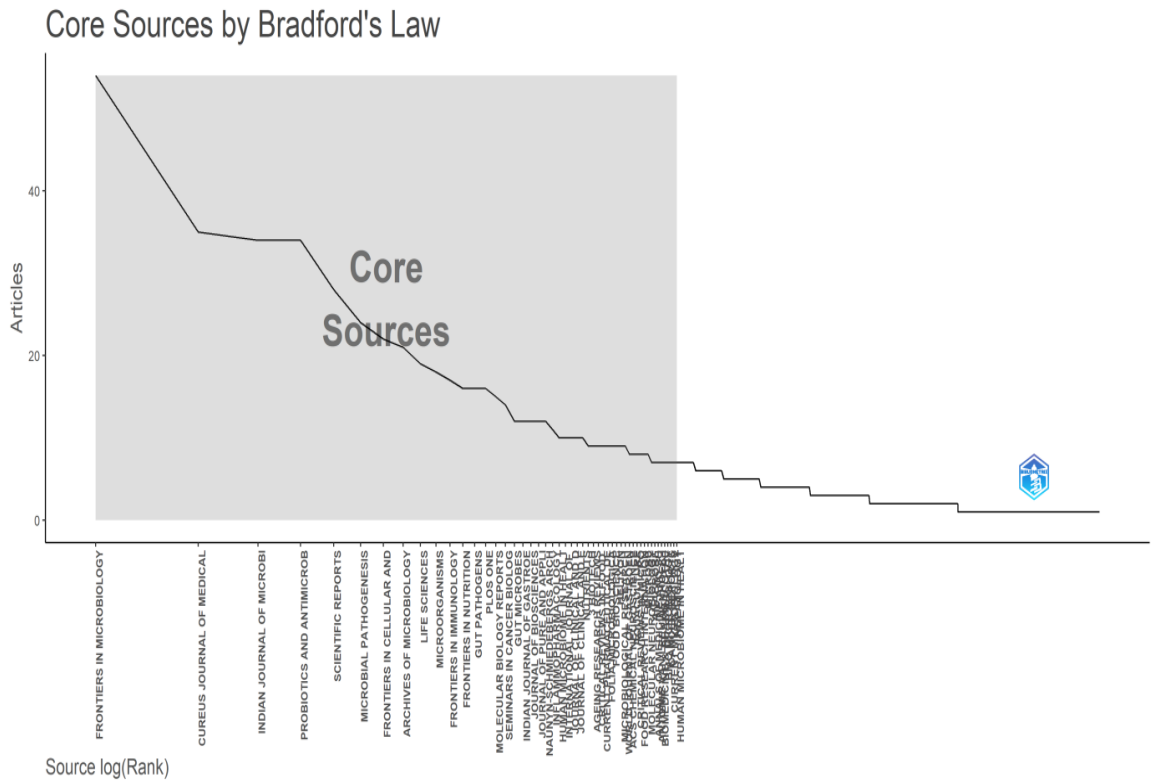


Fig 6 Core Source by Bradford's law

Keyword of Occurrence

Table 9 Distribution of Keyword of Occurrence

	Keyword	Records	ln(Rank)	ln(Records)
1	Gut	1053	0	6.959
2	Microbiome	715	0.693	6.572
3	Microbiota	379	1.099	5.938
4	Disease	240	1.386	5.481
5	Human	193	1.609	5.263
6	Role	190	1.792	5.247
7	Review	182	1.946	5.204
8	Health	169	2.079	5.13
9	Cancer	148	2.197	4.997
10	Probiotics	136	2.303	4.913

Zipf's law analysis of 4,550 keywords indicate an imbalanced COVID-19 keyword distribution led by "Gut," "Microbiome" and "Microbiota." Co-occurrence networks place gut microbiota (TLS 1,250), probiotics (TLS 980) and dysbiosis (TLS 910) at the centre with secondary clusters on gut–brain axis, neuroinflammation and microbial genomics. Highly interconnected clusters (TLS 350–900) Corresponding to the strong links between them suggest strongly connected and integrated research areas.

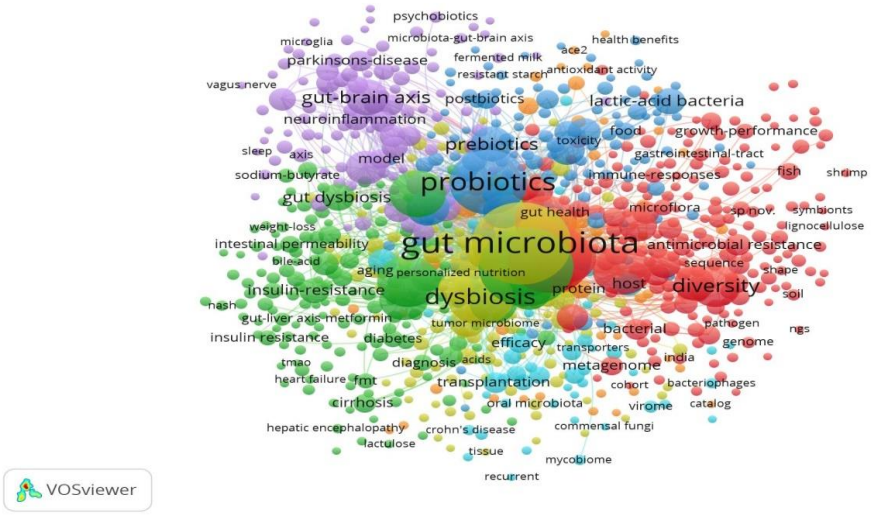


Fig 7 Network visualization of Keywords

Findings of the Study

Indian gut microbiome research has expanded from a peripheral space to relatively well-defined and partnered field in 2010–2025 as is apparent by the rapid increase of publications, citations post-2013, possibly indicating an expansion of human resources (research capacity), funding and clinical relevance. The author orders exhibit a strong preference for multi-author and multi-institutional papers, emphasizing the interdisciplinary nature of this field as well as the high investment in human resources. Within-country collaboration exhibits a hub-and-spoke pattern, with AIIMS at the epicenter backed by major universities and national research institutes, showing significant intranational collaboration as well as an unequal regional capacity. There are significant few core journal, while much literature dispersion that represents an interdisciplinary field. International cooperation, spearheaded by the USA and UK, promotes global integration and methodological solidity. Strategic diagrams and network analysis further indicate a stable conceptual core focused on gut microbiota, probiotics, dysbiosis with strong associations to metabolic disorders, gut–brain axis and microbial genomics pointing toward a mature integrated and increasingly translational research framework. These results imply that Indian gut microbiome research has progressed beyond exploratory phases and is well placed to develop clinically useful and globally impactful knowledge

LIMITATIONS AND SUGGESTIONS

This study is based on the Web of Science (2010–2025) and might have missed earlier or non-indexed literature. Cite-based metrics are biased towards older articles, and bibliometric analysis, as used here, reflects only the quantitative temporal trends in different research domain rather than quantifying the quality or impact of research. The future research should consider a multi-database, long-term, disease-specific and translational study of regions that are underrepresented regions and should use standardised microbiome methodology to get a more comprehensive profile.

CONCLUSION

Indian gut microbiome research has evolved as the collaborative, interdisciplinary area with increasing publications and citations and well-established institutional and international networks. These results indicate core journals lead, and keywords and collaboration analyses are trending toward mechanism-based and translational themes. In this study, systematically evaluated the India's research profile in the field and it will help to assist future direction for research and funding priorities and contribution of India towards global microbiome science.

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Amazon Kindle Direct Publishing as a Platform for Democratizing Digital Publishing: Features and Opportunities

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ABSTRACT

Traditional publishing models have long imposed significant barriers on authors, including high rejection rates, prolonged publication timelines, limited creative control, and low royalty structures. The emergence of digital technologies and self-publishing platforms has transformed this landscape by enabling direct, low-cost, and global dissemination of content. Amazon Kindle Direct Publishing (KDP), launched in 2007, represents a pivotal platform in this transformation, offering authors an accessible and scalable ecosystem for publishing e-books, paperbacks, and hardcovers without upfront investment. This paper examines Amazon KDP as a platform for democratizing digital publishing by analyzing its core features, operational framework, and the opportunities it provides to independent, academic, and underrepresented authors. Key functionalities such as print-on-demand, flexible pricing, royalty rates of up to 70%, global distribution, promotional tools, and rights retention are evaluated in the context of inclusivity and market accessibility. The study highlights how KDP lowers traditional gatekeeping barriers, accelerates time-to-market, and empowers creators with data-driven decision-making capabilities. Furthermore, the paper explores opportunities enabled by KDP in academic publishing, regional language dissemination, entrepreneurial authorship, and knowledge democratization. While acknowledging challenges related to discoverability, quality control, platform dependency, and digital divides, the analysis demonstrates that KDP significantly reshapes publishing dynamics by prioritizing merit, reader demand, and creative autonomy. The findings suggest that Amazon KDP plays a critical role in fostering a more equitable, innovative, and participatory digital publishing ecosystem, positioning self-publishing as a sustainable and influential model within the global knowledge economy.

KEYWORDS: Amazon Kindle Direct Publishing, Digital Publishing, Self-Publishing, Democratization of Knowledge, Print-on-Demand

INTRODUCTION

Traditional publishing has long grappled with challenges such as high rejection rates exceeding 90%, lengthy timelines of 1-2 years from submission to release, escalating production costs for print materials amid declining physical sales, and low royalties of 10-15% that strip authors of creative control and rights. The advent of digital technologies and self-publishing platforms in the 2010s revolutionized this landscape by enabling e-books, print-on-demand, and direct global distribution with minimal upfront costs, allowing indie authors to outsell traditional ones in popular genres like romance and fantasy. Amazon Kindle Direct Publishing (KDP), launched in 2007 alongside the Kindle, emerged as a game-changer by offering user-friendly tools for uploading books in multiple formats, royalties up to 70%, pricing controls, promotional features, and access to Amazon's massive marketplace, now supporting millions of titles including hardcovers and international expansions. This study aims to analyze KDP's key features and opportunities for democratizing digital publishing, particularly for diverse and underrepresented voices, while highlighting its role in lowering barriers and fostering innovation. Its significance lies in equipping authors, educators, and policymakers with insights into sustainable careers amid evolving trends like AI integration and direct-to-consumer models, ultimately promoting equitable access to global storytelling.

CONCEPT OF DEMOCRATIZATION IN DIGITAL PUBLISHING

Democratization in digital publishing refers to the process of broadening access to content creation, distribution, and consumption, empowering diverse voices previously sidelined by entrenched gatekeepers, thereby fostering inclusivity, innovation, and economic viability for creators worldwide (Prickett, 2014). This concept, rooted in the ideal of flattening hierarchies, means transforming publishing from an elite, controlled domain dominated by major houses into a participatory ecosystem where anyone with a compelling story can publish without needing agent approval, massive capital, or institutional backing, as evidenced by the explosion of indie titles reaching global audiences (Mulvany, 2024). Technology plays a pivotal role in dismantling these barriers through affordable tools like e-book conversion software, print-on-demand services, and cloud-based platforms that eliminate high upfront costs for editing, printing, and warehousing once prohibitive at tens of thousands of dollars while enabling instant global reach via internet marketplaces and data analytics for targeted marketing (Tone, 2025). Self-publishing starkly contrasts traditional models: the former grants authors 35-70% royalties, full creative control, rapid timelines from upload to sales (often days), and ownership of rights, allowing nimble responses to reader feedback and genre trends like romance where indies now dominate sales charts; traditional paths, however, impose 10-15% royalties post-recoupment, 1-2 year delays, 90%+ rejection rates, and rights forfeiture to publishers who bear costs but dictate edits and pricing amid declining print revenues (Hviid et al., 2019). Platforms like Amazon KDP exemplify this shift, hosting millions of titles and enabling underrepresented authors—such as those from marginalized communities—to bypass biases, monetize directly, and build sustainable careers, thus truly democratizing digital publishing by prioritizing merit and market demand over connections (Stroud, 2025).

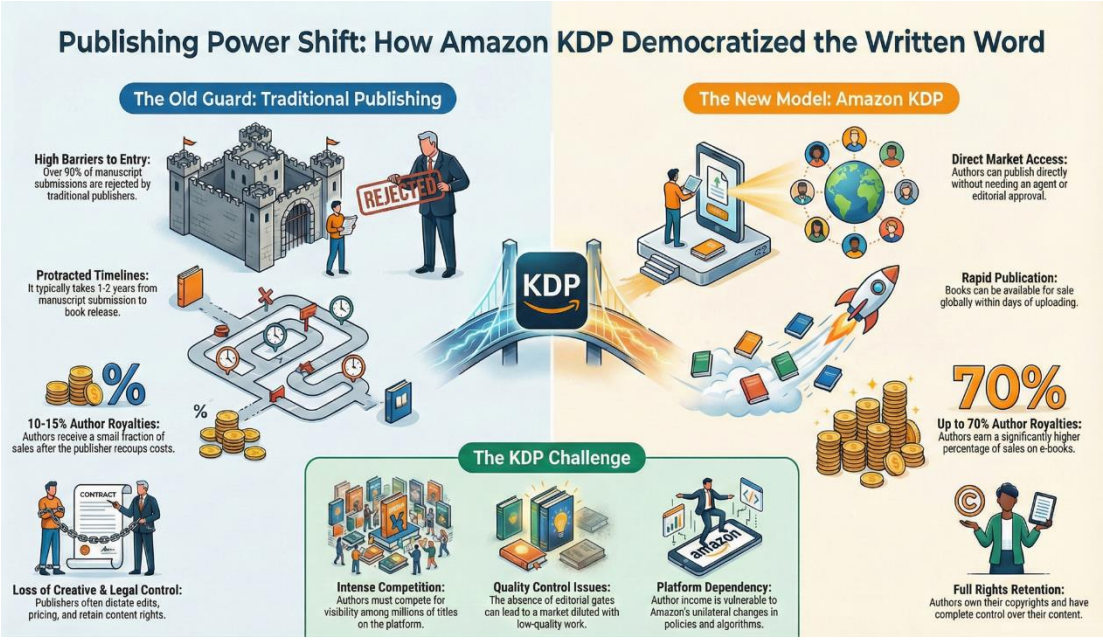
OVERVIEW OF AMAZON KINDLE DIRECT PUBLISHING (KDP)

Amazon Kindle Direct Publishing (KDP) serves as a cornerstone self-publishing platform, enabling authors to upload, format, and distribute books directly to Amazon's global marketplace without upfront costs or traditional gatekeepers, leveraging print-on-demand for physical copies and digital delivery for e-books to reach millions of Kindle users worldwide (Stroud, 2025). Launched in November 2007 alongside the first Kindle device initially as the Digital Text Platform KDP evolved rapidly, expanding from e-books to paperback options in 2016 via print-on-demand technology and hardcovers in 2021, with a pivotal 2018 merger of Amazon's CreateSpace consolidating digital and print services into a unified dashboard for streamlined workflows, pricing controls, and royalty payouts up to 70% (Saleh Al-Sharieh, 2022). KDP supports diverse content types, including e-books in formats like MOBI, EPUB, and PDF for Kindle devices and apps; paperbacks with customizable trim sizes, bleeds, and finishes printed only upon order to eliminate inventory risks; and hardcovers (case-laminated) for premium offerings, alongside tools for children's books, textbooks, and low-content items like journals, all accessible in 44+ languages (Maeda, M. 2015). Deeply integrated into Amazon's ecosystem, KDP connects seamlessly with Kindle Unlimited for subscription-based royalties, Amazon Advertising for targeted promotions, Author Central for unified profiles and sales analytics, and global storefronts across regions like the US, Europe, India, and Australia, enabling real-time dashboards for tracking sales, rankings, and reader insights while offering promotional features like free previews, countdown deals, and KDP Select enrollment for enhanced visibility (Connolly, 2024). This integration not only amplifies discoverability through Amazon's algorithms and recommendations but also empowers authors with full rights retention, rapid publication, and data-driven strategies, solidifying KDP's role in democratizing publishing.

FEATURES

Amazon Kindle Direct Publishing (KDP) embodies democratization through its robust features that empower authors globally. Its easy accessibility and intuitive user interface allow anyone with an internet connection to sign up, upload manuscripts in formats like EPUB or Word, and preview books via a drag-and-drop dashboard, requiring no technical expertise or prior publishing experience. No upfront publishing costs mean authors avoid traditional expenses like editing fees or printing runs, with KDP handling production while taking only a sales cut, enabling even beginners from regions like Tamil Nadu to launch titles instantly. Royalty

and pricing options offer up to 70% earnings on e-books priced $2.99-$9.99, or 35% otherwise, with flexible pricing tools, promotional discounts, and KDP Select enrollment for higher visibility and bonuses based on pages read (Sreeparna, J. 2020). Authors retain full rights and content control, owning copyrights, making unlimited revisions post-publication, and withdrawing books anytime without penalties, unlike traditional models where publishers dictate edits. Print-on-demand technology revolutionizes physical books by printing copies only upon order through integrated partners like IngramSpark, eliminating inventory risks and shipping worldwide in formats from paperbacks to hardcovers, with professional-quality covers and interiors generated automatically (Schroff, S., & Kreutzmann-Gallasch, A. 2024). These features collectively lower barriers, foster inclusivity for diverse voices in library science and education, and create viable income streams, positioning KDP as a cornerstone of digital publishing equity.



OPPORTUNITIES OFFERED BY AMAZON KDP

Amazon Kindle Direct Publishing (KDP) unlocks transformative opportunities for creators by democratizing access to publishing tools and markets. For independent authors, KDP provides a low-barrier entry to professional-grade publishing, enabling rapid release cycles, direct reader feedback via reviews and sales data, and the ability to build personal brands through series and marketing experiments, with many indies earning six-figure incomes by dominating niches like romance or sci-fi (Phillips, J. 2012). In academic and educational publishing, it facilitates self-publishing of textbooks, research monographs, and open-access materials, allowing scholars in library science to disseminate theses, course notes, or AI-in-education guides affordably, bypassing lengthy peer-review delays and high journal fees while integrating multimedia for interactive learning (Jeffress L.2012). The platform's global reach amplifies knowledge dissemination, distributing content to Amazon's 300 million+ customers across 13+ countries and 45+ languages via automated translation tools and Kindle Unlimited, empowering educators to share insights on digital libraries worldwide. Entrepreneurial and income opportunities abound through royalties up to 70%, KDP Select bonuses for pages read, promotional stacks, and print-on-demand scalability, turning writing into scalable businesses with passive revenue streams and crossover into audiobooks or merchandise (Karp, R.2022). KDP champions inclusivity for regional and niche content, supporting Tamil literature, indigenous stories, or specialized topics like scientometrics without gatekeeping biases, as authors retain rights to experiment with covers, pricing, and revisions, fostering diverse voices in underrepresented genres and promoting cultural equity in global digital publishing. These avenues not only sustain careers but redefine publishing as inclusive and merit-driven (Oskarsson, E. 2022).

ROLE OF AMAZON KDP IN DEMOCRATIZING DIGITAL PUBLISHING

Amazon Kindle Direct Publishing (KDP) plays a pivotal role in democratizing digital publishing by systematically removing gatekeeping barriers that once confined entry to elite networks and major publishers. Traditional models demanded agent representation and editorial approval, often rejecting 90% of submissions based on subjective tastes rather than market potential; KDP circumvents this with a self-service model where authors upload directly, gaining instant visibility without intermediaries or favoritism (Phillips, J. 2012). It empowers first-time and marginalized authors by providing free tools for formatting, cover design via Canva integration, and beta testing, enabling newcomers from underrepresented regions or backgrounds to publish polished works and iterate based on real sales data, as seen in the rise of non-Western voices topping bestseller lists (**Murray, S.2012).** Affordable access for readers emerges through low e-book prices starting at $0.99, subscription models like Kindle Unlimited at $9.99/month for unlimited borrows, and free promotions, slashing costs compared to $20-30 print textbooks and broadening literacy in developing economies. Consequently, KDP drives expansion of diverse voices and content, amplifying niche genres, regional languages including Tamil, BIPOC narratives, and experimental formats like serialized fiction or interactive non-fiction that traditional houses overlook, resulting in a richer, more pluralistic literary ecosystem where merit and reader demand dictate success over institutional endorsements. This shift not only diversifies bookshelves but cultivates cultural representation and innovation, solidifying KDP's status as a catalyst for equitable publishing (McAdam, J. 2019).

CHALLENGES AND LIMITATIONS

Amazon Kindle Direct Publishing (KDP), while revolutionary, grapples with notable challenges that temper its democratizing potential. Discoverability amid market competition poses a primary hurdle, as the platform hosts over 12 million titles, forcing authors to vie for attention in an algorithm-driven environment where visibility hinges on paid ads, keyword optimization, and bestseller rankings, often disadvantaging newcomers without marketing budgets (Phillips, J. 2012). Quality control issues arise from the absence of mandatory editorial gates, leading to a proliferation of unedited or low-effort books that dilute reader trust and stigmatize self-publishing, with surveys indicating 40% of Kindle users encountering subpar content (Schroff, S., & Kreutzmann-Gallasch, A. 2024). Dependence on Amazon policies creates vulnerability, as unilateral changes to royalty structures, algorithm tweaks, or program terms like KDP Select exclusivity can slash earnings overnight, exemplified by the 2023 royalty formula updates impacting mid-tier authors (Hviid, M., & McNally, C. 2019). Digital divide and accessibility concerns further complicate equity, with rural or low-income users in regions like South India facing unreliable internet, device shortages, and language barriers despite Kindle's multilingual support, limiting both author participation and reader uptake; data shows only 25% penetration in emerging markets versus 70% in the West (Murray, S. 2012). These limitations underscore the need for supplementary strategies like community networks and policy advocacy to fully realize KDP's promise.

CONCLUSION

Amazon Kindle Direct Publishing (KDP) has redefined digital publishing by dismantling gatekeeping barriers, empowering independent and marginalized authors with accessible tools, affordable reader pricing, and expansive content diversity, while offering robust features like print-on-demand, high royalties, and global reach alongside entrepreneurial opportunities in academic and niche markets. Despite challenges such as fierce competition, quality inconsistencies, policy dependencies, and digital divides, KDP's net impact accelerates democratization, shifting power from traditional publishers to creators and readers, evidenced by indie authors claiming over 50% of e-book sales in key genres and amplifying underrepresented narratives worldwide. Looking ahead, the future scope of self-publishing platforms promises even greater evolution through AI-driven editing, personalized recommendations, blockchain for rights management, and hybrid models integrating virtual reality storytelling, potentially bridging accessibility gaps and enhancing discoverability to make publishing universally inclusive. Policymakers and educators should leverage these platforms to promote digital

literacy and cultural equity, ensuring self-publishing matures into a sustainable pillar of global knowledge dissemination.

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Library and Information Science Theses from Tamil Nadu State Universities in ShodhGanga: An Analytical Study

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Abstract

Shodhganga, India's national electronic repository of theses and dissertations maintained by the INFLIBNET Centre, is a key platform for promoting open access to doctoral research. Tamil Nadu, with 20 state universities, has actively contributed Library and Information Science (LIS) theses to this repository. This study analyzes 800 LIS theses deposited as of January 2026, focusing on university-wise contributions, the distribution of research guides, supervision patterns, and research themes. Furthermore, the study classifies theses into major research domains User Studies, Scientometrics, Technology, Bibliometrics, Management, Impact/Evaluation, and Others and explores subcategories within User Studies, Technology, and Scientometric research. Findings reveal significant concentration of supervision in certain universities, dominance of User Studies, and varied contributions across research domains. The study provides insights into research productivity, supervision trends, and scholarly output in LIS from Tamil Nadu state universities, offering a roadmap for strengthening doctoral research and open-access initiatives.

***Keywords*:** Shodhganga, LIS Theses, Tamil Nadu State Universities, Scientometrics, User Studies, Technology, Research Productivity, Open Access, INFLIBNET Centre

Introduction

Theses and dissertations are valuable repositories of original research, often representing work not published elsewhere. However, restricted access to these works can limit their utilization, leading to duplication and inefficiency. Recognizing this challenge, the University Grants Commission (UGC) mandated electronic submission of doctoral theses to promote transparency, quality, and open access.

Shodhganga, maintained by the INFLIBNET Centre, serves as India's national digital repository for Electronic Theses and Dissertations (ETDs). The repository centralizes doctoral research from universities across India, providing full-text access, metadata standardization, and long-term preservation using DSpace software and standards such as OAI-PMH and Dublin Core. It allows users to search, browse, and access theses by university, department, and subject, enhancing research visibility and fostering academic collaboration.

Tamil Nadu, a leading state in higher education, has 20 state universities, of which 10 actively offer LIS research programs and contribute theses to Shodhganga. The total number of LIS theses deposited by these universities is 800, supervised by 220 research guides. This study analyzes university-wise contributions, supervision patterns, and research themes, highlighting the strengths, gaps, and trends in LIS doctoral research in Tamil Nadu.

Shodhganga: An Overview

Shodhganga, maintained by the INFLIBNET Centre under the UGC, is India's national digital repository of Electronic Theses and Dissertations (ETDs). It provides open access to Indian doctoral research, addressing issues of limited visibility and duplication of work. Mandated by the UGC (2009, amended 2016), Shodhganga allows universities to deposit, preserve, and disseminate full-text Ph.D. theses. Developed using open-source DSpace software and adhering to international standards such as OAI-PMH and Dublin Core metadata, the repository enables searching, browsing by university and department, and long-term preservation. By centralizing access to Indian theses, Shodhganga enhances research visibility, quality, and global scholarly communication.

Statement of the Problem

Tamil Nadu has 20 state universities; however, only 10 of them have Library and Information Science (LIS) departments that have contributed doctoral theses to Shodhganga. As of January 2026, these 10 universities have deposited a total of 800 LIS theses. This study aims to analyze the university-wise contributions, supervision patterns, and major research themes of these theses in order to identify the strengths, gaps, and emerging trends in LIS doctoral research in Tamil Nadu.

Objectives of the Study

The study aims to:

1. To identify the state universities of Tamil Nadu contributing Library and Information Science (LIS) theses to Shodhganga.
2. To analyze the total number of LIS theses deposited by each university.
3. To identify the top and low contributing universities.
4. To analyze the average number of theses supervised per guide.
5. To determine the top three research areas in LIS theses.
6. To analyze the distribution of user Studies in LIS research.
7. To examine the extent of technology-related research in LIS theses.
8. To identify the domains covered under scientometric studies in LIS research.

Scope and Methodology

- **Scope:** The study is limited to Library and Information Science theses submitted to Shodhganga by Tamil Nadu state universities as of January 2026.
- **Data Collection:** University-wise and subject-wise data were retrieved from the Shodhganga repository.
- **Analysis:** Data were analyzed using simple statistical techniques including counting, percentages, and tabular representation.

Data Analysis and Interpretation

1 University-wise LIS Theses Contribution

The table below presents the contribution of Library and Information Science theses deposited in Shodhganga by Tamil Nadu state universities as of January 2026. It highlights the total number of theses submitted by each university and provides insight into the overall research output and participation of universities in the open-access ETD initiative.

Table-1 : University-wise LIS Theses Contribution

S.No	Name of the University	No. of LIS Theses	Percentage (%)
1	Bharathiar University, Coimbatore	169	21.13
2	Manonmaniam Sundaranar University, Tirunelveli	131	16.38
3	Alagappa University, Karaikudi	113	14.13
4	Bharathidasan University, Tiruchirappalli	104	13.00
5	Kamaraj University, Madurai	94	11.75
6	Annamalai University, Cuddalore	86	10.75
7	Periyar University, Salem	48	6.00

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8	University of Madras	34	4.25
9	Mother Teresa Women's University, Kodaikanal	17	2.13
10	Tamil University, Thanjavur	4	0.50
Total		**800**	**100.00**

2 Average Number of Theses per Guide

The table below presents the average number of theses supervised per guide in each university calculated using the formula:

Average Theses per Guide=Total Guides / Total Theses

This measure indicates the concentration of research supervision and reveals that universities with fewer guides often supervise more theses per guide, reflecting highly centralized or concentrated research activity.

Table-2: Average Number of Theses per Guide

S.No	University	Total Theses	Total Guides	Average Theses per Guide
1	Alagappa University, Karaikudi	113	9	12.56
2	Periyar University, Salem	48	8	6.00
3	Madurai Kamaraj University	94	22	4.27
4	University of Madras	34	8	4.25
5	Tamil University	4	1	4.00
6	Bharathidasan University, Tiruchirappalli	104	27	3.85
7	Manonmaniam Sundaranar University, Tirunelveli	131	42	3.12
8	Annamalai University	86	28	3.07
9	Bharathiar University, Coimbatore	169	66	2.56
10	Mother Teresa Women's University, Kodaikanal	17	9	1.89
Total		**800**	**220**	—

The analysis indicates that universities with fewer research guides often supervise more theses per guide, reflecting a concentrated supervision pattern. Alagappa University shows the highest average (12.56), while Mother Teresa Women's University has the lowest (1.89).

3 Classification of LIS Theses by Research Area

The thematic classification of Library and Information Science (LIS) theses reveals the diverse research interests and evolving priorities of doctoral scholars in Tamil Nadu state universities. For systematic analysis, the theses were grouped into seven major research areas: User Studies, Scientometrics, Technology, Bibliometrics, Management, Impact/Evaluation/Analytical Studies, and Others, with each category further subdivided based on research scope and methodological focus.

User Studies constitute the largest research area, emphasizing user behaviour, library usage, information-seeking patterns, and awareness, competency, and public library studies, reflecting a strong user-centred orientation in

LIS research. Scientometric studies form the second most prominent domain and are classified across subject areas such as Biomedical and Health Sciences, Engineering and Technology, Environmental and Agricultural Sciences, Physical and Chemical Sciences, Library and Information Science, and Social Sciences, focusing on research productivity, citation patterns, collaboration, and growth trends. Technology-related research, the third dominant area, highlights the increasing adoption of digital technologies in libraries and includes ICT applications, e-resources and consortia, digital services, and library automation, digitization, and software studies.

The Management category covers studies on library planning, administration, marketing, quality assessment, policy formulation, collection development, services, and LIS professional issues. Impact, Evaluation, and Analytical Studies assess the effectiveness of library systems and services and include research on special libraries and contexts, LIS education and curriculum, legal and intellectual property rights (IPR), and other evaluative dimensions. The category others comprises innovative, interdisciplinary, and miscellaneous studies that extend beyond the traditional LIS core areas.

Overall, User Studies, Scientometrics, and Technology together account for 81.39% of all LIS theses, clearly indicating the primary research priorities of LIS doctoral studies in Tamil Nadu, while the remaining categories contribute to the disciplinary breadth and interdisciplinary expansion of the field.

Table-3: Classification of LIS Theses by Research Area

S.No	Research Area / Domain	No. of Theses	Percentage (%)
1	User Studies	345	43.13
2	Scientometrics	177	22.13
3	Technology	129	16.13
4	Bibliometrics	54	6.75
5	Management/collection	44	5.50
6	Impact / Evaluation / Analytical Study	36	4.50
7	Others	15	1.88
Total		**800**	**100.00**

Subthemes in User Studies

User Studies research is primarily focused on understanding library users' behaviors, preferences, and competencies. "Library Usage Patterns" is the largest subcategory, reflecting efforts to optimize library services. Awareness and competency studies provide insights into training needs for effective library usage, while information-seeking behavior studies help design user-centric services. Public library studies, though smaller in number, highlight the outreach and social impact of libraries.

Table-4: Subthemes in User Studies

S.No	Subcategory of User Studies	No. of Theses	Percentage (%)
1	Library Usage Patterns	98	28.41
2	General User Study	80	23.19
3	Awareness / Competency Studies	74	21.45

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4	Information Seeking Behaviour	59	17.10
5	Public Library Studies	34	9.86
Total		**345**	**100.00**

Subthemes in Technology related Theses

Technology-focused theses emphasize the **integration of ICT and digital tools in library services**. The dominance of ICT applications shows the adoption of modern technologies for information management. E-resources, consortia, and digital services reflect collaboration and resource-sharing initiatives. Automation and software development, though smaller in proportion, indicate ongoing modernization of library operations.

Table -5: Subthemes in Technology related Theses

S.No	Subcategory of Technology	No. of Theses	Percentage (%)
1	ICT, Technology Applications	95	73.64
2	E-Resources / Consortia / Digital Services	22	17.05
3	Library Automation / Digitization / Software	12	9.30
Total		**129**	**100.00**

Scientometrics by Discipline

Scientometric research, the second largest research domain, analyzes productivity, trends, and impact across various disciplines. Biomedical and Health sciences are the most studied, reflecting global emphasis on medical research. Engineering and Technology, and Environmental/Agricultural sciences follow, highlighting emerging research areas and societal priorities. LIS-related scientometric studies, though smaller, are important for evaluating scholarly output, journals, and institutional research performance. This domain helps identify influential research trends and gaps across multiple scientific disciplines.

Table -6: Scientometrics by Discipline

S.No	Domain / Area	No. of Theses	Percentage (%)
1	Biomedical / Health	77	44
2	Engineering / Technology	41	23
3	Environmental / Agricultural	24	14
4	Physical / Chemical Sciences	19	11
5	Library & Information Science / Institutions / Journals	10	6
6	Social Sciences / Education	4	2
Total		**177**	**100**

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Findings of the Study

1. Only 10 out of the 20 state universities in Tamil Nadu actively contribute Library and Information Science (LIS) theses to Shodhganga, indicating limited participation at the state level.
2. Bharathiar University emerges as the highest contributor, with 169 theses (21.13%), reflecting strong LIS research activity.
3. Tamil University records the lowest contribution, with only 4 theses (0.50%), indicating minimal engagement in LIS doctoral research.
4. Alagappa University exhibits the highest supervisory concentration, with an average of 12.56 theses supervised per guide.
5. The three dominant research domains—User Studies, Scientometrics, and Technology—together account for more than 81% of the total LIS theses, indicating concentrated research priorities.
6. User Studies constitute the largest research area, with 345 theses (43.13%), highlighting a strong user-centric orientation in LIS research.
7. Scientometric research ranks second, with 177 theses (22.13%), reflecting growing interest in research evaluation and productivity analysis.
8. Technology-oriented studies occupy the third position, with 129 theses (16.13%), underscoring the increasing role of ICT and digital services in libraries.
9. Within User Studies, studies on library usage patterns dominate, accounting for 28.41%, indicating a strong emphasis on service utilization analysis.
10. ICT and technology applications form the core of technology-related research, representing 73.64% of that category.
11. In scientometric research, Biomedical and Health Sciences emerge as the leading domain, accounting for 44%, demonstrating high research visibility and scholarly output in this field.

Conclusion

The study presents an analytical overview of Library and Information Science (LIS) doctoral research contributed by Tamil Nadu State Universities to the Shodhganga repository and reveals that only a limited number of universities actively participate, resulting in uneven research contributions across the state. The classification of theses shows that **User Studies, Scientometrics, and Technology-related research** are the dominant areas, reflecting a strong user-centric approach, growing interest in research evaluation, and the increasing influence of ICT and digital resources in LIS. Analysis of research supervision indicates considerable variation in average theses per guide, with universities having fewer guides often showing higher supervision loads, pointing to concentrated research supervision. Overall, the findings highlight the need for wider institutional participation, balanced supervisory practices, and continued diversification of research areas to strengthen LIS research output and enhance its visibility through Shodhganga.

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The Role of Libraries in Promoting Information Literacy and Digital Citizenship

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Abstract

In the era of digitalization, information literacy and responsible digital citizenship are essential competencies for navigating and engaging with the vast array of online resources available. Libraries play a central role in equipping individuals with the necessary skills to critically assess and use information, as well as to participate responsibly in digital environments. This article explores how libraries contribute to fostering information literacy and digital citizenship through educational programs, access to digital tools, and community engagement initiatives. By acting as hubs of digital literacy, libraries help individuals become informed, ethical, and responsible users of technology. This paper underscores the critical Libraries' involvement in creating a society that is technologically literate and helping to bridge the digital divide.

Keywords: Information Literacy, Digital Citizenship, Libraries, Digital Literacy, Educational Programs, Media Literacy, Online Safety, Library Services, Critical Thinking, Digital Divide.

Introduction

In the 21st century, the explosion of digital technology has radically transformed society, especially in terms of how individuals access, process, and use information. From social media to scholarly articles, the internet offers vast quantities of content, much of which is unreliable or misleading. This challenge underscores the critical need for information literacy is the ability to identify, evaluate, and use information effectively and ethically. Alongside information literacy, the concept of digital citizenship has emerged as a key focus in preparing individuals to use technology responsibly, ethically, and safely. Libraries, with their long history of supporting education and community development, are uniquely positioned to promote both of these crucial competencies. This article explores the multifaceted role of libraries in fostering guaranteeing that people can successfully navigate the digital age with critical awareness, ethical responsibility, and well-informed decision-making through information literacy and digital citizenship.

The Concept of Information Literacy

The ability to find, assess, and apply information in an ethical and efficient manner is known as information literacy. As the information landscape continues to evolve, with an ever-growing influx of digital content, information literacy has become a necessary skill for individuals to succeed in education, work, and everyday life. In particular, the rise of misinformation and the prevalence of fake news have made it increasingly important for people to critically assess the information they encounter online. Information literacy is no longer confined to the traditional skills of using libraries to locate books and journal articles. It now encompasses the capacity to use digital platforms, assess the reliability of sources, and combine data from many online sources.

For libraries, promoting information literacy is a core mission. Library professionals are equipped to teach patrons how to conduct research, assess the quality of sources, and avoid the pitfalls of misinformation. In fact, libraries have become key institutions for promoting critical thinking, information evaluation, and academic research skills which are the fundamental components of information literacy.

The Role of Libraries in Promoting Information Literacy

Libraries have evolved significantly in their role as knowledge providers. No longer confined to physical books and journals, libraries are at the forefront of promoting digital literacy and information literacy in the 21st century. By providing access to resources, developing educational programs, and offering expert guidance, libraries play an integral role in equipping individuals with the necessary skills to navigate and utilize digital resources effectively.

Educational Programs and Workshops

Libraries are renowned for their educational programs designed to improve information literacy. Workshops, seminars, and tutorials are conducted regularly, focusing on different aspects of information literacy. For example, academic libraries may offer workshops on using scholarly databases, writing citations, and evaluating academic sources, while public libraries may host general workshops on web searches, media literacy, and evaluating news sources (Mackey & Jacobson, 2011).

Public libraries in particular have expanded their programs to reach diverse audiences, including adults and seniors who may have limited digital skills. Programs tailored to improving internet searching, digital tools, and database searching skills help patrons to become more confident in their ability to find and evaluate trustworthy information.

Access to Digital Tools and Resources

In addition to offering workshops, libraries provide access to a wide range of digital tools and resources that patrons might not have otherwise. This includes computers, internet access, eBooks, online databases, and digital archives. For example, libraries often subscribe to specialized research databases that offer access to academic journals, government publications, and industry reports that might be behind paywalls on the open internet. These resources give individuals the ability to perform deep research in a variety of fields, often with guidance from library professionals.

In fact, many libraries have digital literacy centers where patrons can learn not only how to use library resources but also how to engage with the digital world in a meaningful and safe way. By offering these tools and training, libraries are bridging the digital divide and ensuring that people from all socio-economic backgrounds have access to essential information and skills.

Collaborations with Educational Institutions

Libraries work with educational institutions, community organizations, and schools to incorporate information literacy into their curricula. Academic libraries, for instance, work with faculty to design course-specific instruction on research skills, citation practices, and information evaluation. Public libraries often collaborate with local schools to offer tutoring and after-school programs that teach information literacy skills.

Libraries also host "Research Help" desks, where students and community members can receive one-on-one assistance with navigating online research tools, analyzing academic articles, and finding high-quality resources (Gross & Latham, 2007).

Digital Citizenship: Ethical and Responsible Use of Technology

Digital citizenship refers to the responsible, ethical, and safe participation in the digital world. As individuals increasingly engage with technology and social media, understanding how to behave responsibly online has become essential. Digital citizenship encompasses a wide range of skills, from online etiquette and communication to understanding privacy, security, and the social impacts of technology.

For libraries, promoting digital citizenship means educating patrons about the ethical implications of their online behavior and how to protect themselves and others in the digital world. Libraries, as community hubs, are ideally suited to foster discussions about digital ethics and create environments where individuals can learn to use technology responsibly.

Promoting Online Safety and Privacy

One of the most important aspects of digital citizenship is online safety. Libraries teach patrons about the risks of the digital world and how to protect their privacy. Through workshops and seminars, library staff explain topics such as strong passwords, avoiding phishing scams, recognizing malware, and understanding the risks of oversharing personal information online. Libraries also offer resources on safe social media use and how to protect one's online reputation (Ribble, 2015).

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Encouraging Ethical Online Behavior

Libraries promote ethical behavior online, helping users understand the importance of respectful communication and empathy. Many libraries offer programs aimed at preventing cyberbullying, online harassment, and digital plagiarism. By offering these programs, libraries contribute to create a respectful and inclusive online environment.

Bridging the Digital Divide

Libraries are essential for closing the digital divide as well as for fostering information literacy and digital citizenship. The difference between individuals who have access to digital technology and the internet and those who do not is known as the "digital divide." By giving people free access to computers, the internet, and digital materials, libraries aid in closing this gap.

Public libraries are the main source of technology and internet access for many underprivileged people. To enable these communities to prosper in the digital age, library programs that teach digital skills—such as how to use search engines, access online government services, and apply for employment online—are crucial (Bertot *et al*., 2012).

Conclusion

In the digital age, the role of libraries in promoting information literacy and digital citizenship is more important than ever. Libraries serve as community hubs that not only provide access to information but also teach individuals how to engage with that information in a meaningful, ethical, and responsible way. Through educational programs, access to digital tools, and expert guidance, libraries empower individuals to become critical thinkers, responsible digital citizens, and informed users of technology. By helping bridge the digital divide, libraries ensure that everyone has the opportunity to succeed in a digital society, regardless of background or access to resources. As the digital world continues to evolve, libraries will remain at the forefront of shaping an informed, ethical, and responsible digital citizenry.

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Data Privacy & Security in Digital Libraries in the Context of Intellectual Property Rights

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Abstract

Digital libraries handle not only books and articles but also private user data such as reading preferences, search histories, and payment details for digital subscriptions. This necessitates strict data security standards and adherence to global regulations. Libraries must implement encryption, strong authentication mechanisms, and effective access controls to ensure that only authorized users can access sensitive information. Many libraries also possess valuable intellectual property, including rare digital collections and copyrighted materials. A data breach could result in unauthorized distribution, piracy, or misuse of such intellectual content. This paper examines the intersection of intellectual property rights (IPR), and data privacy within the rapidly evolving digital landscape in India. As digital technologies and online platforms continue to expand, the dissemination of creative works and personal data has introduced new legal challenges, particularly in balancing the protection of intellectual property with the safeguarding of individual privacy. The paper begins by exploring the historical development of copyright law in India, tracing its evolution from traditional analog foundations to the complexities introduced by the digital era. This historical perspective provides essential context for understanding the core principles of copyright law and the increasing need for legal reform in response to technological advancements. The paper also critically reviews the current legal framework governing intellectual property rights in India, with particular emphasis on its application in the digital environment, and highlights the challenges faced by lawmakers and courts in addressing complex legal issues arising from content sharing, user-generated content, and data driven innovation.

Keywords: Data Protection, Privacy, Intellectual Property Rights, Digital Libraries, Data Ownership, Digital Personal Data Protection Act, Intellectual Property Rights Reform.

Introduction

Each individual possesses intellectual property rights that protect the freedom to create original works of expression. When a person demonstrates originality in their work through the application of intellect, they are entitled to certain legal protections known as intellectual property rights. In early human societies, particularly nomadic communities, the concept of formal property ownership was largely absent. Gradually, they came to accept ownership over movable goods and personal belongings. The term intellectual property refers to a group of legal rules that regulate the use and protection of ideas and symbols. It includes the rights of an individual over an intangible creation that results from intellectual effort, rather than over a physical object. Intellectual property law grants two types of rights: positive rights and negative rights. Positive rights allow the creator to use and commercially exploit the intellectual creation, while negative rights enable the rights holder to prevent others from using or exploiting the creation without permission.

Objectives of the Study

- To examine the issues and challenges related to data privacy and cyber-security in digital libraries, with special reference to the protection of user data and confidential information.

- To analyze the role of Intellectual Property Rights (IPR) in safeguarding digital library resources, including copyrighted works, research data, and rare digital collections in the digital environment.
- To study the adequacy of the existing legal and regulatory framework in India, including copyright law and data protection laws, in addressing emerging concerns related to digital libraries and intellectual property in the digital era.

Review of Literature

The review of literature examines scholarly sources such as books, journal articles and analytical reports relevant to information security and privacy in digital libraries. Zimmerman (2009) highlighted that the physical infrastructure supporting digital resources is vulnerable to theft, damage, and cyberattacks such as malware and viruses. Al-Suqri and Afzal (2007) emphasized the need to secure hardware, networks, and wireless systems to prevent unauthorized access and data integrity breaches. Regular data backups and preservation strategies are essential to prevent data loss (Anday et al., 2012).

Ohm (2010) discussed the "broken promises of privacy," noting that technological advancements have made traditional privacy protections increasingly inadequate. Nissenbaum (2004) and Solove (2006) argued that privacy challenges are both technical and conceptual, requiring a redefinition of privacy in modern research and information environments. The National Institute of Standards and Technology (NIST) Privacy Framework (2020) emphasized integrating risk management into research and information systems, as breaches can undermine institutional trust.

Intellectual property concerns have also intensified with the growth of global research collaborations. Organizations such as the World Intellectual Property Organization (WIPO, 2018) and initiatives like Creative Commons licensing (2019) aim to provide clarity, yet licensing complexities often discourage data sharing. The open science movement (UNESCO, 2021; Wilkinson et al., 2016) further underscores the need to balance openness with legal and ethical safeguards.

Types of Intellectual Property

The major forms of intellectual property include:

- Copyright
- Patent
- Trademark
- Trade Secret

Copyright: Indian copyright law has historically drawn from British copyright traditions. In ancient times, the copying of manuscripts was a painstakingly slow process carried out mainly by monks and was largely limited to religious works produced for monastic orders and the royal courts of Europe. Toward the end of the seventeenth century, the government allowed the Stationers' Company monopoly to expire. The first recognizably modern copyright law, the Statute of Anne, was enacted in 1710 and came into effect the same year. This Act introduced, for the first time, the concept of the author as the owner of copyright and laid down fixed terms of protection for creative works.

Copyrightable Works (Section 13(1)): Literary works are defined under the Copyright Act, 1957, to include tables, compilations and computer programs, including computer based literary databases. Computer programs refer to programs recorded on any disc, tape, perforated medium, or

other information storage device which, when fed into or located in a computer or computer based equipment, are capable of producing information.

In the case of Kerala Law Times, including headnotes, short notes, long notes, editorial notes, citations and various copy editing inputs, the court held that a law report is the result of the literary skill and intellectual effort of the editor. A law report constitutes a complete document, and copyright subsists in the report as a whole.

Ownership of Copyright (Section 17): The author is generally the first owner of copyright. In the case of a government work, the government shall, in the absence of any contract to the contrary, be the first proprietor of the copyright therein. In the case of a literary, dramatic, or artistic work created by an author in the course of employment under a contract of service or apprenticeship with the proprietor of a newspaper, magazine, or similar periodical for the purpose of publication, the proprietor shall, in the absence of any agreement to the contrary, be the first owner of the copyright in that work.

Term of Copyright: Copyright shall subsist in any literary, dramatic, musical, or artistic work, other than a photograph, published during the lifetime of the author and continue until sixty years from the beginning of the calendar year following the year in which the author dies, as provided under the Copyright Act, 1957.

This provides a strong and succinct summary of the key issues related to balancing data privacy, security, intellectual property concerns, and innovation in research. If this is being drafted for an academic article or a policy paper, certain points may be expanded for greater clarity and depth. The following suggestions may help refine the overall structure.

Patent: A patent is a statutory right granted for an invention that is novel, involves an inventive step, and is capable of industrial application. It provides the holder the exclusive right to prevent others from making, using, selling, or importing the invention without permission, usually for 20 years from the date of filing. In India, patents are governed by the Patents Act, 1970, which encourages innovation while ensuring public disclosure of technological advancements.

Trademark: A trademark is a distinctive sign, symbol, word, or logo that identifies and distinguishes the goods or services of one entity from those of others. Trademarks protect brand identity and consumer trust, and in India, they are governed by the *Trade Marks Act, 1999*. Protection can be renewed indefinitely, provided the mark continues to be used.

Trade Secret: A trade secret refers to confidential business information that provides a competitive advantage and is not generally known to the public, such as formulas, processes, designs, or customer lists. Unlike patents and trademarks, trade secrets are protected through confidentiality and contractual obligations rather than registration. Protection lasts as long as the information remains secret and reasonable steps are taken to maintain confidentiality.

Data Privacy and Security in Digital Libraries

Data Privacy and Open Access: The increasing emphasis on open science and data sharing has accelerated innovation in academic and industrial environments. However, this growth has intensified the challenge of balancing open access to information with the protection of sensitive data, including personal information, trade secrets, and intellectual property.

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User Data Privacy and Confidentiality: User data privacy is paramount. If user data is exposed, it may not only breach trust but also lead to identity theft or fraud. Libraries must ensure that personal data collected for membership, transactions, or research purposes is kept confidential and securely encrypted. Confidentiality is also closely linked to maintaining the integrity of academic research. Exposure of sensitive research data or user queries can affect not only individuals but also academic communities and research outcomes.

Data Encryption and Access Control: Data encryption ensures that, even if unauthorized access is gained, the information remains unreadable without the decryption key. Libraries must encrypt data both at rest (stored on servers) and in transit (while being accessed or transferred). Implementing access control mechanisms is equally vital. Libraries must establish protocols to restrict access based on user roles (such as librarians, researchers and general users) and ensure that sensitive data is accessible only to authorized individuals.

Compliance with Privacy Regulations: Libraries must adhere to legal frameworks such as the GDPR, CCPA, and other applicable laws to ensure the protection of user privacy. This compliance includes practices such as providing users with clear and informed consent mechanisms, enabling users to manage their personal data including requests for deletion and conducting regular audits and compliance checks to ensure that data handling practices meet established regulatory standards. In the Indian context, compliance with the Digital Personal Data Protection Act, 2023 is increasingly relevant for digital libraries handling personal data.

Cyber-security Best Practices in Libraries

Regular Security Audits: Libraries must conduct routine security audits to identify and address vulnerabilities in their systems.

Staff Training: Library staff should receive regular training on cyber security awareness and best practices to prevent phishing and other social engineering attacks.

Multi-Factor Authentication (MFA): Implementing multi-factor authentication provides an additional layer of security, particularly for staff and administrators with access to sensitive systems.

Incident Response Plans: Libraries should maintain well defined incident response plans to ensure timely action in the event of a security breach and to minimize potential damage.

Balancing Accessibility and Security: One of the major challenges for digital libraries is maintaining strong security measures without compromising user accessibility. Libraries must design user-friendly systems that facilitate seamless access to information while upholding robust data protection and security standards.

Protection of Intellectual Property: Today, there are diverse software solutions dedicated to monitoring intellectual property (IP) archives, including physical documents. Many modern security suites include Data Loss Prevention (DLP) tools as standard features; these tools not only track confidential files but also monitor who accesses them and when. IP encryption can further help prevent the loss or unauthorized use of sensitive data in certain circumstances.

Digital libraries store a variety of sensitive information, such as:

- Personal data of users (e.g., names, emails, reading habits, payment information)
- Research findings, including unpublished academic papers or proprietary data
- Intellectual property, such as rare manuscripts, digital books, or multimedia files

Cyber-security ensures that this information remains protected from unauthorized access, theft, or manipulation. A breach could result in identity theft or compromise academic integrity.

Protection of Sensitive Information

Maintaining Trust and Credibility

- Trust is the foundation of any library, digital or physical. Users rely on digital libraries for secure and accurate access to reliable information.
- If a digital library is targeted by a cyber-attack or data breach, it could result in a loss of user trust, causing users to abandon the platform, thereby damaging the library's reputation and user base.
- Trust is not only about protecting personal data but also about ensuring the accuracy and integrity of the information provided. Cyber-attacks, such as data manipulation, can jeopardize this integrity.

Protection of Copyrighted Materials

- Digital libraries often host copyrighted materials, including e-books, journal articles, and multimedia content. Strong cyber-security measures help ensure these resources are protected from unauthorized distribution or reproduction.
- Content creators, publishers, and institutions rely on digital libraries to safeguard their intellectual property. Breaches could lead to piracy, undermining the financial and legal interests of creators and distributors.
- Libraries are responsible for securely delivering digital content, using technologies such as Digital Rights Management (DRM) and encryption to prevent unauthorized access or distribution.

Preventing Intellectual Property Theft

- Digital libraries often house valuable intellectual property, including rare or unique research materials, digital archives, and collections. Cybersecurity protocols help protect this IP from theft, tampering, or unauthorized reproduction.
- A compromised library system may lead to intellectual property theft, such as the theft of research data, manuscripts, or unpublished papers, which can be particularly damaging to researchers or institutions that rely on confidentiality.
- Universities and research institutions often depend on digital libraries to protect proprietary academic research that holds significant financial or academic value.

Regulatory Compliance

Data privacy laws and cyber-security regulations are becoming increasingly stringent. Libraries must ensure compliance to avoid legal and financial repercussions. Examples of such regulations include:

- General Data Protection Regulation (GDPR) (Europe): Sets strict guidelines on how user data should be stored, processed, and shared.
- California Consumer Privacy Act (CCPA) (U.S.): Governs the collection of personal data and grants users greater control over their information.

Libraries must comply with these regulations to maintain legal compliance while ensuring user privacy and data integrity.

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Legal Challenges in India's Intellectual Property Regime

- Outdated IPR Frameworks: Assess whether current IPR laws in India, such as the Copyright Act, 1957, and Patents Act, 1970, are adequate for modern data use and AI-generated content.
- Unauthorized Data Usage: Analyze challenges related to the unauthorized use of personal data for commercial purposes, including issues of consent, data ownership, and the role of intermediary platforms (e.g., social media, tech companies).
- AI-Generated Content and Copyright: Examine legal questions surrounding ownership of AI-generated works whether such outputs are considered "creations" under current copyright laws, or whether new legal frameworks are needed.

Conclusion

Data privacy and cyber-security are foundational to the smooth and safe operation of digital libraries. These libraries not only house valuable and sensitive information but also serve as trusted resources for millions of users worldwide. Therefore, libraries must adopt comprehensive cyber-security strategies to protect against data theft, preserve intellectual property, and maintain their credibility and reliability. By addressing the complexities of data privacy, user confidentiality, and cyber-security, libraries can provide a safe environment for their users while fully embracing the digital age. The Rhysida attack underscores the need for vigilance, not only against external threats but also in complying with global standards and protecting user rights. Finally, the paper highlights the need for legal reforms that balance the interests of creators, platform providers, and consumers, while ensuring that privacy protections are not compromised. Through an in-depth analysis of relevant case law, statutory provisions, and international trends, the paper provides recommendations for modernizing India's IPR laws to better address the challenges posed by the digital era.

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Digital & AI Literacy and Information Ethics Literacy, Ethics, Privacy and Security in Academic Libraries

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ABSTRACT

As digital technologies and artificial intelligence (AI) continue to evolve rapidly, academic institutions are facing new challenges in managing information ethically, securely, and responsibly. Academic libraries play a vital role in supporting students, researchers, and faculty by providing access to digital resources, AI-powered tools, and online information systems. However, the increasing dependence on digital platforms and intelligent technologies has created a strong need for digital literacy, AI literacy, and information ethics awareness. Users must not only know how to access information but also understand how data is collected, processed, and influenced by algorithms. This paper explores the importance of digital literacy and AI literacy in academic libraries, with a special focus on information ethics, privacy, and security. It explains how libraries can promote ethical information practices, protect user privacy, and create secure digital environments. The paper also discusses current trends, benefits, and challenges in implementing literacy programs and ethical policies. Finally, it provides recommendations for strengthening digital and AI literacy initiatives in academic libraries to support responsible information use in the digital age.

INTRODUCTION

The digital transformation of education has significantly changed how information is accessed, used, and shared in academic environments. Academic libraries, which once relied primarily on printed materials, now manage digital collections such as e-books, online journals, databases, institutional repositories, and AI-driven discovery systems. This shift has improved access to information but has also increased ethical, privacy, and security concerns.

Digital literacy and AI literacy have become essential skills for academic success. Students and researchers must be able to evaluate digital information critically, understand AI-generated content, and use technology responsibly. At the same time, libraries must address ethical challenges such as data misuse, plagiarism, surveillance, misinformation, and cyber threats. This paper examines how academic libraries can promote digital and AI literacy while ensuring ethical information practices, user privacy, and data security.

REVIEW OF LITERATURE

1. **Smith (2021)** highlighted the importance of digital literacy in higher education and emphasized that libraries play a critical role in teaching information evaluation and ethical use.
2. **Kumar and Singh (2022)** discussed the adoption of AI tools in academic libraries and stressed the need for AI literacy to avoid algorithmic bias and misinformation.
3. **UNESCO (2022)** emphasized digital and media literacy as essential skills for lifelong learning and responsible citizenship.
4. **IFLA (2023)** focused on information ethics, privacy, and intellectual freedom in digital library environments.
5. **Rao (2024)** examined cybersecurity challenges in academic institutions and recommended strong data protection strategies.

The review shows that while technology adoption is increasing, ethical awareness and literacy remain critical concerns.

Digital and AI Literacy in Academic Libraries

Digital literacy is the foundation upon which students, researchers, and faculty members build their ability to access, evaluate, and use information in today's digital age. It is no longer enough to simply be able to use digital tools or browse the internet; users must possess the skills to critically assess the information they encounter and engage with digital content in an informed and ethical manner. Digital literacy encompasses a variety of skills, including information literacy, which is the ability to find and evaluate resources effectively; technology literacy, which refers to the ability to use various digital platforms and tools; and ethical literacy, which ensures users understand the moral implications of their online actions. In academic libraries, digital literacy initiatives help users become adept at navigating digital resources like e-books, online journals, and academic databases, while also teaching them how to discern between reliable and unreliable sources.

AI literacy, on the other hand, extends beyond the basic understanding of digital tools to encompass the knowledge of how AI systems function, how they make decisions, and how they can be used responsibly. AI-powered tools, from recommendation engines to automated content analysis systems, are increasingly embedded in academic libraries to facilitate information retrieval and research. However, these technologies raise important questions regarding data privacy, algorithmic bias, and transparency. AI literacy helps users understand the underlying algorithms driving these systems, allowing them to make more informed decisions about the tools they use and the data they provide. Libraries can play a crucial role in fostering AI literacy by offering training and resources that educate users on how AI technologies work, their ethical implications, and how to use them responsibly in academic settings.

Together, digital and AI literacy programs ensure that users are equipped not only to engage with digital information but also to navigate the ethical and social challenges posed by new technologies. Libraries can provide critical support in this area through workshops, tutorials, and user guides that highlight the responsible use of technology and address common concerns such as data privacy, information overload, and algorithmic transparency.

Information Ethics in the Digital Age

Information ethics has become a central concern as digital and AI technologies permeate the academic landscape. Information ethics refers to the moral principles that guide the creation, dissemination, and use of information. In the digital age, these ethical considerations have become more complex, as vast amounts of data are generated and shared through interconnected systems. One of the most pressing issues is ensuring that information is used responsibly and ethically, especially when it comes to issues like privacy, intellectual property, and fairness.

For academic libraries, this means ensuring that users have access to reliable information while also respecting the privacy of individuals and protecting their intellectual property rights. Ethical concerns in academic libraries also extend to issues like the potential misuse of AI, algorithmic bias, and misinformation. As AI systems become more prevalent in academic settings, it is crucial that libraries provide guidance on how to use these systems ethically. This includes ensuring that AI systems do not perpetuate bias or discriminate against certain groups of people, as well as making sure that users understand the limitations and risks associated with these technologies.

Moreover, academic libraries must address the growing challenge of misinformation, which is amplified by AI-driven recommendation systems and digital platforms. By promoting information literacy and teaching users how to critically evaluate sources, libraries can help prevent the spread of false or misleading content. Libraries also have an ethical obligation to ensure that their digital collections are inclusive, equitable, and accessible, providing all users with the same opportunities to access information regardless of their background or resources

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Privacy and Security Issues in Academic Libraries

The increased reliance on digital tools and AI-powered systems has raised significant concerns about privacy and data security in academic libraries. As users interact with digital resources, they leave behind a trail of data—ranging from search histories to personal preferences—that can be tracked, analyzed, and potentially exploited. For academic libraries, this means that it is essential to implement robust privacy policies and security measures to protect user data from unauthorized access or misuse.

One of the most critical issues libraries face is ensuring that users' personal information is kept private. Data collected by digital library systems, such as search queries, borrowing records, and reading histories, can be sensitive and must be handled with the utmost care. Libraries must implement security measures, such as encryption and secure authentication systems, to prevent unauthorized access to this data. In addition, libraries should be transparent about the data they collect and how it will be used, ensuring that users are fully informed about their rights and options.

Security risks also extend to the protection of digital library collections. As more content is stored digitally, academic libraries must safeguard against threats such as cyberattacks, malware, and ransomware. Libraries must invest in advanced cybersecurity technologies and regularly update their systems to protect both user data and digital collections from these growing threats.

The Role of Libraries and Librarians in Promoting Digital and AI Literacy

Academic libraries and librarians play a critical role in supporting digital and AI literacy in academic environments. Librarians are uniquely positioned to help users navigate complex digital landscapes by providing training and resources that promote responsible information use. They are also key in raising awareness about the ethical implications of using digital tools and AI systems, ensuring that users understand the importance of privacy, security, and fairness in the digital realm.

Libraries are increasingly becoming hubs of digital education, offering workshops, tutorials, and one-on-one support for students, faculty, and researchers. By providing these resources, libraries ensure that users are equipped with the skills needed to use digital tools effectively and ethically. Librarians also act as advocates for privacy and security, ensuring that library systems respect user confidentiality and protect sensitive data.

Moreover, librarians are instrumental in promoting academic integrity and ethical research practices. As AI tools become more integrated into academic workflows, librarians must ensure that these tools are used in a manner that respects intellectual property rights and promotes fairness. This includes providing guidance on how to avoid plagiarism, use AI responsibly, and make informed decisions about the data and tools used in research.

Challenges in Implementing Digital and AI Literacy in Academic Libraries

Despite the growing importance of digital and AI literacy, academic libraries face several challenges in implementing effective literacy programs. One major challenge is the lack of adequate infrastructure and funding. Many academic libraries, especially in developing regions, struggle with limited access to advanced technologies, high-speed internet, and modern digital tools. This digital divide restricts the ability of libraries to provide comprehensive digital and AI literacy training.

Another challenge is the shortage of trained library professionals. Librarians are expected to guide users in emerging technologies such as artificial intelligence, data analytics, and cybersecurity, but many professionals have not received formal training in these areas. Continuous professional development is essential, yet time and resource constraints often limit such opportunities.

Resistance to change among users is also a concern. Some students and faculty members are hesitant to adopt new technologies or rely on AI-based tools due to fear of complexity, lack of trust, or ethical concerns. Additionally, the rapid evolution of AI technologies makes it difficult for libraries to keep their policies and training programs up to date.

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Ethical challenges such as algorithmic bias, lack of transparency in AI systems, and misuse of personal data further complicate implementation. Libraries must balance innovation with responsibility, ensuring that new technologies do not compromise ethical values, inclusiveness, or user trust.

Strategies and Recommendations for Strengthening Digital & AI Literacy

To address these challenges, academic libraries must adopt proactive and structured strategies. First, libraries should integrate digital and AI literacy programs into the academic curriculum in collaboration with faculty members. Mandatory workshops, orientation programs, and online learning modules can help students develop essential skills from the beginning of their academic journey.

Second, continuous training and upskilling of library professionals is crucial. Librarians should be encouraged to participate in professional development programs, seminars, and certifications related to AI, data ethics, and cybersecurity. This will enable them to confidently support users and manage advanced digital systems.

Third, academic libraries should develop clear policies related to information ethics, privacy, and data security. These policies must be transparent, user-friendly, and aligned with national and international standards. Regular awareness programs can help users understand their rights and responsibilities while using digital and AI-based services.

Finally, libraries should invest in secure technologies and collaborate with IT departments to strengthen cybersecurity measures. Implementing secure authentication systems, encrypted databases, and regular system audits can significantly reduce security risks.

Future Scope of Digital and AI Literacy in Academic Libraries

The future of academic libraries is closely tied to the advancement of artificial intelligence and digital technologies. Emerging trends such as machine learning–based discovery tools, virtual assistants, big data analytics, and personalized learning platforms will further transform library services. As these technologies evolve, the role of libraries will expand from information providers to digital educators and ethical guardians.

In the future, academic libraries are expected to play a leading role in promoting responsible AI use, combating misinformation, and supporting open access initiatives. Libraries can also act as research centers for studying the social and ethical impacts of AI in education. By embracing innovation while upholding ethical principles, academic libraries can remain relevant and essential in the digital knowledge ecosystem.

Conclusion

In conclusion, digital and AI literacy, along with strong ethical awareness, privacy protection, and security practices, are fundamental to the effective functioning of academic libraries in the modern era. As information environments become increasingly complex, libraries must move beyond traditional roles and actively guide users in responsible digital engagement. By strengthening literacy initiatives, enforcing ethical standards, and adopting secure technologies, academic libraries can ensure equitable access to information while safeguarding user rights. These efforts will not only enhance academic success but also contribute to the development of informed, ethical, and digitally responsible citizens.

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Digital and Artificial Intelligence Literacy: Building Ethical Awareness and Responsible Practices in the Digital Age

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Abstract

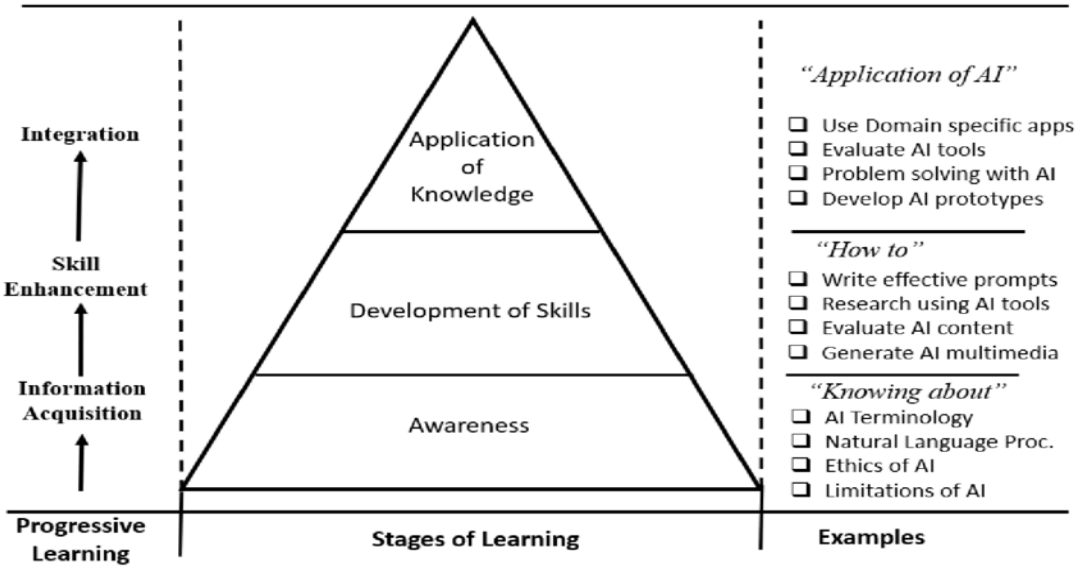
The dynamism and speed with which digital technologies and artificial intelligence (AI) are being introduced in almost all areas of human life has reshaped the manner in which people learn, work, communicate, and make the decisions they are supposed to make. Though digital literacy has always been regarded as a pre-requisite to being involved in the workings of the contemporary society, the emergence of AI systems has now added a more complicated and morally problematic layer the concept of digital and artificial intelligence literacy. The article discusses the notion of digital and AI literacy and the ethical awareness and responsible practices in particular. It investigates the ethical dilemmas of the AI-driven technologies, such as the data privacy, biasing of algorithms, transparency, accountability, and social inequality. The sample size to be used in the current study was 150 individuals which were determined by simple random sampling method. The reason behind adopting this approach is to give all the individuals in the population equal and independent opportunity of being included in the research and reduce sampling bias and maximize sample representativeness. This article contends that digital and AI literacy should not be limited to technical competence and should also encompass the ethical reasoning, critical thinking, and civic responsibility. Through the incorporation of ethical frameworks in education, policy and professional practice, societies will be able to enable the individuals to use intelligent technologies in a responsible and sustainable manner. The article ends with recommendations that are applicable to education systems, institutions, and policymakers in order to inculcate ethical digital and AI literacy during the digital era.

Keywords: Digital literacy, AI literacy, ethics, responsible technology, algorithmic, accountability and education

Introduction

The digital technologies have penetrated modern life influencing the methods, in which people receive information, how they communicate with other people and how they engage in economic and social activities.

Figure: 1 Framework



Artificial intelligence has increased this change in the last ten years, with the systems that have the capability to learn and predict, automate and simulate human intelligence. The use of AI technologies in personal life, as well

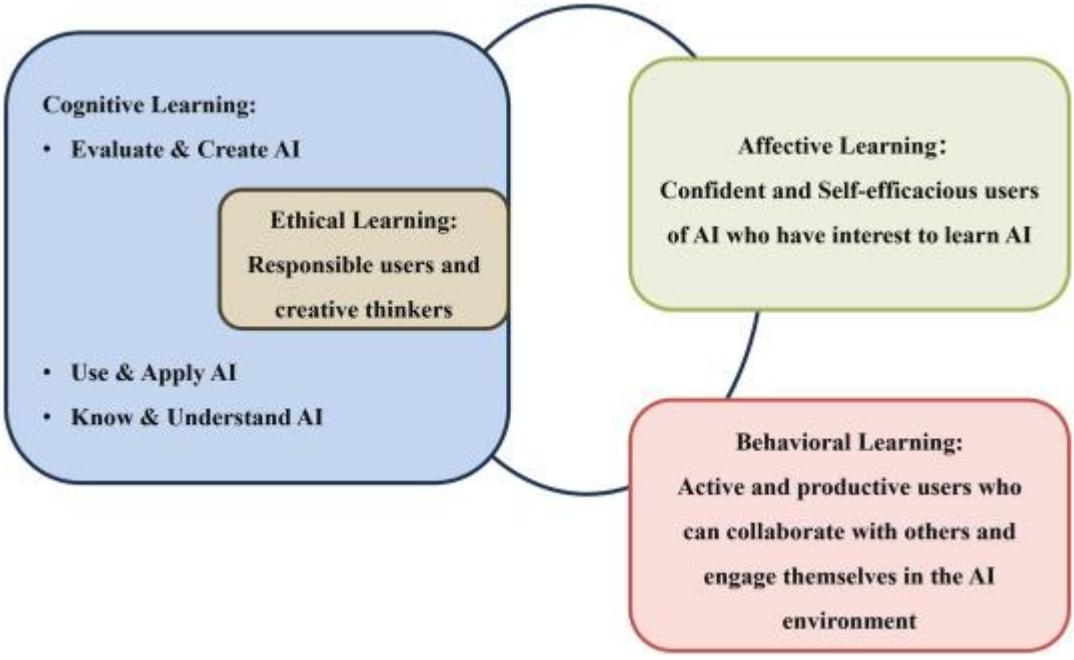
as in institutional decision-making, has come to be affected by the recommendation algorithms and facial recognition systems, the automated recruitment tools, and the generative AI platforms. With the increasing complexity and the scope of these technologies, ethical, social and legal issues have been raised. The problem of data monitoring, algorithmic discrimination, fake news, the loss of privacy, and the monopoly of technology is relevant and indicates that it is time to consider the digital and AI mechanisms in a more comprehensive way. Here, the conventional concept of digital literacy, mostly concentrated on fundamental technical proficiency, can no longer be used. Digital and Artificial Intelligence (AI) literacy should not strictly involve the skill to use digital tools but also the skill to critically analyze, ethically interact as well as to be responsible in the formation of intelligent technologies. This article focuses on the changing definition of digital and AI literacy with a special focus on ethical considerations and responsible approaches.

Research Background

Learning Digital and Artificial Intelligence: Literacy is the ability to apply artificial intelligence skills in order to perform specific tasks or make appropriate decisions.<|human|>Artificial Intelligence Literacy is the skill to use the artificial intelligence skills to accomplish certain tasks or make suitable decisions.. The first definition of digital literacy was the computer, software, and internet literacy. The concept has over the years been broadened to incorporate information literacy, media literacy and communication skills. The current definitions focus on critical thinking, assessment of web-based content, web safety, and responsible use and engagement in web worlds. The advent of AI-based systems has however put these definitions to the test. In addition to the fact that AI systems are not as easy to understand and control as traditional digital tools, they work with a certain level of autonomy, opacitance, and scale. Consequently, digital literacy now should discuss how algorithms work, how information is gathered and used, and how artificial intelligence can influence people and society.

Figure: 2

Fostering responsible AI literacy



Artificial Intelligence Literacy: AI literacy means that the person is capable of understanding, communicating with and critically evaluating AI systems. This involves the essential understanding of the functionality of AI, its uses, and restrictions and how it may affect society. Notably, AI literacy also means being aware that AI systems are not neutral; they carry with them values, assumptions, and biases of the design and data they are engineered to handle. All people do not need high technical skills to be AI literate. Instead, it entails building informed consciousness and moral judgment, whereby individuals will be able to doubt AI-inspired results, seek responsibility, as well as make conscientious decisions in the usage or utilization of AI

technologies. Ethics is also core in digital and AI literacy since technological choice is becoming an important factor in defining social norms, opportunities, and power systems. Moral consciousness can help people to know not only how technology can work, but also how it must work.

Information Security and Monitoring: Data privacy is one of the greatest ethical considerations during the digital era. AI systems are highly dependent on massive data, which may be generated through the use of the online activities of users, their personal gadgets, or even open records. There are numerous people who do not know the way their information is collected, stored, and sold. Informed consent, data ownership, and surveillance capitalism are the concepts that should be familiar to ethical digital and AI literacy. People should be capable of assessing privacy policies, understanding the risks involved in sharing the data, and be able to make informed choices about the digital footprint.

Stereo typing and Discrimination through Algorithms: The AI systems are capable of reproducing and escalating the social biases that exist in the training data. Racial, gender, and socioeconomic bias in facials recognition, credit rating, hiring algorithms, and predictive policing have been recorded. The ethical AI literacy concept entails the awareness that the outputs of algorithms are not objective per se. It will be essential that users and professionals be trained to challenge AI-based decisions, as well as learn how to identify the sources of bias and promote fairness, inclusiveness, and transparency in system design and implementation.

Explainability and Transparency: Numerous AI systems are black boxes, which do not include a clear description of how decisions are made in their outputs. This is ethically problematic, especially in such high stakes areas as health care, finance and criminal justice. An explanation of explainability and accountability should thus be part of digital and AI literacy. Ethical awareness will enable people to insist on the explanation of automated decisions and the creation of AI systems that may be understood and trusted.

Ethical behaviour in the application of AI technologies: Ethical awareness is not the only dimension of digital and AI literacy; the responsible practice is crucial as well. To be responsible involves implementing the use of technology in a way that is aligned with human values, social well-being, and sustainability in the long run. Individually, responsible AI usage involves critical analysis of AI-generated information, knowledge of misinformation and ethical behavior in online social environments. As the idea of generative AI is on the upswing, people need to know how to differentiate between human-generated and machine-generated content and prevent its abuse, including plagiarism, manipulation, or deceit. Responsible citizenship with respect to digital action includes being a responsible citizen on the internet as well as safeguarding personal and others information and cognizance of the effects that digital actions have on the society.

Professional and Institutional Responsibility: Designers, deployers, and operators of AI systems have an increased ethical burden. This involves observing the principles of fairness, accountability, transparency and human oversight. The institutions should have ethical standards, carry out impact assessment, and make sure that the legal and regulatory frameworks are met. Ethical training, interdisciplinary cooperation, and constant assessment of the social impact of AI systems ought to be included as digital and AI literacy in organizations. In influencing ethical digital and AI literacy, educational systems are very important. Learning institutions need to embrace new ethical obstacles of emerging technologies by changing the curricula.

Inclusion of Ethics in Digital Education and AI education: Ethics cannot be considered as a subject that is optional or peripheral. Rather, ethical concerns should be instilled at the level of digital and AI-related curricula. This encompasses the discussions on bias, privacy, power, and social responsibility as well as technical concepts. By using interdisciplinary strategies, which include the integration of computer science, social sciences, humanities, and law, learners with such skills are able to develop holistic and ethical reasoning abilities.

Research Gap: Although the adoption of the digital technologies and artificial intelligence (AI) in education, workplaces, and ordinary life is rather fast, current literature depicts a substantial gap in comprehending the intersection of digital and AI literacy and ethical awareness and responsible practice. Much of the recent literature pays attention to technical skills, e.g., coding, data management, or the usage of AI tools, and relatively, less research is devoted to ethical reasoning, critical thinking, and value-based decision-making in the digital context. Ethics as a core competency in navigating through algorithms and data privacy, misinformation and surveillance technologies is a secondary or abstract concept in studies that discuss digital

literacy. Also, there is limited empirical research on how people internalize ethical principles whenever dealing with AI systems, especially in developing and emerging economies. And integrated frameworks that combine digital competencies, AI literacy and ethical responsibility into a single educational paradigm are also lacking. Current research is either disjointed, academic or policy based and thus there is a dearth of practical, learner based research that can promote responsible digital citizenship. As a result, there is no sufficient research on the way educational interventions can be successfully used to develop ethical awareness in addition to technical expertise in the digital era, which needs to be thoroughly covered in the research.

Importance of the Study

This work is significant in that it touches upon the emerging necessity of providing people with not only digital and AI but also ethical literacy that allows them to use the technologies in a responsible manner. Because AI-powered systems and systems in general can increasingly be used to make decisions in education, healthcare, finance, and governance, the effects of unethical or uninformed application can be tremendous, among which is the discrimination, misuse of data, loss of trust. The ethical digital and AI literacy thus should be developed to create responsible citizens and sustainable technological progress. The article has added to the existing academic literature by highlighting the necessity of ethics as a primary aspect of digital and AI literacy and not a secondary issue. Practically it offers information that would be useful to educators, policymakers and curriculum developers who are interested in introducing ethical reasoning, accountability and critical thinking to online learning environments. This research is particularly timely in regards to preparing learners to apply AI tools in a reasonable and careful manner in India as well as the rest of the world where the digital transformation is becoming more popular. It is possible to build open, clear, and human-friendly AIbases with the help of the study because it focuses on the relationship between ethical consciousness and responsible digital behaviors. Overall, this article can bring forward the importance of education as a tool that can be used to transform ethically accountable individuals who can work in digital ecosystems and behave in a morally upright and socially responsible way.

Statement of the Problem

The use of digital technologies and artificial intelligence has altered the way people communicate, learn, and make their decisions but this process was not accompanied by a proper level of ethical preparedness. As users turn more and more dependent on the AI-powered instruments and digital solutions, they do not have sufficient awareness to assess in an ethical manner such concerns as data privacy, algorithm bias, misinformation, intellectual property, and accountability. Current educational programs tend to focus more on technical literacy than the ethical literacy, which makes them produce digitally-fluent people who might be unprepared to identify or react to the social and ethical consequences of AI technologies. This imbalance is dangerous to people and the society, such as unethical data practices, overreliance on automated systems and reduced human agency. In addition, the lack of formal systems of ethical digital and AI literacy hinders responsible practices to be developed in a systematic way by educators and institutions. The situation is also worsened since rapid technological changes surpass policy formulation and reformation in educational reforms. As a result, there is a pressing necessity to discuss the redesign of digital and AI literacy to utilize ethical awareness and responsibility as its essential part. The article aims at resolving this issue by looking at how ethical awareness can be achieved and how responsible behavior can be encouraged during the digital era.

Research objectives and Methodology

The article discusses the concept of digital and AI literacy and the ethical awareness and responsible practices in particular. It investigates the ethical dilemmas of the AI-driven technologies, such as the data privacy, biasing of algorithms, transparency, accountability, and social inequality. The sample size to be used in the current study was 150 individuals which were determined by simple random sampling method. The reason behind adopting this approach is to give all the individuals in the population equal and independent opportunity of being included in the research and reduce sampling bias and maximize sample representativeness. The sample was made up of people who were involved in learning or use of digital and artificial intelligence. A list of eligible participants was also obtained and randomness was employed in the way it was selected through random number. The chosen respondents had different backgrounds regarding age, gender, and educational levels, and it served to acquire different views concerning digital and AI literacy. The sample size was thought

to be sufficient to provide credible information and make meaningful statistical analysis. Through the use of simple random sampling, the study was able to achieve objectivity and enhanced the generalizability of the results as far as ethical awareness and responsible practice in digital practices were concerned.

Analysis and Findings

Digital and Artificial Intelligence literacy has become one of the key competencies of the new digital age. This is because it is necessary to understand how people understand and interact with digital and AI technologies to be more ethically aware, make rational decisions, and responsibly participate in the society of the technologies.

Null hypothesis: There is no significant relationship between the age of the respondents and their level of awareness towards Digital and Artificial Intelligence Literacy.

The hypothesis is tested with the help of Chi-Square test and Contingent Co-efficiency (CC).

TABLE 1 AGE AND LEVEL OF AWARENESS

Age	Level of Awareness			Total
	Less	Moderate	High	
Less than 30	**7**	**32**	**31**	**70**
	10.0%	**45.7%**	**44.3%**	**100.0%**
30-45 years	**14**	**27**	**17**	**58**
	24.1%	**46.6%**	**29.3%**	**100.0%**
More than 45 Years	**12**	**4**	**6**	**22**
	54.5%	**18.2%**	**27.3%**	**100.0%**
Total	**33**	**63**	**54**	**150**
	22.0%	**42.0%**	**36.0%**	**100.0%**

Table 1 shows the correlation between age of the respondents and their consciousness regarding Digital and Artificial Intelligence (AI) Literacy. The respondents will be divided into three categories in regards to age, less than 30 years, 30-45 years, and more than 45 years and the awareness levels will be grouped as less, moderate, and high.

There is a high percentage of moderate and high awareness among respondents aged less than 30 years with moderate (45.7) and high levels of awareness consisting of a large proportion of 45.7% and 44.3% respectively and a small percentage of 10.0% under the less aware. It means that younger respondents are expected to be more exposed and familiar with digital and AI-related notions.

The respondents in the 30-45 years age group also show moderate awareness (46.6%) with high awareness (29.3) being the second and third place respectively. Nevertheless, the percentage of those that are less aware is relatively higher (24.1) in comparison to those of the younger age category. This implies a moderate though a decreasing trend in awareness with age.

Conversely, the trend among the respondents over 45 years old is significantly different. Over half of them (54.5) are less awareness and only 27.3% are high awareness and 18.2% moderate awareness. This indicates a digital and AI literacy deficit that is evident among the elderly respondents. The table shows that there is a definite difference in the level of awareness among different age groups. Younger respondents show greater levels of awareness, whereas older respondents are less aware of Digital and AI Literacy. Even though the null hypothesis indicates that there is no significant relationship between the nature of the respondents (age) and level of awareness the observed distribution indicates that there may be some association between awareness level and age that can be statistically tested with the help of the appropriate inferential technique (such as the Chi-square test) in order to show that the null hypothesis is accepted or rejected.

Figure: 3

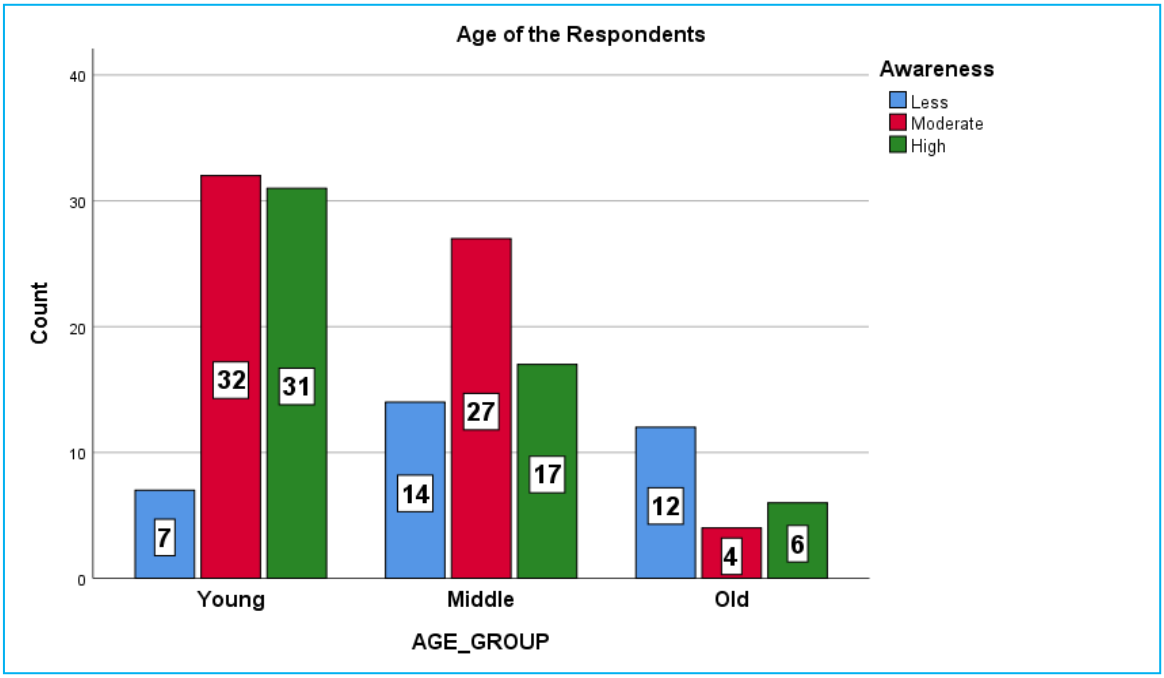


TABLE 2 CHI-SQUARE TEST

Test	χ^2	df	CC	Sig.
Result	2.338	4	0.051	0.654

Table 2 presents the results of the Chi-square test examining the relationship between **age of the respondents** and their **level of awareness towards Digital and Artificial Intelligence Literacy**. The calculated Chi-square value is **2.338** with **4 degrees of freedom**. The corresponding significance value (p-value) is **0.654**, which is greater than the standard significance level of 0.05.

Since the p-value exceeds 0.05, the **null hypothesis is accepted**, indicating that there is **no statistically significant relationship** between the age of the respondents and their level of awareness towards Digital and Artificial Intelligence Literacy. The contingency coefficient value (**CC = 0.051**) further suggests a **very weak association** between the two variables.

Thus, it can be concluded that variations in age do not significantly influence the level of awareness of Digital and Artificial Intelligence Literacy among the respondents in the present study.

GENDER AND LEVEL OF AWARENESS

Null Hypothesis: There is no significant relationship between the gender and their level of awareness towards Digital and Artificial Intelligence Literacy

TABLE 3 GENDER AND LEVEL OF AWARENESS

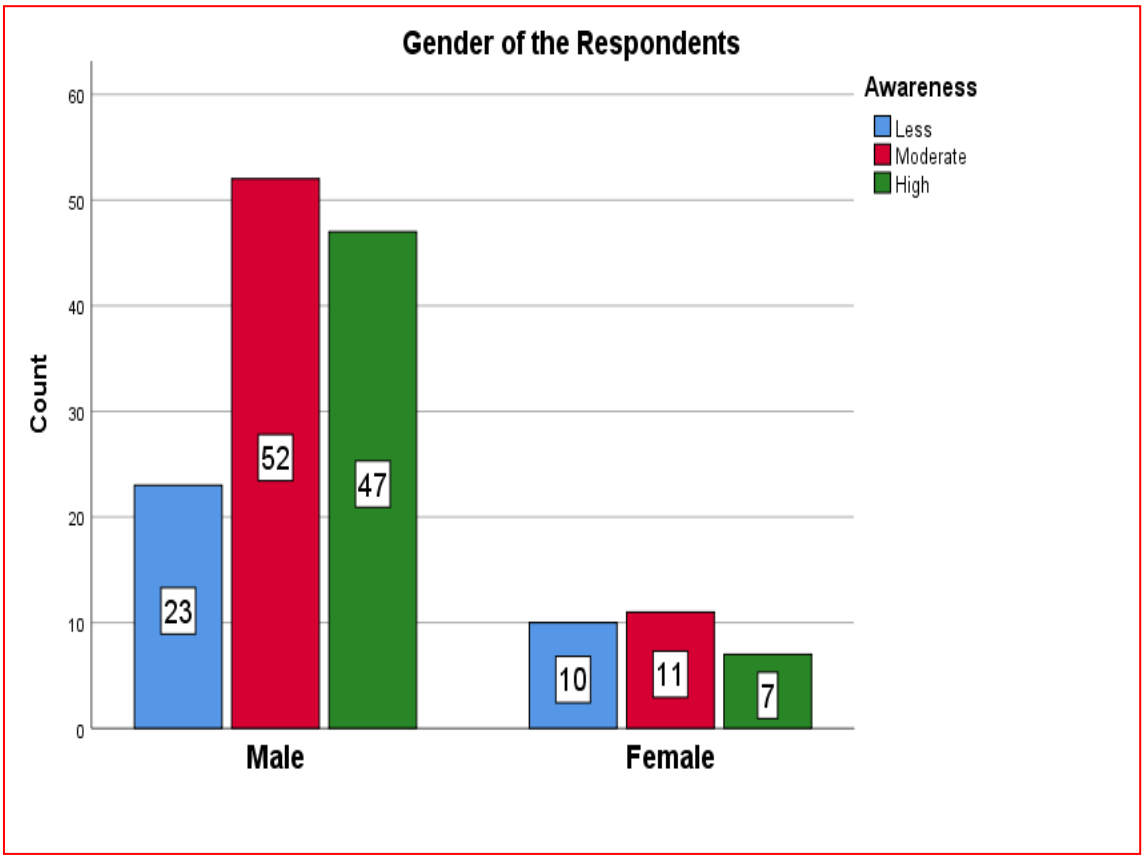
Gender	Level of Awareness			Total
	Less	Moderate	High	
Male	**23**	**52**	**47**	**122**
	18.9%	**42.6%**	**38.5%**	**100.0%**

Female	**10**	**11**	**7**	**28**
	35.7%	**39.3%**	**25.0%**	**100.0%**
Total	**33**	**63**	**54**	**150**
	22.0%	**42.0%**	**36.0%**	**100.0%**

Table 3 illustrates the distribution of respondents' **level of awareness towards Digital and Artificial Intelligence Literacy** across **gender**. Among **male respondents**, the majority demonstrate **moderate awareness (42.6%)**, followed by **high awareness (38.5%)**, while a smaller proportion (**18.9%**) report a low level of awareness. This indicates that most male respondents possess at least a moderate understanding of digital and AI literacy concepts.

In contrast, **female respondents** show a comparatively different pattern. While **39.3%** report a moderate level of awareness, a higher proportion (**35.7%**) fall under the less aware category, and only **25.0%** exhibit high awareness. This suggests relatively lower levels of digital and AI literacy awareness among female respondents when compared to males.

Figure :4



Overall, the table reflects **variations in awareness levels between male and female respondents**. Although males appear to demonstrate higher moderate and high awareness levels, the observed differences require statistical testing to determine whether the relationship between gender and awareness is significant. Accordingly, the null hypothesis stating that *there is no significant relationship between gender and the level of awareness towards Digital and Artificial Intelligence Literacy* may be tested using an appropriate inferential statistical method, such as the Chi-square test.

TABLE 4 CHI-SQUARE TEST

Test	χ^2	df	CC	Sig.
Result	1.726	2	0.033	0.005

The Chi-square test was conducted to examine the relationship between **gender** and **level of awareness towards Digital and Artificial Intelligence Literacy**. The calculated Chi-square value is **1.726** with **2 degrees of freedom**. The corresponding significance value (p-value) is **0.005**, which is **less than the 0.05 level of significance**.

Since the p-value is below 0.05, the **null hypothesis is rejected**, indicating that there is a **statistically significant relationship** between gender and the level of awareness towards Digital and Artificial Intelligence Literacy. Although the contingency coefficient value (**CC = 0.033**) suggests that the strength of association is **weak**, the relationship is nevertheless statistically meaningful.

Therefore, it can be concluded that **gender significantly influences the level of awareness of Digital and Artificial Intelligence Literacy** among the respondents in the present study.

Policy and Governance Implications

Ethical digital and AI literacy is not an individual obligation only, but should be supported by supportive policy and governance frameworks. The creation of standards, regulations and public awareness initiatives are of a core role in governments as well as international organization. Ethical practices can be enhanced with the help of policies that facilitate transparency, data protection, and accountability to avoid harm to the citizens. Simultaneously, widespread investment by people in digital and AI literacy programmes can empower bridging digital disparities and guaranteeing equal involvement in the digital economy.

Implications of the Study

The findings of this study have important implications for education, policy, and practice in the digital age. By emphasizing ethical awareness as a core component of digital and artificial intelligence literacy, the study informs curriculum designers and educators about the need to integrate ethics, critical thinking, and responsible technology use into learning programs. The results can guide policymakers in developing frameworks and guidelines that promote transparent, inclusive, and ethical use of AI technologies. Additionally, the study offers practical insights for organizations and individuals to adopt responsible digital practices reduce ethical risks, and foster informed decision-making. Overall, the study contributes to building ethically conscious and digitally competent citizens.

Limitations of the Study

The study has certain limitations that should be considered when interpreting the findings. First, the sample size was limited and selected from a specific population, which may restrict the generalizability of the results to broader contexts. Second, the use of self-reported data may be subject to response bias, as participants might provide socially desirable answers regarding their ethical awareness and digital practices. Third, the study focused on a particular time period and did not examine changes in digital and AI literacy over time. Finally, rapid technological advancements may limit the long-term applicability of the findings, as ethical challenges related to AI continue to evolve.

Conclusion

Digital and Artificial Intelligence literacy is a needed skill in the digital era, much more than mere technical skill. Since AI systems are becoming more widespread in determining the lives of people and the overall welfare, professional ethics and good morals are very important in ensuring that technological advancement is in line with human ethics. The article has contended that ethical digital and AI literacy should entail the knowledge of data privacy and algorithmic bias, transparency, and accountability and the ability to think critically and act responsibly. These competencies are important to be developed by education, institutions and policymakers. Integrating ethics into the heart of digital and AI literacy, societies will be able to enable

individuals to not only learn how to properly utilize intelligent technologies, but also guide them towards the creation of responsible AI-powered worlds, which is expected to foster fairness, trust, and sustainability in the new era of the so-called personal AI. Although the need to encourage ethical digital and AI literacy is increasingly being taken seriously, there are a number of obstacles in doing so. These are high velocity of change in technology, disproportionate access to education and resources and different cultural and regulatory environments. The work of the future needs to be oriented towards changeability, diversity, and international cooperation. Ethical digital and AI literacy is considered a process of lifetime, which is developing with the changes in technology and the needs of the society.

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Information Ethics in the Age of Digital and Artificial Intelligence Literacy

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ABSTRACT

The rapid advancement of artificial intelligence (AI) and digital technologies has restructured contemporary information ecosystems across education, industry, governance, and everyday life. As societies increasingly depend on data-driven and automated systems, the need for comprehensive digital and AI literacy has become critical. These literacies extend beyond technical competence to include critical thinking, ethical reasoning, and responsible information practices. This paper presents a conceptual examination of digital literacy and AI literacy in relation to information ethics. It explores their meanings, characteristics, types, advantages, disadvantages, and societal roles, while separately examining the meaning and scope of information ethics. The study emphasises ethical challenges such as privacy protection, algorithmic bias, transparency, accountability, and equitable access to information. This paper argues that integrating information ethics into digital and AI literacy frameworks is essential for fostering responsible technology use and supporting sustainable and human- centred digital development.

Keywords: Digital Literacy, AI Literacy, Information Ethics, Ethical Technology, Digital Society

INTRODUCTION

The rapid proliferation of digital innovations has greatly influenced the way information is created, accessed, and utilized. There are a few examples showcasing the penetration of technology in contemporary life such as online education, digital banking, e-governance, artificial intelligence-driven services. As the world becomes increasingly reliant on digital innovations, individuals need to have the required knowledge and skills to effectively navigate these realms. Moreover, the increasing trend of Artificial Intelligence has hastened the pace of change by allowing computers to execute tasks that required human intelligence. Decision- making has been shaped in various fields including health care, financial services, recruitment practices, marketing campaigns and education. Despite of their advantages in terms of efficiency, precision, and creativity, AI and its kind raise ethical issues regarding the infringement and misuse of data. Digital literacy and AI literacy have become key skills in the contemporary information society. Besides possessing technical knowledge in this field, people also need to acquire knowledge of its ethical implications. This paper will discuss its relevance to information ethics in terms of its characteristics, types, advantages, disadvantages, as well as ethical concerns. It will thus demonstrate the significance of incorporating ethical literacy in digital literacy as well as AI literacy, for responsible and sustainable technological development.

DIGITAL LITERACY: MEANING

Digital literacy is about being able to use digital technologies effectively, creatively, and responsibly to access, interact with, and communicate information." This means that digital literacy is about understanding digital tools, platforms, and systems while being aware of their social and ethical implications.

For a person to be digitally literate, he or she can be able to move within online environments, evaluate online content, and solve problems through technology. Being digitally literate is not restricted to the technical aspects of an individual's knowledge; there are cognitive, social, as well as ethical considerations in the process.

CHARACTERISTICS OF DIGITAL LITERACY

- **Information Evaluation Skill**

  Information evaluation skill is considered a very crucial feature of digital literacy.

  "In a digitally enabled world in which there is a lot of online information at our fingertips, there are clearly challenges and issues in terms of assessing its accuracy, its credibility, and its relevance." A strong skill

in "information evaluation" would enable any individual to make a sound and informed decision without any kind of manipulation.

- **Technical Proficiency**

  Technical proficiency can be described as the basic knowledge required for an individual to use digital devices, software applications, and the Internet effectively. Even when an individual doesn't require high-level technical knowledge, the basic knowledge helps participants to handle themselves adequately within the cyber community.

- **Adaptability to Technology**

  Digital technologies are also evolving very fast, and this means that, as a matter of principle or habit, digitally literate individuals are adaptable, as they are not static in their acquisition of knowledge and understanding of evolving technologies and systems of various kinds.

- **Ethical Awareness**

  It is essential to be ethically aware of the ethical responsibilities that are inherent in the use of digital technology. These include data privacy concerns, obtaining consent to share any information, respect for intellectual properties, as well as harmful online behaviors. Being ethically aware ensures that users use digital technology in ways that value human dignity and values.

- **Cybersecurity Awareness**

  Cybersecurity awareness is the learning of safe online practices and online risks. People who are digitally literate cannot be deceived or threatened online by things such as phishing, malware, ID theft, and security breaches. Cybersecurity measures include password security, networking security, and safe online behaviour.

- **Digital Communication Skills**

  Effective digital communication is an important characteristic of digital literacy; it entails the power to communicate clearly and respectfully by email, on social media, by videoconferencing, and on collaborative platforms using various devices and applications. Digitally literate people recognize the need for appropriate tone together with etiquette and sensitivity of culture while using digital devices for communication.

- **Creative Use of Technology**

  Digital literacy may also encompass the creative use of technology in content development, problem-solving, or innovation through technologies such as the development of digital presentations or analysing data appropriately to generate creative ideas or solutions. In this case, creativity is essential to improve participation in technology as a tool or means of expression or innovation.

- **Social Responsibility**

  Being socially responsible means having awareness of the social consequences of one’s activities in the digitized world. Thus, the digitally literate person thinks about the social consequences of one’s activities and behaviours and ensures that one promotes respect, resists harmful content and practices, and makes a positive contribution to the social world.

AI LITERACY: CONCEPT, TYPES, AND CHARACTERISTICS

Literacy in artificial intelligence systems, understanding its functioning, and its effects in society is known as artificial intelligence literacy. It provides conceptual knowledge instead of technical knowledge, thus helping a person work effectively with artificial intelligence systems in a confident manner.

Types of AI Literacy

- **Functional AI Literacy**

  Functional AI literacy refers to basic ability to use AI-powered technologies such as voice assistants, chatbots, and recommender technologies to aid people in their lives.

- **Conceptual AI Literacy**

  Conceptual artificial intelligence (AI) literacy requires understanding how artificial intelligence systems function, which involves knowledge of data collection, model training, and decision-making processes

- **Critical AI Literacy**

  Critical AI literacy involves an analysis of the various social, ethical, cultural, etc., considerations of AI technologies, including considerations of bias, fairness, etc.

Characteristics of AI Literacy

- **Awareness of AI Limitations**

  Being an 'AI-literate' person means knowing how to understand the fact that the performance of the intelligent machines may not always be perfect.

- **Transparency and Questioning Ability**

  Its most important aspect is "the capacity to question results produced by artificial intelligence systems and to seek explanations of automated decisions."

- **Ethical Sensitivity**

  Literate AI supports ethical awareness; it supports the understanding of the social impact, privacy risks, and if some AI applications are fair.

- **Human-Centered Judgment**

  AI-literate users are aware of human oversight and avoid dependence on automatic systems.

INFORMATION ETHICS: MEANING AND SCOPE

Information ethics looks at moral principles in regard to information production, storage, processing, and use. The significance of information ethics in relation to responsible behavior in information environments and human values in computer environments cannot be overstated.

THE SCOPE OF INFORMATION ETHICS

The range of information ethics issues spans data privacy, consent, intellectual property, freedom of expression, information access, etc. As more AI systems are implemented in combination with data analytics tools, issues of surveillance ethically align into the spotlight.

Another issue covered within information ethics is concepts of fairness and equity with regards to information access. Ethical information practices work towards closing the information gap and ensuring that all citizens within a society have access to the benefits of technology. With concepts of transparency and accountability, information ethics fosters trust within the information environment.

ADVANTAGES OF DIGITAL AND AI LITERACY

- **Educational Advantages**

  Digitally literate individuals will be able to better access educational materials, online- learning opportunities, as well as personally tailored learning settings made possible through AI tools.

- **Professional and Economic Advantages**

  These forms of literacy increase "employability and productivity." People who are AI literate are able to work effectively with intelligent systems.

- **Social and Civic Advantages**

  Citizens can play a more active role in digital governance and communities through digital literacy while fulfilling ethical considerations as digitally aware individuals.

- **Ethical Advantages**

  Ethically informed digital literacy encompasses the ethics related to the proper use of data.

DISADVANTAGES AND CHALLENGES

- **Digital Divide and Inequality**

  Due to limited accessibility and exposure towards technology, as well as infrastructure and education systems.

- **Over-Reliance on Technology**

  Similarly, over-reliance on digital technology and AI systems can also lead to a decline in human thinking, creativity, and judgment.

- **Privacy and Security Risks**

  Lack of appropriate expertise in digital systems may result in data breaches, surveillance issues, and misuse of personal information.

- **Ethical and Social Risks**

  Algorithmic biases, lack of transparency, and abuse of these AI-related technologies raise critical ethical concerns.

ROLE OF EDUCATION AND INSTITUTIONS

- **Educational Institutions**

  Schools and universities have to incorporate digital literacy, artificial intelligence literacy, and information ethics into the curriculum to promote well-informed and responsible learners.

- **Teachers and Trainers**

  Educators have a critical task in promoting responsible use of technologies in society and teaching students to be critical thinkers through professional growth.

- **Government and Policy Makers**

  Therefore, governments need to develop regulations, ethical requirements, and policies that encourage the practice of transparency and accountability and the safeguarding of their data.

- **Organisations and Industry**

  Businesses must foster ethical artificial intelligence practices, data fairness, and promote the development of digital skills among their workforce.

CONCLUSION

The key competencies in a new information society are digital and artificial intelligence literacy. With digital platforms and artificial intelligence systems growing in influence in communication, education,

employment, and decision-making, people also require a form of literate understanding, apart from skills in those areas. The meaning, characteristics, categories, strengths, weaknesses, and role of digital and artificial intelligence literate, as well as distinguishing information ethics from those terms, have been discussed in this paper.

Informed ethical approaches are highly necessary to address different challenges that arise with respect to privacy and copyrights. In fact, without ethical approaches, the rapid growth and application of digital and AI technologies have a great chance of promoting social inequalities and undermining trust and human rights. Informed ethical approaches to digital and AI literacy education encourage people to question and apply information and AI appropriately while valuing social and cultural values.

In conclusion, the development of ethically informed digital and AI literacy is imperative to the creation of an inclusive, transparent, and sustainable digital society. There is an urgent need for the collaborative promotion of ethical awareness by the education sphere, policymakers, industries, and individuals to ensure that digital and AI innovations are utilised for the common good.

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Digital and Artificial Intelligence Era: Literary Information Ethics, Privacy and Security

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Abstract

The rapid growth of digital technologies and Artificial Intelligence (AI) has transformed the way information is created, stored, shared, and interpreted. In the literary and informational domain, AI tools are increasingly used for content generation, translation, analysis, and preservation of knowledge. While these advancements offer efficiency and accessibility, they also raise serious ethical concerns related to information authenticity, intellectual property, privacy, and data security. Literary information ethics focuses on responsible creation and use of digital content, ensuring fairness, transparency, and respect for human values. At the same time, privacy and security have become critical challenges in the digital age, as personal and intellectual data are often collected, analyzed, and stored by AI systems. This paper examines the ethical dimensions of digital and AI-driven literary information, with a special focus on privacy and security issues. It also highlights the need for ethical frameworks, legal regulations, and human oversight to ensure that digital and AI technologies are used responsibly and sustainably.

Keywords: Digital Technology, Artificial Intelligence, Information Ethics, Literary Ethics, Privacy, Data Security, Intellectual Property

Introduction

Digital technology and Artificial Intelligence (AI) have become integral parts of modern society. From education and literature to healthcare and governance, AI-driven systems influence decision-making and knowledge creation. In the literary and information world, digital platforms and AI tools are widely used for writing, editing, publishing, data analysis, and archiving. These developments have significantly increased access to information and reduced human effort.

However, the growing dependence on AI also introduces complex ethical challenges. Information ethics deals with moral principles governing the creation, dissemination, and use of information. When literature and knowledge are processed by AI systems, questions arise about authorship, originality, bias, accountability, and misuse of information. Moreover, digital platforms often collect vast amounts of personal and intellectual data, raising concerns about privacy violations and data security breaches.

In this context, understanding literary information ethics, privacy, and security in the digital and AI era is essential. Ethical awareness helps protect human dignity, creativity, and rights, while strong security measures safeguard sensitive data from misuse. This paper explores how digital and AI technologies impact literary information ethics and examines the associated privacy and security challenges.

OBJECTIVES OF THE STUDY

The objectives of the present study are:

1. To examine the impact of digital technology and Artificial Intelligence on literary and informational practices.
2. To analyze ethical issues related to authorship, originality, bias, and intellectual property in AI-driven literary environments.
3. To identify major privacy concerns arising from data-driven digital and AI systems.
4. To discuss security challenges affecting digital literary information systems.
5. To highlight the need for ethical frameworks and regulatory measures for responsible AI use.

METHODOLOGY

The study is conceptual and descriptive in nature. It is based on an extensive review of secondary sources, including scholarly journal articles, books, conference proceedings, policy documents, and ethical guidelines related to Artificial Intelligence, information ethics, privacy, and data security. Relevant literature was systematically analyzed to identify key ethical concerns, challenges, and governance approaches applicable to literary and information environments.

Digital and Artificial Intelligence in Literary Information

Digitalization has changed traditional literature into digital literature, including e-books, online journals, blogs, and multimedia texts. AI systems such as natural language processing (NLP) tools can analyze texts, summarize content, generate stories, and even mimic human writing styles. These technologies are widely used in education, publishing, journalism, and research.

AI tools help scholars analyze large volumes of literary data, identify patterns, and preserve cultural heritage through digitization. Translation software enables cross-cultural knowledge sharing, while recommendation algorithms suggest books and articles to readers. Despite these benefits, AI-generated content blurs the boundary between human creativity and machine output, creating ethical dilemmas related to originality and ownership.

Literary Information Ethics in the Digital Age

Literary information ethics refers to ethical principles guiding the creation, distribution, and consumption of literary and informational content. In the digital and AI context, several ethical issues emerge:

Authorship and Originality

AI-generated texts challenge traditional concepts of authorship. When a machine produces content based on existing data, it raises questions about who owns the output—the developer, the user, or society. Ethical concerns arise when AI content is presented as original human work without proper disclosure.

Intellectual Property Rights

Digital platforms make copying and sharing content easy. AI systems trained on copyrighted texts may reproduce similar content, potentially violating intellectual property laws. Ethical use of AI requires respect for copyrights and fair use policies.

Bias and Fairness

AI systems learn from existing data, which may contain cultural, gender, or social biases. In literary analysis and content generation, biased AI outputs can reinforce stereotypes and misinformation. Ethical responsibility demands transparency and bias mitigation.

Accountability and Transparency

When AI systems make errors or spread harmful content, determining responsibility becomes difficult. Ethical frameworks emphasize human oversight, explainability, and accountability in AI-based literary applications.

Privacy Issues in Digital and AI Systems

Privacy is a fundamental human right, yet it is increasingly threatened in the digital era. AI systems often rely on large datasets that include personal information such as reading habits, search history, and user preferences.

Data Collection and Surveillance

Digital platforms track user behavior to personalize content and improve services. However, excessive data collection can lead to surveillance and misuse of personal information without informed consent.

Personal Data Protection

In literary and educational platforms, students' and researchers' data may be stored and analyzed by AI tools. Without proper safeguards, this data can be exposed to unauthorized access or exploitation.

Ethical Use of User Data

Ethical AI practices require transparency about data usage, user consent, and the right to data deletion. Privacy-by-design approaches help integrate ethical values into technological systems.

Security Challenges in the Digital and AI Environment

Security is closely linked to privacy and ethics. Digital literary information systems face multiple security threats, including hacking, data breaches, and manipulation.

Data Breaches and Cyber Attacks

Large digital databases containing literary works and user information are attractive targets for cybercriminals. Breaches can lead to financial loss, identity theft, and loss of trust.

AI System Vulnerabilities

AI models can be manipulated through malicious inputs, leading to false outputs or data leakage. Securing AI systems requires robust technical safeguards and continuous monitoring.

Preservation and Integrity of Information

Ensuring the authenticity and integrity of digital literary content is essential. Security mechanisms such as encryption, access control, and digital signatures help protect information from tampering.

Ethical Frameworks and Regulatory Measures

To address ethical, privacy, and security challenges, governments and organizations are developing regulations and guidelines. Data protection laws, ethical AI principles, and institutional policies play a crucial role in responsible technology use. Education and ethical training for developers, researchers, and users are equally important.

Conclusion

Digital technology and Artificial Intelligence have revolutionized literary information creation and access. While these innovations offer immense benefits, they also pose serious ethical, privacy, and security challenges. Literary information ethics emphasizes responsible authorship, fairness, transparency, and respect for intellectual property. Privacy protection and strong security measures are essential to safeguard personal and cultural data in the digital age. A balanced approach combining technological innovation with ethical awareness and regulatory oversight is necessary to ensure that digital and AI systems serve humanity positively. By adopting ethical frameworks and secure practices, society can harness the power of AI while preserving human values and rights.

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Awareness and Use of Artificial Intelligence (AI) Tools among the Library User Community in Nirmala College for Women: A Study

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ABSTRACT

Artificial Intelligence has profoundly reshaped the academic library landscape by revolutionizing how information is accessed, retrieved, and delivered. This research investigates the awareness, utilization trends, and attitudes toward AI tools among students at Nirmala College for Women, Coimbatore. Through a structured survey of undergraduate and postgraduate students, the study assesses their engagement with AI-driven applications including intelligent search engines, personalized recommendation systems, chatbots, and academic support platforms. The results indicate a significant, growing familiarity with AI technologies and their adoption for scholarly tasks, while also identifying persistent gaps in user training and institutional infrastructure. These insights underscore an imperative for academic libraries to champion AI literacy and strategically embed intelligent systems into their services, thereby fostering enriched user engagement and greater academic achievement.

Keywords: Artificial Intelligence, Academic Libraries, AI Tools, User Awareness, Information Services

INTRODUCTION

The rapid proliferation of digital technologies has fundamentally altered the information ecosystem, transforming the processes of creation, access, and dissemination. Within this digital landscape, Artificial Intelligence has emerged as a particularly transformative force, actively reshaping academic environments. By deploying intelligent search systems that understand natural language queries, AI provides more precise and relevant results. It powers personalized recommendation engines that curate scholarly resources tailored to individual research trajectories, while automated reference services, such as AI-driven chatbots, offer users instant, around-the-clock assistance. Furthermore, AI facilitates data-driven decision-making within libraries, analyzing usage patterns to optimize collections and services. Consequently, academic libraries, serving as the central intellectual hubs of higher education, are strategically integrating these AI tools. This adoption is not merely a trend but a necessary evolution aimed at enhancing operational efficiency, expanding the scope of user support, and ultimately elevating the overall satisfaction and academic productivity of their user communities.

In recent years, library users especially students have begun to rely on AI-powered applications for information retrieval, research assistance, and learning support. However, the effective use of these tools depends largely on users' awareness, accessibility, and training. In this context, the present study focuses on assessing the awareness and use of AI tools among the library user community of Nirmala College for Women.

CATEGORIES OF E-RESOURCES IN AI

E-resources in AI can be broadly categorized into educational platforms, research databases, datasets, AI development tools, and collaborative communities.

Educational Platforms

With the growing demand for AI skills, several e-learning platforms offer specialized courses and certifications in AI, machine learning, and data science.

Massive Open Online Courses (MOOCs): Platforms like Coursera, edX, and Udacity offer AI courses from renowned universities and institutions, including Stanford, MIT, and Google. These platforms provide interactive learning through video lectures, hands-on projects, and quizzes.

YouTube Channels and Online Tutorials: Channels like "3Blue1Brown" and "Two Minute Papers" provide accessible and high-quality educational content on AI concepts, algorithms, and research papers.

Interactive Platforms: Platforms like DataCamp and Kaggle provide practical, hands-on learning through coding challenges, tutorials, and competitions focused on machine learning and AI topics.

Research Databases and Journals

Research papers, journal articles, and conference proceedings are vital for keeping up with AI developments.

arXiv: A widely used open-access archive for academic papers, arXiv is particularly popular in the AI community for preprints on machine learning, computer vision, natural language processing (NLP), and robotics.

Google Scholar: This academic search engine offers access to research papers and articles on AI topics from various journals and conferences.

IEEE Xplore: The IEEE Xplore digital library offers a wealth of peer-reviewed research articles, technical papers, and standards in AI, robotics, and computational intelligence.

ACM Digital Library: The Association for Computing Machinery (ACM) provides access to AI research papers, journals, and proceedings from AI-focused conferences such as NeurIPS (Neural Information Processing Systems) and ICML (International Conference on Machine Learning).

Datasets

Data is the fuel for AI. High-quality datasets enable AI algorithms to learn, optimize, and make predictions. Various e-resources provide publicly accessible datasets for AI researchers and developers.

Kaggle Datasets: Kaggle hosts a vast collection of datasets across different domains, such as healthcare, finance, and computer vision, enabling users to practice AI model training and participate in competitions.

Google Dataset Search: This search engine allows users to discover open-access datasets from multiple fields, making it easier to find relevant data for AI research.

ImageNet: One of the most well-known datasets in AI, ImageNet contains millions of labeled images, serving as a benchmark for computer vision models.

UCI Machine Learning Repository: This repository contains a wide variety of datasets for machine learning algorithms, ranging from healthcare and social sciences to marketing and finance.

AI Development Tools and Platforms

Cloud-based AI platforms and open-source software play a critical role in AI research and development, providing essential tools for building, training, and deploying AI models.

TensorFlow and PyTorch: TensorFlow (by Google) and PyTorch (by Facebook) are two of the most widely used open-source AI frameworks. They provide developers with the necessary tools to build neural networks, train deep learning models, and experiment with AI algorithms.

Google Colab: This cloud-based platform allows users to write and execute Python code for free using Google's hardware, including GPUs and TPUs. Colab is widely used by researchers and developers for AI model prototyping and experimentation.

IBM Watson: IBM Watson provides a suite of AI tools for building models, analyzing data, and creating AI-powered applications. It offers natural language processing, computer vision, and machine learning tools, making it accessible to both AI professionals and business users.

Microsoft Azure AI: Azure provides a range of AI services, including machine learning tools, pre-built AI models, and cognitive services for natural language processing, vision, and decision-making.

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IMPACT OF E-RESOURCES ON AI INNOVATION AND DEVELOPMENT

The extensive availability of electronic resources has been a transformative force in AI, fundamentally democratizing innovation and accelerating its development. By providing universal access to open-source tools, public datasets, and peer-reviewed research, e-resources have lowered barriers to entry, empowering a global and diverse community of developers and researchers to contribute. This inclusivity not only speeds progress but also fosters essential interdisciplinary collaboration—enabling experts in fields from healthcare to linguistics to leverage AI frameworks, apply them to specialized challenges, and drive solutions to complex real-world problems. Ultimately, this open ecosystem nurtures a more creative, equitable, and rapid cycle of discovery and implementation.

REVIEW OF LITERATURE

The review of literature provides a comprehensive understanding of earlier studies related to the awareness, use, perception, and ethical implications of Artificial Intelligence (AI) tools in education and library environments. It helps to identify trends, methodologies, findings, and research gaps relevant to the present study. Several studies have examined students' awareness and acceptance of AI tools in academic contexts. **Albayati (2024)** analyzed undergraduate students' acceptance of ChatGPT using an extended Technology Acceptance Model, finding that factors such as privacy, security, trust, and social influence significantly affect user adoption. Similarly, **Sova et al. (2024)** revealed that awareness and perceived usefulness strongly influence students' attitudes toward AI, while concerns negatively impact adoption. These findings collectively indicate that awareness alone is insufficient for fostering AI adoption unless it is supported by a foundation of trust and reinforced by institutional guidance. Research conducted in different geographical contexts highlights varying levels of awareness and usage. **Alimi et al. (2021)** reported low awareness of AI tools among university students in Kwara State, attributing poor usage to limited access and digital skills. From a library and LIS perspective, **Fasola (2024)** highlighted high awareness and positive perceptions of AI tools among LIS lecturers, though actual usage was constrained by infrastructure and skill gaps. Studies by **Idika et al. (2025)** and Soko et al. (2025) stressed the importance of institutional support, training, and policy frameworks to promote responsible AI use in higher education.

Overall, the literature reveals that although awareness and use of AI tools are increasing, challenges related to training, ethical concerns, and institutional support persist. The present study builds upon these findings by examining the awareness and use of AI tools among the library user community of Nirmala College for Women, thereby providing institution-specific insights.

METHODOLOGY

The study adopted a descriptive survey method to assess the awareness and use of AI tools among library users. A structured questionnaire was designed based on the objectives of the study and relevant literature. The questionnaire included sections on demographic details, awareness of AI tools, frequency of use, purposes of use, and challenges faced while using AI-based applications.

The population of the study comprised undergraduate and postgraduate students of Nirmala College for Women, Coimbatore. A convenient sampling technique was used to collect **100** responses from a representative sample of students. The collected data were carefully scrutinized, coded, and analysed using simple statistical techniques such as percentages and tabulation. The methodology ensured systematic data collection and provided a reliable basis for interpreting users' perceptions and practices related to AI tools.

DATA ANALYSIS AND DISCUSSION

The responses collected through the questionnaire were examined using simple percentage analysis to understand trends in awareness and usage of AI tools among the library user community. For clarity and academic presentation, the findings are supported with five tables and corresponding charts. A total of **100 valid responses** were considered for analysis

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Table 1: Course-wise Distribution of Respondents

Category	Number of Respondents	Percentage (%)
UG	40	40
PG	20	20
Research Scholar	20	20
Faculty	20	20
Total	**100**	**100**

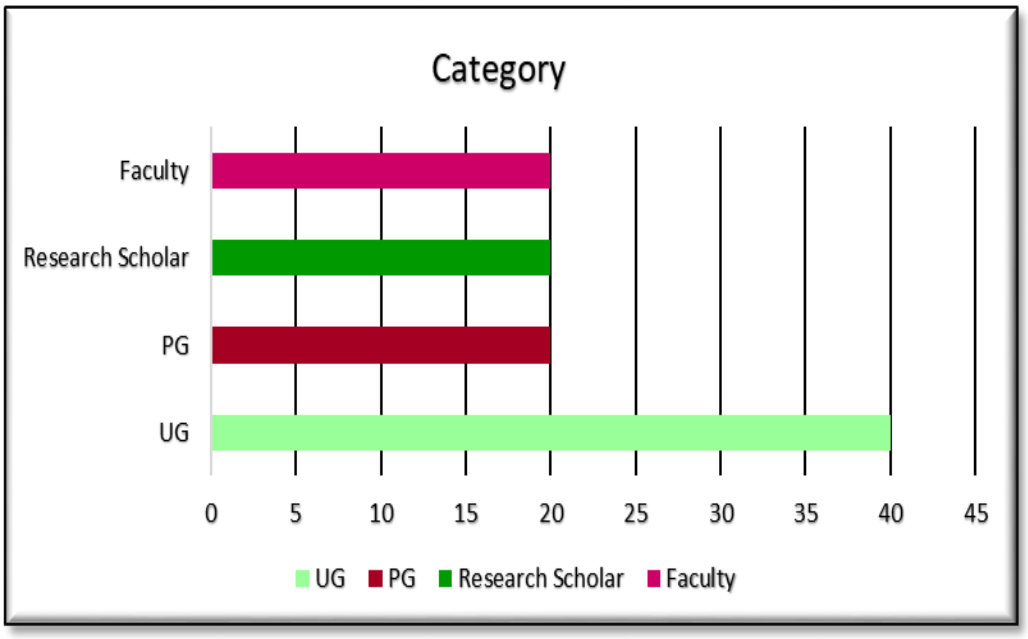


Figure 1. Category Wise distribution

Interpretation

The table indicates the category wise distribution which includes respondents from UG course 40%, PG course 20%, research scholar is 20%, and faculty 20%, which indicates most respondents are students and few research scholars and faculty members.

Table 2: Awareness of AI Tools

Response	Number of Respondents	Percentage (%)
Yes	92	92
No	8	8
Total	**100**	**100**

Interpretation

The table shows that the majority of respondents are aware of AI tools with (92%), and people who are not aware are (8%).

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Table. 3: Confidence Level in Using AI Tools

Confidence Level	Number of Respondents	Percentage (%)
Very High	7	7
High	45	45
Moderate	38	38
Low	8	8
Very Low	2	2
Total	**100**	**100**

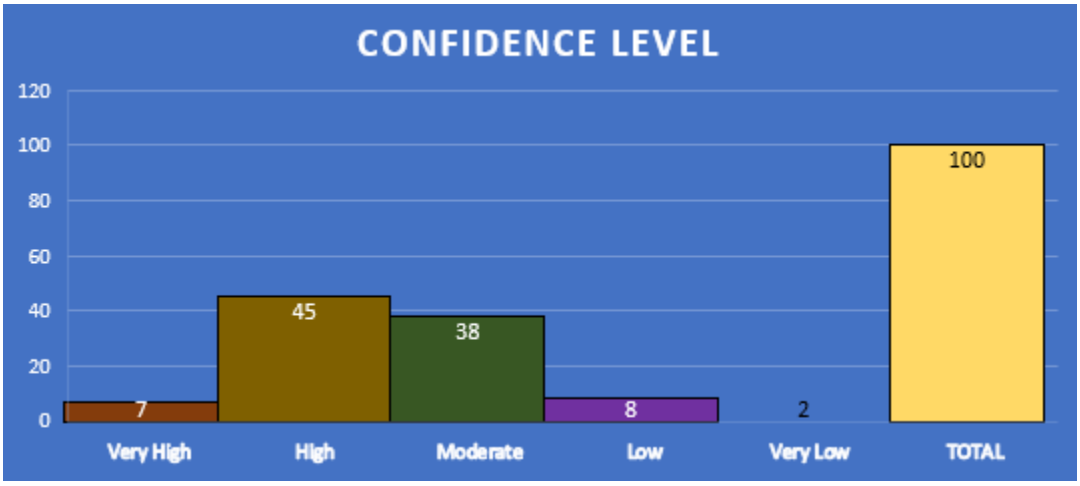


Figure 2. Confidence level of AI tools

Interpretation

The table indicates the confidence level of users in using AI tools, distributed as high level (45%), moderate level (38%), low level of (8%), very high level (7%), and very low level with (2%), most respondents have moderate to high confidence in using AI tools.

Table 4. AI Tools Used for Academic Purposes (Multiple Choice)

AI Tool	Number of Responses	Percentage (%)
ChatGPT	77	32.35
Gemini	51	21.42
Grammarly	29	12.18
Elicit	5	2.10
Perplexity	27	11.34
Turnitin	12	5.04
Research Rabbit	19	7.98

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Zotero	13	5.46
Others	5	2.10
Total	**238**	**100.00**

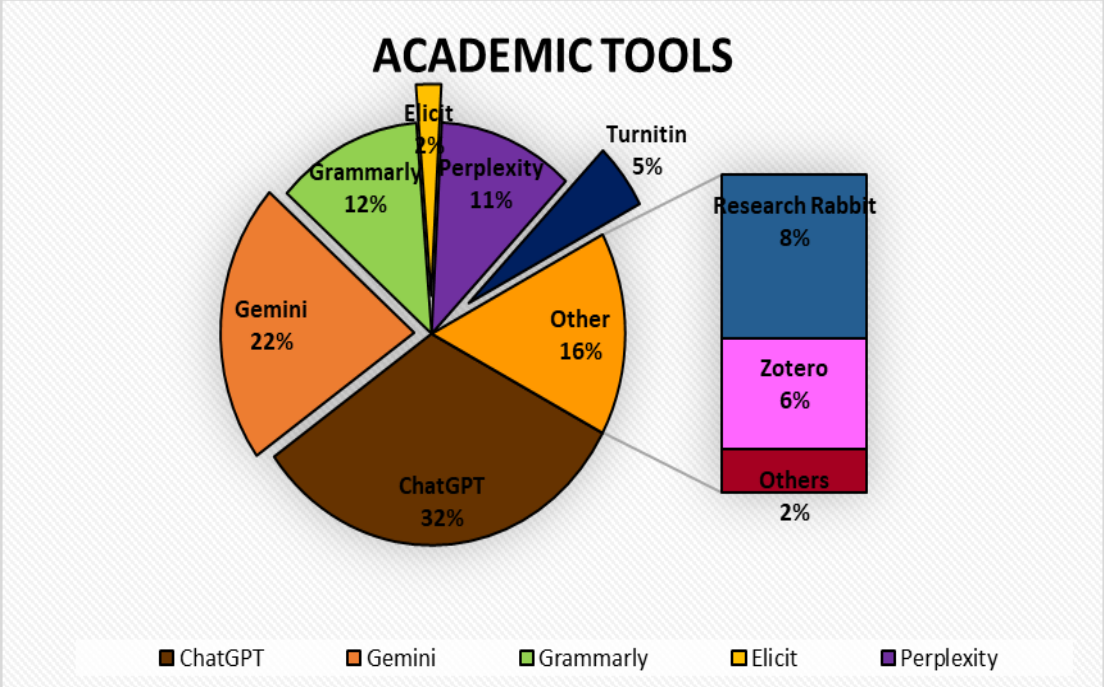


Figure 3. Academic AI tools

Interpretation

The table indicates that respondents use ChatGPT (32%), Gemini (22%), Grammarly (12%), Perplexity (11%), Others (16%), Research Rabbit (8%), Zotero (6%), Turnitin (5%), Elicit (2%) ,the respondents use multiple AI tools for academic and research activities, in that ChatGPT and Gemini are used in majority.

Table.5 Purpose of Using AI Tools (Multiple Choice)

Purpose	Number of Responses	Percentage (%)
Assignments	63	23.68
Research	44	16.54
Literature Review	12	4.51
Exam Preparation	48	18.04
Writing	55	20.67
Referencing	19	7.14
Summarization	25	9.39
Total	**266**	**100**

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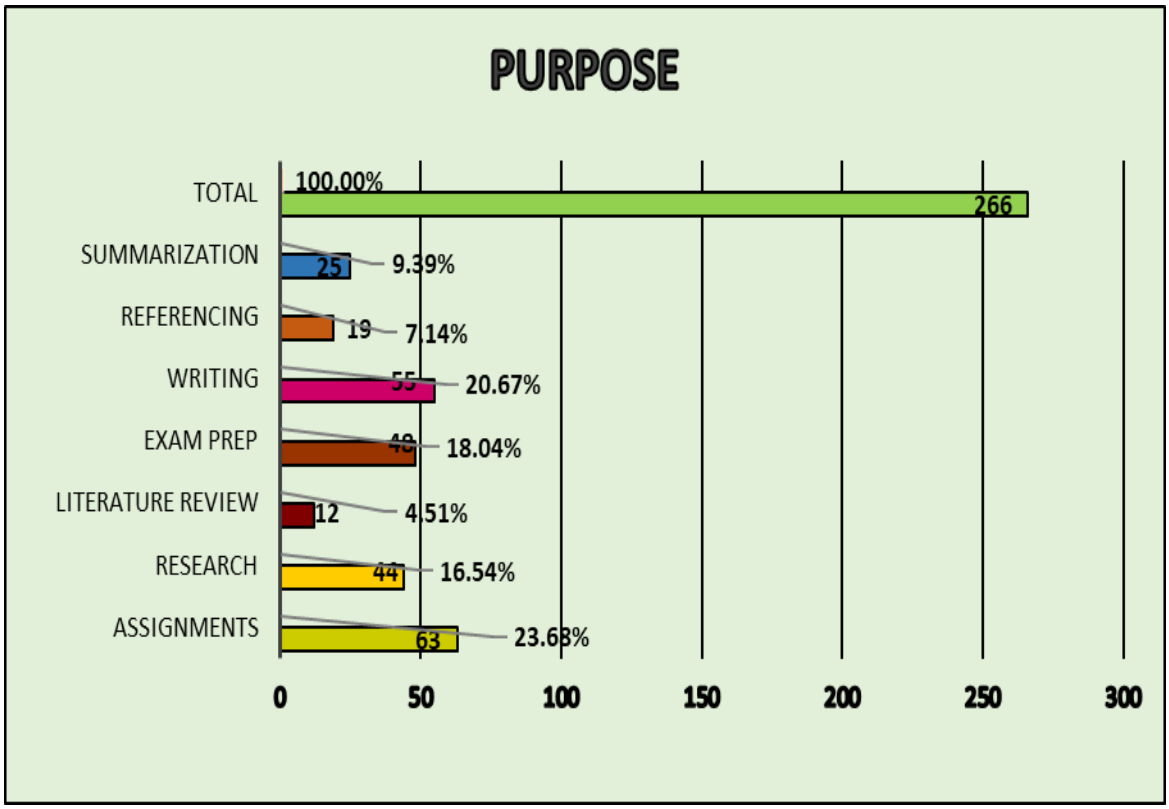


Figure 4. Purpose of AI tools

Interpretation

The table shows that the purpose of using AI tools is mostly for Assignments (23.68%), writing and language correction (20.67%), Exam preparation (18.04), Research (16.54%), Summarization of articles (9.39%), Referencing (7.14%), Literature review (4.51%), are the major purposes for using AI tools.

Table. 6 Challenges in Using AI Tools (Multiple Choice)

Challenge	Number of Responses	Percentage (%)
Lack of awareness	24	12.56
Lack of training	22	11.51
Internet issues	59	30.89
Cost	23	12.04
Evaluation difficulty	23	12.04
Language barriers	14	7.32
Library support	26	13.61
Total	**191**	**100**

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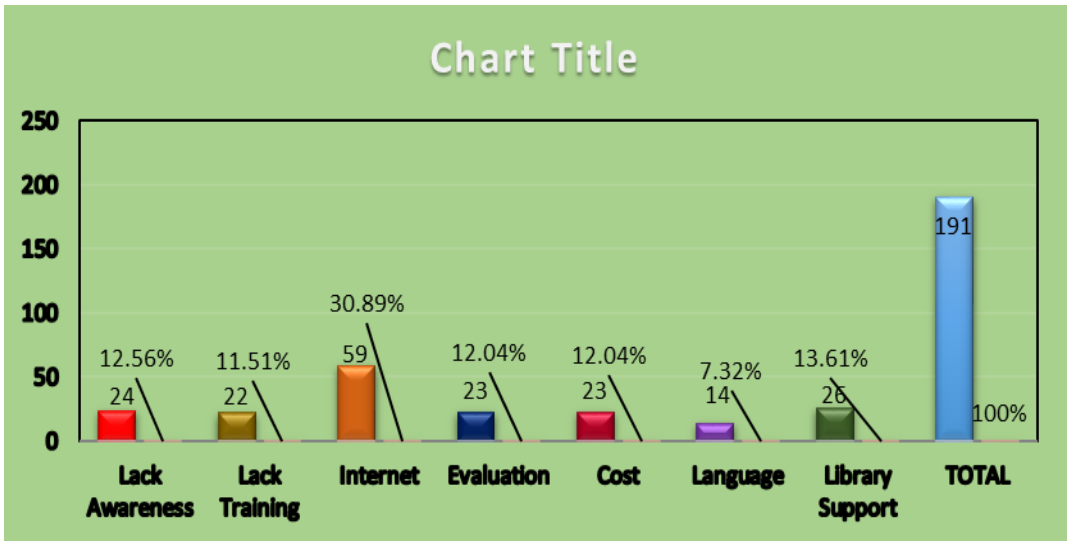


Figure 5. Challenges in using AI tools

Interpretation

The table shows the challenges in using AI tools are Internet issues (30.89%), Lack of library support (13.61%), Lack of awareness (12.56%), cost (12.04%), Evaluation (12.04%), Lack of training (11.51%), Language (7.32%), internet issues are the major challenges faced by respondents.

Overall, the data analysis demonstrates that although AI tools are increasingly integrated into students' academic practices, their effective and responsible use depends on structured training, ethical awareness, and proactive library involvement.

FINDINGS AND SUGGESTIONS

Data analysis reveals that most library users possess a basic to moderate understanding of AI tools, demonstrating greater familiarity with general-purpose applications than with those specifically embedded within library services. These tools are predominantly employed for academic tasks, such as completing assignments, developing projects, and preparing for examinations. However, their effective utilization is hindered by persistent challenges, including ethical concerns, potential over-reliance, and a lack of structured training. The study further underscores the pivotal role of institutional support and guidance in cultivating responsible and proficient AI use. To mitigate these barriers, it is recommended that academic libraries institute regular, hands-on training and awareness initiatives, alongside the implementation of dedicated AI services such as intelligent search systems and responsive chatbots, supported by robust infrastructure and licensed tools. Concurrently, institutions should develop clear ethical frameworks and promote collaborative partnerships between librarians and faculty to embed AI literacy directly into the curriculum, thereby empowering students to engage with artificial intelligence both critically and constructively.

CONCLUSION

Artificial Intelligence holds significant potential to revolutionize academic library services, enhancing their efficiency, user-centeredness, and capacity for innovation. This study illustrates that students at Nirmala College for Women exhibit growing awareness of and readiness to adopt AI tools in support of their academic pursuits. To fully realize this transformative potential, however, libraries must strategically prioritize raising awareness, fostering practical skill development, and ensuring the ethical application of these technologies. In conclusion, AI should be embraced by academic libraries not simply as a technological upgrade, but as a core strategic instrument for advancing learning and research. The insights from this research offer valuable guidance for librarians and institutional policymakers in designing and implementing effective, forward-looking AI-integrated services.

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Enhancing Information Literacy Skills among Research Scholars: Tools, Techniques, and Identified Gaps

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Abstract

In today's digital age, information literacy has become an essential skill for research scholars facing a more complex and data-heavy academic world. The rapid growth of digital information resources, along with quick advancements in artificial intelligence (AI) and data analytics, has changed how we access, evaluate, and use knowledge. This article looks at the tools and methods used to improve information literacy skills among research scholars. It also points out key gaps that make it hard to manage information effectively and conduct ethical research. The article highlights the need to include digital and AI literacy in academic programs to encourage responsible use of information, awareness of privacy, and data security. By examining current practices and proposing practical strategies, this article aims to add valuable insights to the ongoing conversation about building stronger information literacy frameworks in higher education.

Introduction

The contemporary research landscape is profoundly shaped by the rapid evolution of digital technologies and the unprecedented availability of information resources. Scholars today operate in an environment characterized by information abundance, where access to knowledge is no longer the primary challenge; rather, the ability to critically evaluate, synthesize, and ethically apply information has become paramount. Information literacy, defined by the American Library Association (2000) as the ability to recognize when information is needed and to locate, evaluate, and use that information effectively, is now recognized as a foundational skill for academic success and lifelong learning.

For research scholars, information literacy extends beyond basic search skills. It encompasses critical thinking, digital competence, ethical awareness, and the capacity to engage with emerging technologies such as artificial intelligence, big data, and machine learning tools. As scholarly communication increasingly relies on digital platforms, open-access repositories, and algorithm-driven discovery systems, researchers must develop sophisticated competencies to navigate these systems effectively.

Despite the growing recognition of information literacy as a core academic skill, many research scholars struggle to develop and apply these competencies consistently. Challenges arise from uneven access to training, rapidly evolving technologies, and limited institutional support structures. This article explores the tools and techniques currently employed to enhance information literacy among research scholars and identifies critical gaps that limit their effectiveness. By addressing these issues, the study underscores the need for a more integrated, standardized, and future-oriented approach to information literacy education.

Tools and Techniques for Enhancing Information Literacy

Digital Libraries and Databases

Digital libraries and academic databases form the backbone of modern scholarly research. Platforms such as JSTOR, PubMed, Scopus, Web of Science, and Google Scholar provide researchers with access to peer-reviewed journals, conference proceedings, theses, and other scholarly materials across disciplines. These resources have significantly reduced barriers to information access, enabling scholars to retrieve relevant literature with unprecedented speed and convenience.

Beyond access, digital libraries offer advanced search functionalities that enhance information literacy. Boolean operators, controlled vocabularies, citation tracking, and filtering tools allow researchers to refine their queries and evaluate the relevance and credibility of sources. Understanding how to use these features

effectively enables scholars to avoid information overload and focus on high-quality, evidence-based materials. Borgman (2007) emphasizes that mastery of digital library tools is essential for conducting rigorous and reproducible research.

However, effective use of digital libraries requires training in search strategies, evaluation criteria, and source comparison. Without such guidance, scholars may rely on superficial searches or prioritize convenience over quality, undermining the integrity of their research.

Reference Management Software

Reference management software plays a crucial role in supporting information organization and scholarly writing. Tools such as EndNote, Mendeley, Zotero, and RefWorks enable researchers to collect, store, categorize, and cite sources efficiently. These applications reduce the cognitive burden associated with managing large volumes of literature and help ensure accuracy and consistency in citations.

Beyond citation management, many reference tools support collaboration, annotation, and integration with word-processing software. These features promote transparency and efficiency in the research process, particularly for interdisciplinary and multi-author projects. Pettigrew and McKechnie (2001) note that effective use of reference management software enhances researchers' ability to synthesize information and maintain intellectual rigor.

Despite their benefits, reference management tools are often underutilized or used superficially. Many scholars are unaware of advanced features such as metadata editing, PDF annotation, or citation style customization. Structured training in these tools can significantly improve information literacy and research productivity.

Online Learning Platforms

Online learning platforms have become increasingly important for developing information literacy skills. Massive Open Online Courses (MOOCs), webinars, and self-paced tutorials offered by platforms such as Coursera, edX, Udemy, and institutional learning management systems provide flexible and accessible opportunities for skill development.

These platforms offer courses on research methodologies, academic writing, data management, digital literacy, and ethical information use. For research scholars, online learning allows continuous skill enhancement beyond formal classroom settings. Kop and Fournier (2011) highlight that MOOCs support learner autonomy and foster lifelong learning habits, which are essential in rapidly evolving academic environments.

However, the effectiveness of online learning depends on learners' motivation, digital competence, and the quality of instructional design. Institutions must ensure that online resources are aligned with academic standards and integrated into broader research training programs.

Workshops and Seminars

Workshops and seminars organized by academic institutions, libraries, and research centers remain a vital component of information literacy education. These events often provide hands-on training in database searching, citation practices, research ethics, and data management. Interactive formats allow scholars to apply concepts in real-time, reinforcing learning through practice.

Workshops also create opportunities for interdisciplinary engagement and peer learning, fostering a collaborative research culture. Rader (2002) argues that face-to-face instruction, when combined with practical exercises, significantly enhances information retention and skill acquisition.

Despite their effectiveness, workshops are often optional and inconsistently attended. Scheduling constraints and lack of institutional incentives may limit participation. Embedding workshops into formal research training requirements could enhance their impact.

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Identified Gaps in Information Literacy Skills

Lack of Standardized Curriculum

One of the most significant challenges in information literacy education is the absence of a standardized curriculum across higher education institutions. While some universities have developed comprehensive information literacy frameworks, others rely on ad hoc or optional training sessions. This inconsistency results in uneven skill development among research scholars (Julien & Barker, 2009).

A standardized curriculum would ensure that all scholars acquire foundational competencies, regardless of discipline or institution. Such a framework should include core components such as information evaluation, digital research tools, ethical practices, and emerging technologies. Without standardization, information literacy remains fragmented and dependent on individual initiative.

Insufficient Emphasis on Ethical Use of Information

Ethical considerations are central to information literacy, yet they often receive inadequate attention in research training. Issues such as plagiarism, intellectual property rights, copyright compliance, and data privacy are critical for maintaining academic integrity. However, many scholars lack a comprehensive understanding of these issues, leading to unintentional misconduct.

McClure (2018) emphasizes that ethical information use must be taught as an integral part of research education rather than as an isolated topic. With the rise of AI-generated content and automated research tools, ethical challenges have become even more complex, underscoring the need for explicit instruction and policy guidance.

Limited Access to Advanced Tools

Access to advanced research tools is often constrained by institutional resources, particularly in developing regions or underfunded institutions. Subscription-based databases, specialized software, and high-performance computing resources may be unavailable to many scholars, limiting their ability to conduct cutting-edge research.

O'Reilly (2017) notes that disparities in access contribute to inequities in research output and scholarly visibility. Promoting open-access resources, institutional collaborations, and shared infrastructures can help bridge this gap and democratize information literacy.

Inadequate Training on Emerging Technologies

The rapid integration of artificial intelligence, machine learning, and data analytics into research practices presents both opportunities and challenges. While these technologies can enhance literature discovery, data analysis, and knowledge synthesis, many scholars lack the skills to use them effectively.

Bawden and Robinson (2012) argue that information literacy must evolve to include AI literacy, algorithmic awareness, and critical understanding of automated systems. Without adequate training, scholars risk misinterpreting results, over-relying on automated tools, or overlooking ethical implications.

Conclusion

Enhancing information literacy skills among research scholars is essential for fostering effective, ethical, and innovative research practices in an increasingly digital and data-driven world. While a wide range of tools and techniques—such as digital libraries, reference management software, online learning platforms, and institutional workshops—support information literacy development, significant gaps remain.

Addressing these gaps requires a coordinated and strategic approach. The establishment of standardized information literacy curricula, greater emphasis on ethical information use, expanded access to advanced research tools, and targeted training in emerging digital and AI technologies are critical steps toward strengthening information literacy frameworks. By investing in comprehensive information literacy education,

academic institutions can empower research scholars to navigate the complexities of the modern information landscape with confidence, responsibility, and intellectual rigor.

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The Erosion of Humanity: How Unchecked Technology Undermines Our Core Values

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Abstract

Technology, now inextricable from modern existence, promises unparalleled advancement in efficiency, connectivity, and capability. Yet, this progress carries a profound and often overlooked cost: the systematic erosion of fundamental human values. This paper argues that the uncritical and imbalanced adoption of digital technologies actively endangers the pillars of human life—empathy, privacy, authentic connection, mental integrity, and ethical accountability. By examining the displacement of human interaction, the commodification of personal experience, and the abdication of moral responsibility to systems, this analysis calls for a critical paradigm shift. It concludes that sustaining a human future necessitates not merely using technology wisely, but fundamentally re-centering human flourishing in its design and governance.

Keywords: Technology, Human Values, Ethics, Dehumanization, Digital Society, Surveillance, Moral Responsibility

Introduction: The Paradox of Progress

Technology stands as the hallmark of contemporary achievement, reshaping existence from the intimate to the global. However, beneath the narrative of unmitigated benefit lies a dissonant reality: the very tools designed to empower us are subtly degrading the qualities that define our humanity. This paper confronts this paradox, moving beyond a simple cost-benefit analysis to explore how technological systems and logic can corrode empathy, erode privacy, flatten relationships, and fragment the self. The central question is not if technology changes society, but whether, in its current trajectory, it preserves what makes human life meaningful.

The Illusion of Connection: Technology and the Atrophy of Relationship

Human depth is forged in the crucible of sustained, embodied interaction—nuanced by tone, touch, and shared physical presence. Digital communication, optimized for speed and scale, replaces this richness with transactional exchange. Social media platforms commodity interaction, encouraging performance over authenticity and breadth over depth. The consequence is a pervasive loneliness amidst hyper-connectivity, where networks expand as relationships hollow. This erosion of communal fabric represents not just a social shift, but a fundamental loss of a primary human nutrient: genuine, empathetic connection.

The Digitized Self: Mental Well-being in the Attention Economy

The human mind is not merely interfacing with technology; it is being rewired by it. Digital environments, engineered to capture and hold attention, foster addiction, chronic distraction, and cognitive fragmentation. The constant curation of a digital identity generates anxiety and fractures self-worth, as internal value becomes tied to external validation metrics—likes, shares, and followers. The resulting epidemic of stress, depression, and emotional dysregulation, particularly among youth, signals not individual failure but a systemic conflict between human psychology and an economy built on harvesting its attention.

Privacy, Dignity, and the Surveillance Paradigm

In the digital age, the personal has become the political—and the commercial. Privacy, once a bedrock of individual autonomy and dignity, is systematically dismantled through pervasive data extraction, surveillance, and predictive analytics. This architecture of surveillance capitalism treats human experience as raw material to be mined, refined, and sold. The ethical crisis extends beyond mere data breaches to a fundamental redefinition of the person: from a sovereign individual to a datafied object, whose value is determined by informational utility rather than inherent worth.

The Automation of Morality: Abdicating Ethical Responsibility

As decision-making authority is ceded to algorithms and automated systems, a critical human faculty atrophies: moral judgment. When machines filter news, recommend sentences, or triage healthcare, the obscurity of their logic ("the black box") and the diffusion of accountability ("the algorithm decided") create a moral vacuum. This disengagement is profoundly dehumanizing, reducing complex ethical landscapes to mere optimization problems. In fields from warfare to criminal justice, this shift risks cementing systemic biases and absolving individuals and societies of the hard work of ethical deliberation.

Cultural Homogenization and the Loss of Shared Reality

Technology, particularly global platforms, functions as a powerful cultural solvent. Local traditions, languages, and forms of communal life are marginalized by a dominant, often commercially driven, digital monoculture. Furthermore, the proliferation of personalized information bubbles and synthetic media (deepfakes) erodes a consensus reality, undermining the shared truths upon which democratic discourse and social trust depend. The public square fragments into a million private feeds, weakening collective identity and our capacity for common action.

Toward a Human-Centered Techno-Ethics: Reclaiming Agency

Technology is not destiny but a product of human choice. Averting a value-less future requires a deliberate, multi-faceted intervention. This includes: embedding ethical by design principles in technological development; promoting critical digital literacy that emphasizes human psychology and ethics; establishing robust legal and regulatory frameworks that defend human dignity over corporate or state control; and fostering cultural practices that consciously privilege analog, embodied experience. The goal is to cultivate technological citizenship, where users are not merely consumers but arbiters of the tools they use.

Conclusion: Reasserting the Human in the Human-Machine Era

The ultimate risk of technology is not malevolent robots, but passive humans—ones who trade depth for convenience, privacy for personalization, and moral agency for automated ease. The evidence suggests we are en route. Preserving the essence of human life—our capacity for empathy, introspection, ethical courage, and authentic community—now requires conscious, collective resistance against technological determinism. Our task is to ensure that our tools serve to amplify, not amputate, our humanity, making the preservation of human values the central metric of true technological progress.

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Use of Internet Services by PG Teachers in Higher Secondary Schools in Salem District, Tamilnadu: A Study

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ABSTRACT

This study is confined that Utilization of Internet Services by PG Teachers in Government Higher Secondary Schools in Salem District. The main aim of this study is to measure the influence of the internet on Higher Secondary PG Teachers for their teaching profession and using of information search tools, problems they encountered while using internet.

KEYWORDS: Internet, Teachers, School, Information, Search Engines.

INTRODUCTION

The present era is called as "Information era." Information has become the most important element for progress of society. To thrive in this modern era, one needs a variety of information, no matter how well versed one is in a field or profession. Psacharopoulous (1982) discusses the necessity of information in the present age. We can reorganize the educational system and redefine scientific research only with the help of information. Information plays a significant role in our professional and personal lives. People need information to work properly in their fields.

OBJECTIVES

- To know the awareness of internet among the PG Teachers of Higher Secondary Schools
- To find out the influence of the internet on Higher Secondary School PG Teachers
- To find out purpose of using internet among Higher Secondary School PG Teachers
- To trace out the most used search engine and web browser
- To find out the problems they encounter while using internet.

SCOPE AND METHODOLOGY

In this study the data collected from the availability of PG Teachers working in Government Higher Secondary Schools in Salem District. In this study we had taken 11 Government Higher Secondary Schools and 2 Government Aided Schools for sample data collection. Matriculation schools are exempted from the study. There were 100 Questionnaires were distributed personally to the PG Teachers of Higher Secondary Schools in Salem District. Out of 100 Questionnaires, only 82 filled questionnaires were received. The response rate is 82%. The collected data were analysed.

ANALYSIS AND INTERPRETATION

Table 1 – Gender wise Distribution

S.No	Sex	No. Of Respondents	Percentage
1	Male	47	57.32
2	Female	35	42.68
Total		**82**	**100.00**

Table 1 show that gender wise respondents. The majority of the respondents (57.32%) are from Male teachers and 42.68% of the respondents are from female teachers. It is clear that the majority of the teachers are from male. It is proved that 33% of the government reservation for female teachers.

Table 2 - Age wise Distribution

S.No	Age	No.Of Respondents	Percentage
1	Below 25 Years	01	01.22
2	25-30 Years	05	06.10
3	31-40 Years	28	34.15
4	41-50 Years	29	35.36
5	Above 50 Years	19	23.17
Total		**82**	**100.00**

Table 2 shows that, age wise respondents. The majority of the respondents (35.36%) are from the age group between 41-50 years followed by 31-40 years (34.15%). A meagre (1.22%) percentage of the respondents are below 25 years. It is clear that the experienced teachers are working in the Govt higher secondary schools in Salem District.

Table 3 - Year of Experience

S.No	Experience	No. Of Respondents	Percentage
1	Below 5 Years	16	19.51
2	5-10 Years	20	24.41
3	11-15 Years	21	25.60
4	16-20 Years	11	13.41
5	21-25 Years	03	03.66
6	Above 25 Years	11	13.41
Total		**82**	**100.00**

Table 3 shows that the majority of the (25.60%) respondents are having 11-15 years experience in teaching followed by (24.41%) the teachers are having 5-10 years experience and (19.51%) of teachers are having below 5 years experience. Only (3.66%) of the teachers are having 21-25 years. It is understand that the teachers working in schools are having rich experience.

Table 4– Experience in Internet Use

S.No	Use Of Internet	No. Of Respondents	Percentage
1	Less than 5 Years	67	81.71
2	6-10 Years	11	13.41
3	11-15 Years	04	04.88
4	Above 15 Years	-	-
Total		**82**	**100.00**

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Table 4 examines 81.71% of teachers are using internet less than 5 years and 13.41% of teachers are using 6-10 years and only 4.88% of teachers are using 11-15 years and none of the teachers using above 15 years.

Table 5 - Frequency of Internet Use

S.No	Frequency Of Internet Use	No. Of Respondents	Percentage
1	Daily	27	32.93
2	Twice in a Week	27	32.93
3	Fortnightly	01	01.22
4	Once in a Month	02	02.44
5	Occasionally	15	18.28
6	Rarely	10	12.20
Total		**82**	**100.00**

Table 5 shows that 65.86% of the teachers used the internet daily as well as 32.93% teachers used twice in a week where as 18.28% of the teachers use the internet occasionally and followed by 12.20% of the teachers using the internet rarely. Only 1.22% of the teachers are using the internet fortnightly. This table clearly indicates that majority of the teachers are using Internet frequently. It is also clearly indicates that Internet is part of the teaching and learning process among the teachers.

Figure:1- Frequency of Internet Use

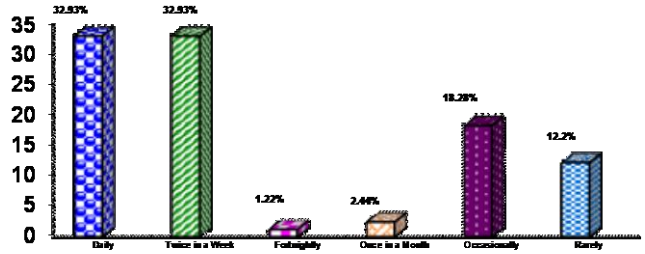


Table 6 - Internet Facility in School

S.No	Internet Facility In School	No. Of Respondents	Percentage
1	Yes	82	100.00
2	No	-	-
Total		**82**	**100.00**

Table 6 shows that all Government Higher Secondary Schools in Salem District having Internet facility. It clearly shows that ICT facility is necessary for teaching community.

Table 7- Most Frequently Used Place of Internet

S.No	Place Of Internet Use	No. Of Respondents	Percentage	Rank
1	At School	23	25.84	**2**
2	At Home	56	62.93	**1**
3	At Friends Place	03	03.37	**4**
4	At Cyber Café	01	01.13	**5**
5	Other Places	06	06.73	**3**
Total		**89**	**100.00**	

Table 7 reveals that the majority of the teachers (62.93%) access the internet in home followed by 25.84% of the teacher's access the internet in school and 6.73% of the teacher's access in other places. This table shows that majority of the teachers having Internet facility in their Homes.

Figure: 2 - Most Frequently Used Place of Internet

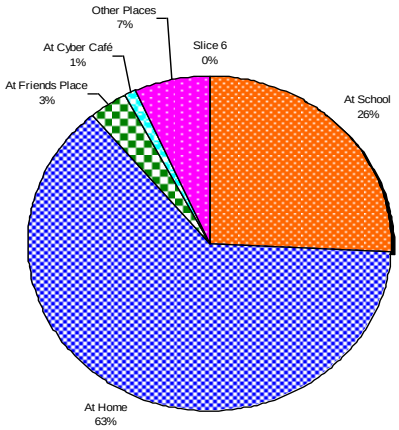


Table 8 - Most Frequently Used Browser

S.No	Most Used Browser	No. Of Respondents	Percentage	Rank
1	Mozilla Fire Box	13	13.82	**3**
2	Google Chrome	58	61.72	**1**
3	Internet Explorer	21	22.34	**2**
4	Opera Mini	02	02.12	**4**
Total		**94**	**100.00**	

Table 9 shows that the majority of the teachers are using (61.72%) Google Chrome Browser followed by Internet Explorer and (13.82%) of the teachers using Mozilla Fire Box. Only meagre amount of teachers using Opera mini. It is clearly understand that the teachers are using Google Chrome Browser for their

Table 8 shows that the majority of the teachers are using (61.72%) Google Chrome Browser followed by Internet Explorer and (13.82%) of the teachers using Mozilla Fire Box. Only meagre amount of teachers are

using Opera Mini. It is clearly understand that the teachers are using Google Chrome Browser for their searching.

Table 9 - Favourite Search Engine

S.No	Favourite Search Engine	No. Of Respondents	Percentage	Rank
1	Google	76	85.39	**1**
2	Yahoo	13	14.61	**2**
3	Bing	-	-	**-**
4	Ask	-	-	**-**
5	Duck Duck Go	-	-	**-**
6	123 Khoj	-	-	**-**
7	AOL	-	-	**-**
8	Netscape	-	-	**-**
9	Alta Vista	--	-	**-**
10	Excite	-	-	**-**
11	Rediff	-	-	**-**
12	Lycos	-	-	**-**
Total		**89**	**100.00**	

Table 9 represents that 85.39% of teachers searching their needed information through Google search engine and only 14.61% of the teachers searching Yahoo. None of the teachers are using other search engines. It is clearly indicates that almost all teaches are using through Google search engine only.

Table 10 - Purpose of Browsing Internet Services

S.No	Purposes	No. Of Respondents	Percentage	Rank
1.	For taking Class Notes	29	13.74	**3**
2.	For taking Model Question Papers	33	15.64	**2**
3.	For Up to Date Knowledge	20	09.48	**5**
4.	For Chatting	02	00.95	**9**
5.	To Develop Friendship through Social Networks(Face book, Twitter etc)	05	02.37	**8**
6.	To Download E-Book, E-Journals etc	06	02.84	**7**
7.	Research	06	02.84	**7**
8.	Entertainment	09	04.27	**6**
9.	Educational	50	23.69	**1**
10.	Downloading	22	10.42	**4**
11.	Email	29	13.74	**3**
Total		**211**	**100.00**	

Table 10 elaborates the majority of the teachers (23.69%) prefer to browse Internet for educational purpose, followed by (15.64%) teachers by taking model question papers, 13.74% of the teachers using internet service and 13.74% of teachers browse for email purpose. Only 2.37% of teachers using internet service for developing friend through social networks (Facebook, Twitter etc) and 0.95% of teachers using internet for chatting.

Table 11 - Problems Encountered while Using Internet

S.No	Problems In Using Internet	No. Of Respondents	Percentage	Rank
1	Slow access speed	50	51.02	**1**
2	Difficulty in finding relevant information	22	22.45	**2**
3	It takes too long to download pages	17	17.35	**3**
4	Cost associated with accessing internet	09	09.18	**4**
5	Privacy Problems	-	-	
Total		**82**	**100.00**	

Table 11 shows that 51.02% of the teachers facing problems in slow access speed while using internet followed by 22.45% of the teachers facing difficult to find relevant information. Only 17.35% of the teachers are facing problems during download of information and accessing time problem and 9.18% of the teachers facing cost of the access information in the internet.

CONCLUSION

The present study has unfolded many new facts about the use of Internet by PG Teachers. Internet is emerging as a valuable tool for quick information retrieval. Most of the teachers feel internet is very important to education and the students. The majority of the teachers are using internet at home only. Teachers have time to access information with freedom after working hours only. Most of the teachers feel comfortable to access the internet service. At the same time they are facing problems in slow access speed. In the digital environment internet is fastest information source for all. Teaching Professionals need to organize internet & information awareness, orientation programs and hands on training to all the teachers of Higher Secondary Schools. With the advent of Internet and Digital technologies and availability of easy access today the teachers have multiple ways to deliver the information to the students for their leaving.

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Sustainable Development and Libraries: Enabling Progress toward the Sustainable Development Goals (SDGS)

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Abstract

Libraries play a vital role in promoting sustainable development by ensuring equitable access to information, knowledge, and learning resources. In alignment with the United Nations' Sustainable Development Goals (SDGs), libraries function as key institutions that support education, social inclusion, digital literacy, and community empowerment. This paper examines the transformative role of libraries in advancing sustainable development initiatives and contributing to the achievement of the SDGs. It highlights how libraries support lifelong learning, bridge the digital divide, promote environmental awareness, and strengthen informed decision-making at individual and community levels. The study also emphasizes the role of libraries in supporting open access, cultural preservation, and evidence-based policymaking. By integrating information and communication technologies, libraries enhance their capacity to deliver inclusive and sustainable information services. The findings suggest that libraries are not merely information repositories alone but active agents of sustainable development, capable of driving social, economic, and environmental progress in both urban and rural contexts.

Keywords: Libraries, Sustainable Development, Sustainable Development Goals (SDGs), Information Access, Community Empowerment, Digital Inclusion

Introduction

Sustainable development has emerged as a global priority aimed at balancing economic growth, social inclusion, and environmental protection to meet the needs of present and future generations. In 2015, the United Nations adopted the Sustainable Development Goals (SDGs), a comprehensive framework consisting of 17 goals designed to address critical global challenges such as poverty, inequality, quality education, climate change, and access to information. Achieving these goals requires inclusive institutions that facilitate knowledge dissemination, informed decision-making, and community participation. In this context, libraries play a pivotal role as trusted public institutions that provide equitable access to information and learning resources.

Libraries serve as gateways to knowledge by supporting education, research, and lifelong learning, which directly align with several SDGs, particularly those related to quality education, reduced inequalities, and innovation. With the integration of digital technologies, libraries have expanded their services beyond traditional print resources to include digital collections, open access platforms, and online learning opportunities. These services help bridge the digital divide and ensure that marginalized and underserved communities are not excluded from development initiatives.

Furthermore, libraries contribute to sustainable development by promoting information literacy, environmental awareness, cultural preservation, and civic engagement. They support evidence-based policymaking by providing reliable data and research resources to governments, institutions, and civil society. By fostering inclusive access to information and empowering communities with knowledge, libraries act as catalysts for social and economic transformation. This paper explores the transformative role of libraries in achieving the Sustainable Development Goals and highlights their significance as key partners in advancing sustainable development at local, national, and global levels.

Libraries and Their Usefulness in Education and Society

Libraries are fundamental institutions that support the intellectual, educational, and social development of individuals and communities. They serve as repositories of knowledge and provide equitable access to

information resources, enabling learners of all ages to pursue education, research, and lifelong learning. In educational settings, libraries complement formal instruction by offering textbooks, reference materials, digital resources, and research support that enhance academic achievement and critical thinking skills. School, college, and university libraries play a crucial role in fostering reading habits, information literacy, and independent learning among students.

Beyond education, libraries significantly contribute to societal development by promoting social inclusion, cultural preservation, and informed citizenship. Public libraries act as community hubs where people can access information, digital technologies, and government services, especially in underserved and rural areas. By providing free access to the internet and digital tools, libraries help bridge the digital divide and empower individuals to participate effectively in the knowledge society.

Libraries also support democratic values by ensuring access to reliable and unbiased information, which is essential for informed decision-making and civic engagement. Through literacy programs, community outreach, and lifelong learning initiatives, libraries enhance social awareness and economic opportunities. Thus, libraries are not merely centers for books but dynamic institutions that play a vital role in strengthening education systems and fostering sustainable societal development.

Empowering Research and Advancing SDGs: the Transformative Role of Libraries

Libraries play a transformative role in empowering research and supporting the achievement of the Sustainable Development Goals (SDGs). As knowledge hubs, libraries provide access to scholarly resources, research data, and digital platforms that enable evidence-based research and innovation. By supporting open access initiatives, institutional repositories, and research data management, libraries enhance the visibility, accessibility, and impact of scholarly output, thereby strengthening research ecosystems.

In the context of the SDGs, libraries contribute directly to goals related to quality education, reduced inequalities, innovation, and sustainable communities. They promote information and digital literacy, enabling researchers, students, and citizens to critically evaluate information and apply knowledge to address social, economic, and environmental challenges. Libraries also support interdisciplinary research and collaboration by facilitating access to diverse information sources and fostering knowledge sharing.

Furthermore, libraries act as bridges between research and society by disseminating reliable information to policymakers, practitioners, and communities. Through outreach programs, capacity-building initiatives, and technology-enabled services, libraries empower marginalized groups and support inclusive development. In doing so, libraries move beyond their traditional role as information repositories to become active agents of research empowerment and sustainable development, contributing meaningfully to the realization of the Sustainable Development Goals at local, national, and global levels.

Conceptual Framework: Empowering Research and Advancing SDGs through Libraries

The conceptual framework illustrates the central role of libraries as transformative institutions that connect research empowerment with the achievement of Sustainable Development Goals (SDGs). Libraries act as enabling platforms that integrate information access, digital infrastructure, and capacity-building initiatives to support education, research, and community development.

At the core of the framework, libraries function as knowledge hubs providing access to print and digital resources, open access publications, research databases, and institutional repositories. These resources enhance research empowerment by improving information availability, research visibility, data management, and scholarly communication. Libraries also promote information and digital literacy, enabling users to effectively locate, evaluate, and utilize information for academic and societal purposes.

Transformational library services such as technology-enabled learning spaces, research support services, and community outreach programs serve as mediating factors that strengthen the link between research and sustainable development. These services support inclusive education, innovation, evidence-based policymaking, and community engagement, which directly align with multiple SDGs, including quality education, reduced

inequalities, industry and innovation, and sustainable communities. The framework further recognizes enabling factors such as leadership, policy support, digital infrastructure, and skilled library professionals that influence the effectiveness of library services. Ultimately, the interaction between library resources, research empowerment, and supportive institutional conditions leads to positive SDG outcomes, including social inclusion, economic growth, environmental awareness, and sustainable knowledge societies.

Case Studies and Global Initiatives: Libraries Empowering SDGs

Libraries worldwide have demonstrated transformative impacts on research, education, and sustainable development through innovative programs and initiatives. Several case studies and global efforts illustrate how libraries actively contribute to achieving the Sustainable Development Goals (SDGs).

1. **UNESCO Global Library Initiatives:**UNESCO has emphasized the role of libraries in promoting lifelong learning, digital literacy, and equitable access to information. The *UNESCO Public Library Manifesto* encourages libraries to support sustainable communities, education, and inclusive knowledge societies. Initiatives under UNESCO, such as the *IFLA-UNESCO Partnership*, provide guidance, training, and resources to strengthen library services globally, particularly in underserved regions.
2. **Digital Public Library of America (DPLA), USA:**The DPLA aggregates digital resources from libraries across the United States, making research materials freely accessible. By enabling open access to educational and scholarly content, it supports SDGs related to quality education, reduced inequalities, and innovation.
3. **e-Granthalaya, India:**Launched by the National Informatics Centre, e-Granthalaya is a digital library management system implemented across Indian public and academic libraries. It promotes access to digital resources and research materials, bridging the digital divide in rural and semi-urban areas and supporting inclusive education.
4. **HINARI and AGORA Programs:**Managed by the World Health Organization and FAO respectively, these initiatives provide free or low-cost access to research journals in health, agriculture, and related fields for developing countries. These programs enhance research capacity, promote evidence-based decision-making, and contribute to SDGs such as good health, zero hunger, and industry innovation.
5. **Finland's National Library of Finland Initiatives:**The National Library focuses on digital preservation, open access research, and public outreach. Its programs support lifelong learning and sustainable knowledge dissemination, enabling citizens to actively participate in societal development.

Objectives of the Study

The objectives of the study are:

1. To examine the role of libraries in promoting sustainable development in alignment with the Sustainable Development Goals (SDGs).
2. To analyze how libraries contribute to education, research empowerment, and community development.
3. To explore the role of libraries in bridging the digital divide and promoting information literacy.
4. To highlight global initiatives and best practices demonstrating libraries' contributions to SDGs.
5. To suggest strategic measures for strengthening libraries as agents of sustainable development.

Scope and Methodology

The present study is conceptual and descriptive in nature. It is based on an extensive review of secondary sources, including scholarly journal articles, international reports, policy documents, and publications from organizations such as the United Nations, UNESCO, and IFLA. The scope of the study is limited to examining the role of libraries in supporting sustainable development and advancing the Sustainable Development Goals (SDGs) through education, research empowerment, digital inclusion, and community engagement.

No primary data were collected, and the study focuses on synthesizing existing literature and global best practices to provide insights into the transformative role of libraries in sustainable development.

Suggestions

1. **Strengthen Digital Infrastructure:** Libraries should invest in modern digital tools, databases, and online platforms to enhance access to research and educational resources.
2. **Promote Open Access and Research Visibility:** Encouraging open access publications and institutional repositories will increase the reach and impact of scholarly work.
3. **Capacity Building and Training:** Continuous professional development for library staff and users is essential to improve digital literacy, research skills, and the effective use of library resources.
4. **Community Outreach and Engagement:** Libraries should design programs targeting marginalized communities to bridge the digital divide and promote equitable access to information.
5. **Policy Support and Collaboration:** Governments and institutions should recognize libraries as key partners in achieving SDGs and support them through funding, policies, and international collaborations.
6. **Monitoring and Evaluation:** Regular assessment of library initiatives and services can ensure alignment with SDGs, identify gaps, and improve overall impact.

Conclusion

Libraries serve as vital catalysts for research, education, and sustainable development, transforming the way knowledge is accessed, shared, and applied. By providing equitable access to information, digital resources, and research support, libraries empower individuals, communities, and institutions to make informed decisions, foster innovation, and promote lifelong learning. Their contributions extend beyond educational settings, supporting social inclusion, cultural preservation, and community engagement, thereby directly advancing multiple Sustainable Development Goals (SDGs).

Global initiatives and case studies highlight that when libraries are equipped with digital infrastructure, skilled personnel, and strategic leadership, they can significantly enhance research capacity, bridge the digital divide, and drive societal progress. To maximize their transformative impact, libraries must continue to embrace digital technologies, implement innovative services, and actively collaborate with governments, academic institutions, and communities. In this way, libraries evolve from traditional repositories of information into dynamic agents of change, playing a central role in empowering research, fostering sustainable development, and contributing meaningfully to the creation of inclusive, resilient and knowledge driven societies.

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Achieving Sustainable Development Goals through Academic Libraries: An Indian Perspective

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Abstract

The United Nations 2030 Agenda for Sustainable Development outlines seventeen Sustainable Development Goals (SDGs) addressing global challenges related to education, inequality, innovation, environmental sustainability, and governance. Within higher education institutions, academic libraries function as strategic knowledge infrastructures that support these goals through inclusive access to information, digital transformation, research facilitation, and sustainability-oriented practices. This paper examines the role of academic libraries in contributing to the achievement of the SDGs in the Indian context. Using a descriptive and analytical approach based on policy review and secondary sources, it analyses key areas of library intervention, identifies challenges faced by academic libraries, and discusses strategic approaches for aligning library services with national policies and global sustainability frameworks. The study underscores the potential of academic libraries to act as institutional partners in advancing sustainable development through policy integration, capacity building, and collaborative engagement.

Keywords: Academic Libraries, Sustainable Development Goals (SDGs), Higher Education, Knowledge Infrastructure, India

Introduction

Sustainable development has become a central concern in global policy discourse as nations seek to address interconnected economic, social, and environmental challenges. The adoption of the United Nations' 2030 Agenda for Sustainable Development in 2015 represents a collective global commitment to achieve inclusive, equitable, and sustainable progress through the implementation of seventeen Sustainable Development Goals (SDGs). Access to information, quality education, research, and knowledge dissemination are widely recognised as essential enablers for achieving these goals.

Academic libraries, situated at the core of higher education institutions, play a critical role in supporting teaching, learning, and research ecosystems. Beyond their traditional functions, academic libraries increasingly contribute to digital inclusion, open knowledge initiatives, research visibility, and sustainability awareness. In a country like India, where higher education institutions serve a diverse and expanding academic community, the role of academic libraries in supporting national development priorities and global sustainability agendas is particularly significant.

This paper explores the contribution of academic libraries towards achieving the Sustainable Development Goals, with a specific focus on the Indian higher education landscape. It examines the scope of library services aligned with SDGs, highlights institutional challenges, and discusses strategic measures and best practices that enable libraries to function as active partners in sustainable development.

Objectives of the Study

The study aims to:

- Examine the role of academic libraries in supporting the Sustainable Development Goals.
- Identify key service areas through which libraries contribute to SDG achievement in India.
- Analyse challenges faced by academic libraries in aligning with sustainability goals.
- Suggest strategic measures to strengthen the role of libraries in sustainable development.

Scope of the Study

This study focuses on academic libraries within Indian higher education institutions. It considers library services, policies, and national-level digital initiatives that align with the SDGs. The study does not include quantitative field surveys but relies on documented initiatives, policy frameworks, and existing literature.

Methodology

The study adopts a descriptive and analytical methodology based on review of literature, analysis of national education and library policies, and examination of major Indian academic library initiatives such as INFLIBNET, NDLI, SWAYAM, and Shodhganga.

Review of Literature

The literature consistently recognises libraries as key stakeholders in achieving the SDGs. In 2016, the International Federation of Library Associations and Institutions (IFLA) recognised libraries as key partners in advancing the 2030 Agenda by facilitating access to information, promoting digital inclusion, and supporting lifelong learning.

Studies emphasise the role of academic libraries in SDG 4 through information literacy, open educational resources, and equitable access to scholarly content (Cox & Tinson, 2018; Kaur & Mahajan, 2020). Research on SDG 9 highlights libraries' contribution to research visibility and innovation through institutional repositories and open access initiatives (Pinfield et al., 2017; Sinha & Basu, 2019).

Environmental sustainability (SDG 13) has gained attention through the concept of green libraries, focusing on eco-friendly infrastructure and sustainable practices (Jankowska & Marcum, 2010; Sharma & Singh, 2021). Recent Indian studies underline the importance of librarian readiness, policy literacy, and digital competence in aligning library services with SDGs (Rao & Babu, 2022).

Overall, the literature affirms that academic libraries are strategically positioned to support multiple SDGs through education, innovation, inclusivity, and environmental stewardship. However, it also reveals gaps related to policy integration, impact assessment, and capacity building, particularly in the Indian higher education context, indicating the need for more systematic and coordinated approaches.

Scope of Academic Library Services in Supporting SDGs

Service Dimensions of Academic Libraries:

Academic libraries contribute to the SDGs through multiple service dimensions aligned with the objectives of the UN 2030 Agenda. These service dimensions are reflected in several national and institutional initiatives within the Indian higher education system.

Beyond access to information, academic libraries contribute to sustainable development by promoting open knowledge practices, strengthening research and innovation support, building information and sustainability literacy, and fostering community engagement. Through digital inclusion initiatives, green practices, and evidence-based services, libraries align institutional missions with national and global sustainability frameworks. However, realizing this potential requires adequate policy support, capacity building, and systematic impact assessment.

SDG-wise Library Contributions:

- **SDG 4 (Quality Education):** Access to print and electronic resources, information literacy programmes, and support for lifelong learning.
- **SDG 9 (Industry, Innovation and Infrastructure):** Research support services, institutional repositories, open access publishing, and research analytics.
- **SDG 10 (Reduced Inequalities):** Bridging the digital divide and providing inclusive services for disadvantaged learners.

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- **SDG 11 (Sustainable Cities and Communities):** Community outreach, cultural heritage preservation, and awareness programmes.
- **SDG 13 (Climate Action):** Green library initiatives and environmental information services.
- **SDG 16 (Peace, Justice and Strong Institutions):** Promoting transparency and access to information through open knowledge systems.

Indian Case Examples of Academic Libraries Supporting SDGs

The Sustainable Development Goals comprise seventeen interlinked objectives addressing poverty eradication, quality education, gender equality, innovation, climate action, and strong institutions. Unlike earlier development frameworks, the SDGs adopt a holistic approach that integrates social, economic, and environmental dimensions.

India has introduced a series of national-level academic and library-driven initiatives over the past decades that collectively demonstrate a strong alignment with the SDGs. Beginning with early networking and automation efforts such as DELNET and INFLIBNET, academic libraries have progressively evolved into digitally enabled knowledge infrastructures supporting quality education, innovation, and institutional strengthening. Initiatives such as Shodhganga, e-ShodhSindhu, and the National Digital Library of India have significantly enhanced equitable access to scholarly and learning resources, while platforms like SWAYAM and IRINS have strengthened research visibility and learner engagement. In recent years, policy-driven reforms under NEP 2020 and transformative initiatives such as One Nation One Subscription (ONOS) have further reinforced libraries' roles in reducing inequalities, supporting research ecosystems, and promoting transparent knowledge governance. Collectively, these initiatives position academic libraries as strategic partners in advancing sustainable development through inclusive, innovative, and policy-aligned knowledge services.

Challenges Faced by Academic Libraries and the Strategies to Overcome

Despite their potential, academic libraries in India face challenges such as limited financial resources, inadequate infrastructure, shortage of trained professionals, and persistent digital divides between urban and rural institutions. Lack of awareness about SDGs among library users and professionals, along with the absence of formal policy frameworks linking library services to sustainability goals, further constrains systematic implementation. To overcome these challenges, the following strategies are proposed:

Strengthening Financial Support and Resource Mobilization: Dedicated funding mechanisms should be established at institutional and governmental levels to support sustainability-oriented library initiatives in all kinds. Libraries may also explore alternative funding sources such as research grants, public–private partnerships, alumni contributions, and CSR initiatives.

Infrastructure Development and Digital Inclusion: Investment in digital infrastructure, including high-speed internet connectivity, institutional repositories, and access to e-resources, must be prioritised, particularly for rural and semi-urban institutions. National platforms such as INFLIBNET, SWAYAM, NDLI, ONOS and Vidya Mitra can help bridge infrastructural gaps and promote equitable access.

Capacity Building and Professional Training: Continuous professional development programmes should equip library professionals with competencies in sustainability, digital literacy, data management, and emerging technologies. Integrating SDG-oriented modules into LIS curricula and offering periodic refresher courses through The Malaviya Mission Teacher Training Programme (MMTTP) will strengthen human resource capacity.

Awareness Creation and User Engagement: Libraries should promote SDG awareness through orientation programmes, workshops, exhibitions, curated reading lists, and community outreach. Embedding SDG-related resources into teaching–learning processes encourages active participation from students and faculty.

Policy Integration and Strategic Alignment: Formal policy frameworks linking library services with institutional sustainability goals should be developed. Alignment with national policies such as NEP 2020 and the UN SDGs will enable systematic planning, implementation, and evaluation.

Collaboration and Networking: Academic libraries should strengthen collaborations with academic departments, research centres, NGOs, and international agencies. Consortium-based approaches enhance access, reduce costs, and support collective progress towards sustainability goals.

Monitoring, Evaluation, and Documentation: Mechanisms to assess the impact of library-led SDG initiatives are essential for accountability and continuous improvement. Documentation and dissemination of successful practices can support replication across institutions.

Role of Librarians in Advancing SDGs

Librarians play a central role in translating sustainability goals into actionable library services. As information professionals, they act as facilitators of access to knowledge, educators in information and digital literacy, and advocates for open and inclusive information systems. Librarians support SDG 4 by designing user education programmes that promote lifelong learning and critical information skills. Through research support services, they contribute to SDG 9 by enabling innovation, scholarly communication, and evidence-based research.

Librarians also function as sustainability advocates by curating collections on environmental awareness, social justice, and governance, thereby supporting SDGs 11, 13, and 16. Their role extends beyond traditional library operations to include policy participation, institutional planning, and collaboration with faculty and administrators on sustainability initiatives.

Readiness Required for Librarians to Meet SDG Objectives

To effectively support the SDGs, librarians must demonstrate professional readiness in multiple dimensions. Digital readiness is essential, including competencies in managing e-resources, institutional repositories, open access platforms, and emerging technologies. Policy literacy is equally important, enabling librarians to align library strategies with national frameworks such as NEP 2020, NIRF, NAAC quality indicators, and the UN SDGs.

Capacity building through continuous professional development programmes offered by UGC, AICTE, INFLIBNET, and professional associations is critical. Librarians must also cultivate skills in data management, research analytics, sustainability reporting, and user engagement. Ethical awareness, particularly in relation to equitable access, data privacy, and inclusive services, further strengthens librarian readiness which enhances libraries' contributions to institutional quality indicators and performance metrics.

Linking Sustainable Development Goals with Institutional Performance Metrics

Although the NIRF ranking framework does not explicitly allocate separate weightage to the SDGs but SDG-aligned initiatives significantly contribute to performance across key parameters such as outreach, inclusivity, research impact, and institutional perception. Similarly, NAAC accreditation places strong emphasis on sustainability, environmental responsibility, and social engagement under multiple criteria, particularly Criterion VII. Consequently, autonomous institutions that systematically embed SDGs into curricular, co-curricular, and governance practices often achieve higher NIRF rankings and superior accreditation grades such as A+ and A++.

Recommendations

- Integration of SDGs into institutional library policies
- Dedicated funding for sustainability-oriented library initiatives
- National framework for measuring SDG contributions of libraries
- Capacity-building programmes on sustainability librarianship

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Conclusion

Academic libraries occupy a strategic position in advancing the Sustainable Development Goals within higher education institutions by facilitating equitable access to information, supporting research and innovation, promoting digital inclusion, and fostering sustainability awareness. In the Indian context, academic libraries contribute meaningfully to multiple SDGs, particularly those related to quality education, innovation, reduced inequalities, environmental sustainability, and transparent knowledge systems.

However, the effective realisation of this potential depends on sustained institutional support, policy alignment, adequate infrastructure, and continuous capacity building of library professionals. Integrating SDG principles into library planning, services, and governance frameworks enables academic libraries to move beyond supportive roles and function as active institutional partners in sustainable development initiatives.

By aligning their services with national policies such as the National Education Policy 2020 and global frameworks like the UN SDGs, academic libraries can enhance their relevance and impact in a knowledge-driven society. Strengthened collaboration, systematic evaluation, and policy recognition will further empower academic libraries to contribute to national and global sustainability goals in a meaningful and measurable manner.

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An Overview of Apex Public Libraries in Tamil Nadu and their Adoption of Environmental Practices

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Abstract

Environmental sustainability has become an essential concern for public institutions, including libraries, due to increasing resource constraints and environmental challenges. Public libraries, particularly apex libraries, play a significant role in promoting sustainable practices through infrastructure development, resource management, and service delivery. The study examines the adoption of environmental practices in selected apex public libraries of Tamil Nadu, namely Connemara Public Library, Anna Centenary Library, and Kalaignar Centenary Library. The study is descriptive and analytical in nature and is based on secondary data collected from official library websites, government reports, published literature, and institutional documentation. An Environmental Practices Assessment Framework was used to analyse sustainability practices across variables such as energy efficiency, water conservation, sustainable building design, indoor environmental quality, green campus initiatives, and digital practices. The findings reveal uneven adoption of environmental practices among the selected libraries, with modern, purpose-built libraries demonstrating higher environmental responsiveness than heritage libraries. The study highlights the importance of formal sustainability frameworks and certification in strengthening environmental performance and visibility in public libraries.

***Keywords**:* Apex Public Libraries, Environmental Sustainability, Green Libraries, Public Library System, Tamil Nadu

Introduction

Libraries are no longer confined to their traditional role as repositories of knowledge; they have evolved into dynamic public institutions that support social, educational, and cultural development. In recent years, increasing attention has been given to the environmental responsibilities of libraries, particularly in the context of sustainable development and efficient resource utilisation. As public institutions with substantial physical infrastructure and continuous user engagement, libraries have the potential to significantly contribute to environmental sustainability through energy-efficient design, water conservation, digital services, and environmentally responsible operations. In India, the public library system is organised in a hierarchical structure, with apex libraries occupying the highest level of administration and service provision. Apex public libraries serve as state-level knowledge centres, offering advanced reference services, preservation of heritage collections, and leadership within the public library network. In Tamil Nadu, the Directorate of Public Libraries governs an extensive network of libraries, among which Connemara Public Library, Anna Centenary Library, and Kalaignar Centenary Library function directly under its control and are recognised as apex institutions. Despite their importance, limited empirical research has been conducted on the environmental sustainability practices adopted by apex public libraries in Tamil Nadu. This study seeks to address this gap by examining and comparing the environmental practices of selected apex libraries, thereby contributing to the growing body of literature on sustainable library management in the Indian context.

Review of Literature

The concept of a "green library" encompasses a wide array of practices that minimise ecological impact while enhancing the socio-cultural role of libraries as community hubs for sustainable knowledge and behaviour. Recent research underscores the multidimensional nature of sustainability practices, ranging from facility design and operations to digital resource management and community engagement. **Jain, Kashyap, and Jhamaria (2025**) provide a comprehensive global perspective on sustainable library practices, identifying a

clear disparity in implementation levels between developed and developing contexts. The authors note that while many libraries internationally have integrated green building practices and sustainable operations, institutions in India are still in early stages of adoption due to barriers such as limited infrastructure and policy frameworks. A systematic review by **Tariq, Shahzad, and Sulehri** (2025) identifies key factors influencing the adoption of green libraries. Through a PRISMA-based literature synthesis, the authors find that institutional goals, technological readiness, and alignment with SDGs significantly affect the adoption of sustainable practices. Funding limitations and lack of technology are recurrent challenges hindering full implementation, particularly in resource-constrained environments. This underscores the need for strategic planning and policy support to mainstream sustainability within library operations. In the context of facility management, **Bansal et al. (2026)** propose a sustainability metrics framework that identifies critical indicators across energy consumption, water use, indoor environmental quality, waste management, and procurement. Their work emphasises the importance of holistic measurement systems to monitor and improve sustainability performance, reinforcing the idea that environmental sustainability in libraries must be systematically assessed rather than addressed through isolated measures. Furthermore, **Ritu (2024)** examines sustainable practices implemented in green libraries globally, highlighting case study evidence of strategies such as eco-friendly building design, renewable energy adoption, waste reduction and community engagement. This review suggests that successful library sustainability initiatives often combine technology, infrastructure adaptations, and stakeholder involvement to achieve measurable environmental benefits. Beyond design and operations, research indicates that library professionals play a role in sustainability awareness and practices. For example, studies on environmental awareness among library staff demonstrate that individual behaviours and professional attitudes influence the successful adoption of sustainable practices, even where formal frameworks are lacking. This aligns with **Ren's (2024)** findings from a multi-state U.S. survey that many libraries engage in everyday sustainable actions such as recycling and energy saving, yet lack comprehensive policies to systematically address environmental issues.

Collectively, the literature suggests a growing recognition of the importance of environmental sustainability in library science. However, it also reveals common challenges including limited resources, lack of formal policies, and varying levels of institutional commitment. These findings highlight the need for integrated frameworks, formal sustainability strategies, and context-specific approaches that consider both infrastructure and service dimensions. The present study builds on this foundation by systematically analysing sustainability practices in apex public libraries of Tamil Nadu, addressing a gap in region-specific empirical research on environmental practices in public library systems.

Objectives of the Study

- To provide an overview of apex public libraries in Tamil Nadu
- To examine the environmental sustainability practices adopted by apex public libraries in Tamil Nadu

Scope of the Study

The study is confined to apex public libraries functioning under the Directorate of Public Libraries, Tamil Nadu. It focuses exclusively on environmental sustainability practices related to infrastructure, resource management, and digital services. The study does not include user perception surveys or primary field measurements of energy or water usage.

Research Methodology

1. **Area of the Study:** The public library system in Tamil Nadu functions under the administrative control of the Directorate of Public Libraries, Government of Tamil Nadu. According to the official classification provided by the Directorate, the state library network consists of 4,661 libraries, including District Central Libraries, branch libraries, mobile libraries, village libraries, and part-time libraries. Significantly, only three libraries are shown as single, standalone institutions directly functioning under

the control of the Directorate of Public Libraries**,** distinct from all other categories which exist in multiple numbers.

Table 1: Apex Public Libraries of Tamil Nadu

Sl. No.	Name of the library	Year of establishment	Location
1	Connemara Public Library	1896	Chennai
2	Anna Centenary Library	2010	Chennai
3	Kalaignar Centenary Library	2023	Madurai

Data Source: https://tamilnadupubliclibraries.org/about-the-directorate

This unique administrative positioning indicates that these three libraries occupy the highest hierarchical level in the Tamil Nadu public library system, functioning as apex libraries responsible for state-level resource provision, leadership, and reference services. Hence, these libraries have been purposively selected for the present study.

2. **Period of the study:** The study covers the current operational period of the selected libraries. The study examines environmental practices that are currently in operation and actively implemented at the time of data collection

3. **Sample Size and Sampling Technique:** The sample size of the study comprises three apex public libraries of Tamil Nadu. The libraries were selected using the purposive sampling technique, as the study focuses on institutions occupying the highest level in the state public library hierarchy. The selection was based on the following criteria:

- Apex or state-level status within the Tamil Nadu public library system
- Availability of reliable and documented information relating to infrastructure, services, and operational practices relevant to environmental sustainability

4. **Sources of Data:** The study is based exclusively on secondary data sources. Data were collected from official library websites and institutional publications**,** government documents and reports issued by the State Directorate of Public Libraries and the Raja Rammohun Roy Library Foundation (RRRLF**),** published journal articles, conference papers, and case studies**,** architectural and institutional documentation, as well as newspaper articles and other credible online sources relevant to the study.

5. **Variables of the Study:** Chart 1 presents the variables covered in this study. These are the environmental variables the selected libraries have commonly adopted.

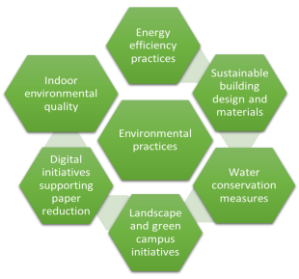


Chart 1: Environmenal Practices

Data Source: Author's Work: Public libraries in Tamil Nadu were established under the provisions of the Tamil Nadu Public Libraries Act, 1948, and the Directorate of Public Libraries was formed in 1972 to strengthen and coordinate library services across the state (Directorate of Public Libraries, Government of Tamil Nadu, n.d.).

6. **Analytical Framework:** The study adopts an Environmental Practices Assessment Framework**,** under which each selected apex library is systematically evaluated across key sustainability dimensions. The framework enables the identification of best practices, existing gaps, and areas requiring improvement in the adoption of environmental practices

Overview of Selected Apex Libraries in Tamil Nadu

The public library system in Tamil Nadu is one of the oldest and most structured systems in India, functioning under the administrative control of the Directorate of Public Libraries, Government of Tamil Nadu. Within this hierarchical framework, a limited number of libraries function at the apex level, providing leadership, reference, and state-wide public library services. The present study focuses on three such apex libraries, namely **Connemara Public Library**, **Anna Centenary Library**, and **Kalaignar Centenary Library**, which operate directly under the Directorate and occupy the highest tier in the state public library network.

1. **Connemara Public Library**, located in Chennai, is one of the oldest public libraries in India and serves as a State Central Library and one of India's four National Depository Libraries under the Delivery of Books Act. Established in the late nineteenth century, the library is renowned for its extensive collection of books, periodicals, and rare documents. It also holds the status of a National Depository Library, receiving copies of all publications released in India. As a heritage institution, Connemara Public Library plays a pivotal role in preservation, reference services, and bibliographic support within the state's public library system.
2. **Anna Centenary Library**, situated in Chennai, represents a modern and technologically advanced apex library. Established to commemorate the birth centenary of Dr. C. N. Annadurai, the library functions as a comprehensive knowledge and resource centre catering to diverse user groups, including students, researchers, and the general public. The library is notable for its large built-up area, extensive print and digital collections, and advanced infrastructure. It is also recognised for its environmentally responsible design, having incorporated green building principles in its construction and operations.
3. **Kalaignar Centenary Library**, located in Madurai, is the most recent addition to the apex library system of Tamil Nadu. Established to honour the legacy of Kalaignar M.Karunanidhi, the library was envisioned as a major public knowledge hub for southern Tamil Nadu. With modern infrastructure, spacious reading areas, and a strong emphasis on digital services, the library extends the reach of apex-level public library services beyond the state capital. Its establishment reflects the government's intent to decentralise advanced library facilities and promote equitable access to information.

Environmental Practices Adopted by Selected Apex Libraries

Table 2 presents the list of environmental practices adopted by the selected libraries separately. These practices are collected from the official websites of the libraries and their disclosures.

Table 2: Presents the Environmental Practices Adopted by the Selected Apex Libraries

Environmental Dimension	Anna Centenary Library (Chennai)	Connemara Public Library (Chennai)	Kalaignar Centenary Library (Madurai)
Green Building Certification	LEED NC Gold certified (IGBC)	Not available (heritage building)	Not reported
Energy Efficiency Measures	Extensive use of natural daylight; LED lighting; high-efficiency HVAC systems; reduced energy consumption compared to conventional buildings	Limited documentation; conventional lighting and cooling systems; partial digitisation reduces indirect energy use	Energy-efficient lighting; modern electrical systems

Water Conservation Practices	Rainwater harvesting; wastewater treatment and reuse for flushing and landscaping; low-flow fixtures	Not documented	Not documented
Sustainable Materials & Construction	Use of recycled and locally sourced materials; low-VOC paints and finishes	Heritage conservation materials used; sustainability not an explicit objective	Use of modern and relatively sustainable construction materials
Landscape & Site Sustainability	Green landscaping; terrace gardens; mitigation of heat island effect	Limited green planning; reported tree removal during renovation	Landscaped green spaces integrated into campus
Indoor Environmental Quality	Improved ventilation; CO_2 monitoring; enhanced thermal and visual comfort	Natural ventilation in heritage structure; no documented IAQ management	Comfortable indoor environment through modern design
Digital & Paper-Reduction Practices	Digital catalogues; e-resources; automated services	Digitisation of catalogues and collections (partial)	Strong emphasis on digital resources and e-library services
Overall Level of Environmental Practice Adoption	**High (Comprehensive and documented)**	**Low (Indirect and undocumented)**	**Moderate (Infrastructure-based, partially documented)**

Leadership in Energy and Environmental Design (LEED) is an internationally recognized green building certification system that evaluates buildings based on energy efficiency, water conservation, sustainable materials, and indoor environmental quality (U.S. Green Building Council [USGBC], n.d.).

Interpretation and Discussion

Anna Centenary Library emerges as a benchmark green public library. Its LEED Gold certification demonstrates a systematic and measurable approach to environmental sustainability, encompassing energy efficiency, water conservation, sustainable materials, indoor environmental quality, and site management. Environmental sustainability is clearly integrated into the planning, construction, and operational phases, making it a model institution for green public infrastructure in India. In contrast, Connemara Public Library, being a heritage library, shows minimal explicit environmental practices. Sustainability-related actions are largely incidental rather than intentional, such as conservation of an existing structure and partial digitisation. The absence of formal environmental planning, coupled with reported concerns regarding tree removal during renovation, indicates that environmental sustainability is not a core operational priority. However, its heritage preservation role contributes indirectly to sustainability through resource conservation. Kalaignar Centenary Library represents an intermediate stage of environmental adoption. As a modern facility, it incorporates energy-efficient lighting, digital services, and landscaped green spaces, reflecting awareness of environmental considerations. However, the absence of formal green building certification and limited public documentation on water management, waste management, and energy performance suggests that sustainability practices are selective rather than comprehensive.

Dimension-wise Interpretation

- **Energy Management**: Anna Centenary Library demonstrates advanced energy management through passive design and efficient systems, whereas Kalaignar Library adopts basic efficiency measures. Connemara Library lags due to structural and heritage constraints.

- **Water Sustainability**: Only Anna Centenary Library has clearly documented water conservation mechanisms, highlighting a major gap in the other two libraries.
- **Environmental Governance & Documentation**: The presence of certification and measurable indicators at Anna Centenary Library contrasts sharply with the lack of formal sustainability reporting at Connemara and Kalaignar Libraries.
- **Digital Sustainability**: All three libraries show progress in digitisation, indicating that technological sustainability is more readily adopted than physical environmental measures in public libraries.

Findings of the Study

- The study reveals that apex public libraries in Tamil Nadu demonstrate an uneven level of adoption of environmental practices, indicating the absence of a uniform sustainability approach across institutions.
- Purpose-built modern libraries, such as Anna Centenary Library and Kalaignar Centenary Library, exhibit greater environmental responsiveness compared to heritage institutions, largely due to their contemporary infrastructure and design flexibility.
- The presence of formal green building certification and structured sustainability reporting is found to significantly enhance both the effectiveness and visibility of environmental practices within public libraries.
- Despite isolated sustainability initiatives, most apex libraries lack a comprehensive environmental management framework, particularly in critical areas such as water conservation and waste management.
- Digitization emerges as the most widely adopted sustainability practice across all selected libraries, including heritage institutions, reflecting its role in reducing paper usage and supporting resource efficiency.

Conclusion

The study provides a comparative assessment of environmental practices adopted by selected apex public libraries in Tamil Nadu. The findings indicate that while environmental sustainability is increasingly recognised within the public library sector, its adoption remains uneven across institutions. Anna Centenary Library emerges as a benchmark in environmental sustainability due to its certified green building design and comprehensive environmental practices. Kalaignar Centenary Library demonstrates moderate adoption, reflecting awareness of sustainability principles but lacking formal documentation and certification. Connemara Public Library, constrained by its heritage status, shows limited explicit environmental practices, although its preservation role contributes indirectly to sustainability. The study underscores the need for a structured and holistic environmental management framework for apex public libraries. Formal sustainability policies, systematic documentation, and government-supported green initiatives can significantly enhance environmental performance. The findings suggest that apex libraries, owing to their leadership role, can serve as models for promoting sustainable practices across the broader public library network.

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Sustainability and Green Libraries: Eco-Friendly Practices, Sustainable Development Goals, and the Transformation towards Paperless Library Systems

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ABSTRACT

Sustainability has emerged as a defining concern of the twenty-first century, driven by environmental degradation, climate change, and unsustainable patterns of resource consumption. Institutions across all sectors are increasingly expected to adopt environmentally responsible practices, and libraries are no exception. Libraries function not only as repositories of knowledge but also as social institutions that influence learning, behaviour, and community development. The concept of green libraries emphasizes the integration of sustainable principles into library buildings, operations, services, and professional practices. This paper examines sustainability in the context of libraries, focusing on eco-friendly practices, digital and paperless transformations, and the contribution of libraries toward achieving the United Nations Sustainable Development Goals (SDGs). It also explores the evolving role of librarians as facilitators of sustainable change and critically analyzes the challenges faced in implementing green library initiatives. The study concludes that sustainable and green libraries are essential for reducing environmental impact while strengthening access to information, educational equity, and institutional resilience.

Keywords: Sustainability, Green Libraries, Eco-friendly Practices, Paperless Libraries, Sustainable Development Goals, Digital Libraries

INTRODUCTION

The growing emphasis on sustainability reflects increasing global awareness of environmental crises such as climate change, loss of biodiversity, deforestation, and depletion of natural resources. Sustainability broadly refers to development that meets present needs without undermining the capacity of future generations to meet their own needs. While governments and industries are often viewed as primary actors in sustainability efforts, educational and cultural institutions also bear significant responsibility.

Libraries occupy a unique position within society as centers of learning, information dissemination, and intellectual engagement. Traditionally, library operations have depended heavily on physical resources, including printed books, journals, paper-based records, and energy-intensive infrastructure. Large-scale printing, storage, lighting, and climate control contribute to environmental stress and increased operational costs. At the same time, libraries promote values such as access, equity, and knowledge preservation, which closely align with sustainable development principles.

The emergence of green libraries represents a shift in how libraries perceive their social and environmental responsibilities. Modern libraries are increasingly embracing digital resources, energy-efficient infrastructure, and environmentally conscious policies. The movement toward paperless library systems further reinforces sustainability by reducing material consumption and enhancing service efficiency. This paper seeks to examine the concept of sustainability in libraries, explore green practices and digital transformation, analyze the role of librarians, and identify challenges that must be addressed to achieve long-term sustainability.

SUSTAINABILITY: A THEORETICAL PERSPECTIVE IN LIBRARIES

Dimensions of Sustainability

Sustainability is commonly understood through three interrelated dimensions: environmental, social, and economic sustainability. Environmental sustainability focuses on minimizing ecological damage through conservation of energy, water, and natural resources. Social sustainability emphasizes equity, inclusion, education, and community well-being. Economic sustainability concerns cost efficiency, long-term financial viability, and responsible resource allocation.

In the library context, these dimensions intersect closely. Environmentally sustainable practices reduce waste and energy use; socially sustainable libraries ensure equitable access to information and digital inclusion; economically sustainable libraries manage limited resources efficiently while maintaining quality services. A comprehensive approach to sustainability in libraries must address all three dimensions simultaneously.

Sustainability in Library and Information Science

Within Library and Information Science (LIS), sustainability is increasingly recognized as a core professional concern. Libraries are no longer passive service units but active participants in sustainable knowledge societies. Sustainable library practices support lifelong learning, informed citizenship, and responsible information use. By embedding sustainability into policies, services, and professional values, libraries contribute to long-term societal resilience.

GREEN LIBRARIES: SIGNIFICANCE & ELEMENTS

Green libraries are libraries that consciously apply sustainability principles in their design, management, and service delivery. The concept extends beyond environmentally friendly buildings to include sustainable workflows, user education, and professional practices. Green libraries aim to reduce their ecological footprint while maintaining high standards of service.

The significance of green libraries lies in their dual role. Internally, they reduce environmental impact and operational costs. Externally, they function as visible symbols of sustainability, influencing users' attitudes and behaviors. Libraries that adopt green principles demonstrate that environmental responsibility and information access can coexist harmoniously.

ELEMENTS OF GREEN LIBRARY

- **Community & Locality:** Library locations should be ideal, away from noise and public transportation, to ensure patron concentration and focus on study, as per guidelines from LEED and U.S. Green Building Council.
- **Area:** India's diverse landscape necessitates comprehensive planning for construction, considering locality, weather, and area, ensuring effective planning for hilly and plain areas.
- **Constructional material:** Green libraries are constructed using recyclable and sustainable materials, adhering to various Indian and international standards and protocols.
- **IGBC:** The Indian Green Building Council (IGBC), a subsidiary of the Confederation of Indian Industry, offers green building rating programs, training programs, and certification services.
- **LEED:** LEED is a renowned program that promotes environmentally friendly, highperformance green buildings, aiming to minimize waste at every stage of construction.
- **LIGHT:** A library should have windows, glass windows, and skylights that allow natural light, reducing electricity usage during the day.Using low energy bulbs and lights in non-reading areas can indirectly save money and electricity.
- **AIR:** Air quality is crucial for comfort and breathability, and proper plantation around campuses helps cool the library and control air conditioner operation.

ROLE OF GREEN LIBRARIES

- Encouraging users to use e-books, e-journals, etc., which can work as space, paper saving tools, and also leads to reducing costs
- Undertaking practices like making soft copies, microfilming of old and scares books and by weeding-out of old and outdated books, which help in optimum utilization of space
- Using different electronic medias and online communication tools like social media, which offers a number of benefits to both library management and users
- Working under eco-library system and identifying those people who are willing to work under such an environment, which may strengthen the movement

- Promoting green library tools, techniques and encouraging others to use the same, which may ensure active participation of all those concern
- Encouraging other librarians to go for green library by discussions, seminars, and conferences, which may help to joining hands together
- Handling and managing the library budgets to support the organizations, which may ensure optimum utilization of financial resources and ensure economies in operations
- Using wooden furniture and other bio-degradable material making the place quite eco friendly and sustainable one
- Using wool bricks instead of burnt bricks as construction material, which is considered as eco friendly material
- Using solar tiles or panel i.e. reflective material for library roofing so as to ensure maximum use of renewable energy
- Using recyclable paper insulation which considered as an ultimate trick to make environment friendly building
- Making use of bamboo, fiber, etc. by replacing steel material, which is also considered as eco friendly material
- Taking necessary steps for conservation of energy, water, paper, etc., which not only allows big savings in resources, costs but also brings about sustainability

ECO-FRIENDLY PRACTICES IN LIBRARY OPERATIONS

Energy Conservation and Efficiency

Energy use constitutes a major component of library operations. Lighting, heating, cooling, and computer systems consume significant amounts of electricity. Libraries can adopt energy-efficient lighting systems, improve insulation, maximize natural daylight, and use energy-saving equipment to reduce consumption. Smart energy management systems further optimize usage by adjusting energy output according to occupancy and demand.

Sustainable Infrastructure and Building Design

Sustainable library buildings are designed to reduce environmental impact while enhancing user comfort. Features such as passive cooling, natural ventilation, solar energy systems, and green roofs contribute to energy efficiency. Water conservation measures, including rainwater harvesting and low-flow fixtures, further support sustainability. Sustainable design not only lowers operational costs but also creates healthier learning environments.

Waste Reduction and Responsible Disposal

Libraries generate waste through discarded paper, outdated materials, and electronic equipment. Sustainable waste management involves reducing paper use, recycling materials, reusing furniture, and ensuring safe disposal of electronic waste. Digital workflows, such as electronic communication and record management, significantly reduce paper waste.

Sustainable Collection Development

Green collection development emphasizes quality over quantity, prioritizing digital resources and shared access models. Resource sharing through consortia reduces duplication and environmental impact while expanding access. Evaluating resource life cycles ensures responsible acquisition and disposal practices.

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PAPERLESS LIBRARIES AND DIGITAL TRANSFORMATION

Evolution of Paperless Library Systems

Paperless libraries represent a shift from print-centric services to digital information environments. Advances in information and communication technologies have enabled libraries to provide access to e-books, e-journals, databases, and digital repositories. Automated systems streamline cataloguing, circulation, and reference services, reducing reliance on physical documentation.

Environmental and Educational Benefits

Paperless systems reduce deforestation, waste generation, and energy consumption associated with printing and storage. Digital access enhances educational equity by allowing users to access information remotely and instantly. These systems also support flexible learning models and research collaboration.

Limitations and Risks

Despite their advantages, paperless libraries face challenges related to digital preservation, data security, and technological dependence. Unequal access to technology and digital literacy gaps may exclude certain user groups. Sustainable digital transformation therefore requires inclusive planning and continuous user support.

LIBRARIES AND THE SUSTAINABLE DEVELOPMENT GOALS (SDGs)

Libraries contribute directly and indirectly to several SDGs. They promote **SDG 4 (Quality Education)** by supporting inclusive learning. By adopting paperless systems and responsible resource management, they contribute to **SDG 12 (Responsible Consumption and Production)**. Energy-efficient practices and environmental education support **SDG 13 (Climate Action)**. Libraries thus function as local institutions with global sustainability impact.

ROLE OF LIBRARIES AND LIBRARIANS IN SUSTAINABILITY

Libraries as Agents of Sustainable Knowledge

Libraries facilitate access to sustainability-related information, enabling informed decision-making. Through curated resources and programs, they foster environmental literacy and critical thinking.

Librarians as Leaders and Advocates

Librarians act as advocates for sustainable practices within institutions. They design policies, guide users toward eco-friendly resources, and integrate sustainability into professional ethics.

Capacity Building and Community Engagement

By organizing training programs and outreach activities, librarians strengthen digital literacy and environmental awareness. Community engagement ensures that sustainability efforts extend beyond library walls.

CHALLENGES IN IMPLEMENTING GREEN AND SUSTAINABLE LIBRARIES

Financial Constraints

One of the primary challenges in implementing green libraries is the lack of adequate funding. The installation of energy-efficient systems, renewable energy sources, and digital infrastructure requires substantial initial investment. Many libraries operate under limited budgets, making it difficult to prioritize sustainability initiatives despite their long-term benefits.

Technological Limitations

The transition toward paperless and digital libraries depends on reliable technological infrastructure. Inadequate internet connectivity, outdated hardware, and lack of advanced software hinder effective

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implementation. Additionally, ensuring data security and long-term digital preservation requires technical expertise that may not be available in all libraries.

Lack of Skilled Staff and Training

Green library initiatives demand new skills related to digital resource management and sustainability practices. However, many library professionals lack sufficient training in these areas. The absence of regular professional development programs limits the capacity of librarians to plan, implement, and maintain sustainable practices effectively.

Resistance to Change

Resistance from staff and users poses another significant challenge. Many users prefer traditional printed materials, while staff may be hesitant to adopt new technologies and workflows. This resistance can slow the transition toward paperless services and eco-friendly operations.

Policy and Administrative Barriers

The absence of clear institutional policies and administrative support restricts the implementation of green initiatives. Without formal sustainability guidelines and long-term planning, green practices often remain fragmented and inconsistent.

STRATEGIES AND RECOMMENDATIONS FOR PROMOTING GREEN LIBRARIES

To effectively implement sustainability and green practices in libraries, a strategic and phased approach is essential. The following strategies and recommendations focus on practical, achievable measures that libraries can adopt according to their resources and institutional context.

Policy Integration and Strategic Planning

Libraries should integrate sustainability into their institutional vision, mission, and policy frameworks. Clearly defined sustainability goals and action plans help ensure systematic implementation rather than isolated efforts. Library administrators should include green objectives in annual plans and allocate specific responsibilities for monitoring progress. Policy-level integration strengthens institutional commitment and ensures long-term continuity of green initiatives.

Phased Implementation of Green Practices

Instead of attempting complete transformation at once, libraries should adopt a phased approach to sustainability. Simple and low-cost measures such as reducing paper usage, switching to LED lighting, promoting digital communication, and encouraging resource sharing can be implemented initially. Gradual adoption allows libraries to manage costs effectively while building confidence among staff and users.

Capacity Building and Staff Training

Continuous training and professional development are crucial for successful green library implementation. Librarians should be trained in digital resource management, sustainable practices, and emerging technologies. Workshops, seminars, and online training programs can enhance awareness and skills related to sustainability. Well-trained staff are more likely to adopt innovative practices and guide users effectively.

Promotion of Digital Literacy and User Awarenes

User acceptance plays a key role in the success of paperless and green libraries. Libraries should organize orientation programs, user training sessions, and awareness campaigns to promote digital resources and environmentally responsible behavior. Educating users about the benefits of paperless services helps reduce resistance and encourages active participation in sustainability initiatives.

Strengthening Technological Infrastructure

Investment in reliable technological infrastructure is essential for paperless library services. Libraries should upgrade hardware, improve internet connectivity, and adopt secure digital platforms. Cloud-based systems and shared digital resources can reduce costs while improving accessibility. Ensuring data security and digital preservation should also be prioritized.

Collaboration and Resource Sharing

Collaboration with other libraries, academic institutions, government agencies, and non-governmental organizations can strengthen sustainability efforts. Resource-sharing initiatives, library consortia, and joint digital repositories reduce duplication, lower costs, and minimize environmental impact. Partnerships also provide opportunities for funding, expertise exchange, and innovation.

Monitoring and Evaluation of Sustainability Practices

Regular monitoring and evaluation help assess the effectiveness of green initiatives. Libraries should develop simple indicators to measure energy consumption, paper usage, and user engagement with digital services. Periodic evaluation enables libraries to identify gaps, improve strategies, and demonstrate the impact of sustainability efforts to stakeholders.

CONCLUSION

Sustainable and green libraries represent a necessary evolution in the knowledge society. By integrating eco-friendly practices, digital transformation, and community engagement, libraries can significantly reduce environmental impact while enhancing access to information. Although challenges remain, strategic planning, professional leadership, and institutional support can transform libraries into resilient and sustainable knowledge centers. The future of libraries lies in balancing environmental responsibility with their enduring mission of education and access.

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Green Libraries as Catalysts for Sustainable Development Goals in India: Evidence from Public Library Initiatives (2021–2026)

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Abstract

The role of public libraries is becoming increasingly important in the promotion of sustainable development through the provision of equal access to information and the adoption of environmentally responsible practices. In recent years, India has seen the development of green public library projects that combine sustainable infrastructure, renewable energy systems, and resource-efficient practices. This paper will discuss some of the green public library projects that have been developed in India between 2021 and 2026, with a focus on their alignment with the United Nations Sustainable Development Goals (SDGs). This study adopts a descriptive and analytical research design and is based on secondary data that has been collected from official websites, government publications, project reports, and relevant literature. The green aspects of selected public libraries are systematically identified in relation to the relevant SDGs to determine their contribution to quality education, clean energy, sustainable cities, responsible consumption, climate action, and partnerships. The results of this study show that green public libraries in India are not only knowledge centers but also community-level agents of sustainable development. The paper concludes by emphasizing the importance of the development of guidelines and institutional commitment to the adoption of green practices in public libraries in India.

Introduction

Sustainable development, which focuses on the interrelated challenges of social inclusion, economic development, and environmental protection, has become a prominent global agenda. The United Nations' 2030 Agenda for Sustainable Development, consisting of 17 Sustainable Development Goals (SDGs), serves as a comprehensive guide for countries to achieve sustainable development (United Nations, 2015). In light of this global agenda, public institutions are increasingly called upon to incorporate sustainable principles in their planning, infrastructure, and service delivery. As hubs of knowledge and community engagement, libraries are crucial to the achievement of sustainable development. In addition to their role as information providers, libraries are social change agents that promote environmental awareness, digital inclusion, and lifelong learning through sustainable practices (Ajani et al., 2024; Anyaegbu et al., 2025). In the wake of climate change and environmental degradation, libraries are increasingly embracing green practices such as energy-efficient buildings, renewable energy sources, waste reduction, and environmentally sustainable service practices. Despite the widespread discussion of green library concepts, there aren't many systematic studies on green public library initiatives in India. Instead of recording recent real-world implementations, the majority of research is conceptual and concentrates on awareness. The Sustainable Development Goals (SDGs) are rarely mapped to particular characteristics, such as net-zero energy, renewable energy use, and digital inclusion, and recent initiatives between 2021 and 2026, such as urban net-zero libraries and rural digital libraries, have not been examined collectively. This study addresses these gaps by examining selected green public library initiatives and their contribution to SDGs.

Despite growing recognition of libraries' contributions to sustainable development, systematic research linking specific SDGs to green public library initiatives in India remains limited. Existing studies largely focus on conceptual discussions or general awareness, with little empirical evidence demonstrating how public library practices contribute to particular SDGs, especially within the Indian context (Panda, Sharma, & Sati, 2025). Moreover, recent initiatives developed between 2021 and 2026—such as urban net-zero public libraries and rural digital library projects—have not been examined collectively. Addressing these gaps, the present study analyses selected green public library initiatives in India and evaluates their contribution to the achievement of

the Sustainable Development Goals, thereby offering evidence-based insights for policymakers and library professionals (IFLA, 2018).

Objective

The following objectives serve as the study's direction:

- Identify major green public library initiatives developed in India between 2021 and 2026.
- Examine the sustainable practices implemented in these public libraries.
- Assess the contribution of these practices by mapping them to relevant Sustainable Development Goals (SDGs).
- Analyse the role of public libraries as catalysts for sustainable development and provide evidence-based insights for policymakers and library professionals.

Review of Literature

Libraries are becoming more widely acknowledged as important organisations that support the Sustainable Development Goals (SDGs) of the United Nations by promoting inclusive community development, lifelong learning, and fair access to information. Libraries around the world support several SDGs, including SDG 10 (Reduced Inequalities), SDG 11 (Sustainable Cities and Communities), and SDG 4 (Quality Education). In a mixed-methods review of academic libraries across the globe, Dabengwa (2025) discovered that while libraries participate in a variety of sustainability-related activities, systematic SDG integration and quantifiable results are still scarce. The study warned against superficial "SDG washing" practices while highlighting partnerships, organisational culture, and leadership as critical enablers.

Sustainability has become a major area of study in Library and Information Science (LIS) from a disciplinary standpoint. Odularo (2024) emphasised that despite growing recognition of libraries' potential in promoting sustainable development, empirical evidence demonstrating their direct contribution to SDG achievement remains insufficient. Particularly in developing-country contexts, the study found enduring issues like insufficient funding, institutional obstacles, and a lack of long-term impact assessments.The idea of the "green library" has become more well-known in this larger sustainability conversation as a calculated and useful approach to environmental responsibility. Green libraries focus on sustainable building design, efficient energy and water use, waste reduction, and environmental literacy programmes. By classifying practices into green infrastructure, sustainable operations, green collections, and innovative technologies, Gupta (2020) offered a comprehensive understanding of green libraries. Additionally, the study highlighted how green library initiatives relate to SDGs 7 (Affordable and Clean Energy), 12 (Responsible Consumption and Production), and 13 (Climate Action) by connecting them with global sustainability frameworks like LEED and GRIHA. By addressing issues with governance, standards, and implementation, recent literature has broadened the conversation about green libraries. Bychkova (2022) looked at green libraries from the perspective of Environmental, Social, and Governance (ESG) principles and made the case that sustainability should be incorporated into library planning, assessment, and collaborations with community and governmental stakeholders. Despite the lack of empirical support, this governance-oriented approach is especially pertinent to public libraries.

The concept of green libraries has been clarified by a number of Indian studies. Kulkarni (2023) highlighted Indian green library initiatives and the changing role of green librarians while discussing the characteristics, components, standards, and elements of green libraries. The study highlighted libraries' role in tackling environmental issues like energy conservation and climate change and traced the beginnings of the green library movement. However, the study largely remained descriptive and did not explicitly link initiatives to SDGs. Similar to this, Sivaprasad et al. (2024) looked at the difficulties in creating green libraries in India, emphasizing staff training, maintenance needs, financial limitations, and architectural redesign. The study also covered how national and international programs like the Indian Green Building Council, LEED, IFLA Green

Library Award, and UNESCO's SDGs support sustainable library practices. Although insightful, the study did not assess the results of recent public library initiatives; instead, it focused on strategies and barriers.

More recently, Barde et al. (2025) offered a thorough review of green libraries in the Indian scenario, covering topics such as concepts, standards, issues, and implementation strategies. The article emphasized the use of renewable energy, water conservation, and community participation as essential features of green libraries and the importance of librarians in raising sustainability literacy. While the article reviewed specific green library projects in India, it did not analyze public library developments over a specific period of time or their contribution to specific SDGs. There have also been empirical studies that specifically targeted green library adoption. Tariq et al. (2025) conducted a systematic literature review using PRISMA to identify the key drivers of green library adoption, which include organizational objectives, technology readiness, and alignment with SDGs, while funding and technology constraints are identified as significant challenges. However, the study did not distinguish between the types of libraries, thus reducing its applicability to public libraries.

In general, the literature shows an increasing interest in green libraries and sustainable development among scholars. Nevertheless, the current literature on green initiatives in India is mostly conceptual and fragmented, and there is a need to focus on current public library initiatives. Furthermore, there is a need for systematic research that specifically identifies green practices in public libraries in relation to the achievement of the Sustainable Development Goals, especially those developed between 2021 and 2026. It is within this context that this study aims to investigate the contribution of selected green public library initiatives in India to the achievement of the Sustainable Development Goals.

Methodology

A descriptive and analytical research design is used in this study. It is based on secondary data gathered from several reliable sources, such as published scholarly works, official library project reports, government publications, and verified websites. The sustainable aspects of the chosen green public library projects such as net-zero urban libraries and rural digital public libraries were scrutinized, and their compatibility with particular SDGs was assessed. After that, the information was methodically mapped to assess the ways in which these programs support partnerships, clean energy, sustainable cities, responsible consumption, high-quality education, and climate action.

Challenges and Limitations

However, despite the growing need for green public libraries as tools for sustainable development, there are a number of challenges that have been hampering the successful implementation of green libraries in India. One of the most significant challenges is the lack of funding, as green library infrastructure such as net zero energy buildings, renewable energy, and sustainable materials is quite expensive. Public libraries in India are mostly dependent on government funding, which is not sufficient for large-scale sustainability projects. The lack of funding has been identified as one of the most significant challenges in implementing green library initiatives, especially in the public sector (Gupta, 2020; Sivaprasad et al., 2024; Tariq et al., 2025).

Another significant challenge is the absence of technical know-how and qualified human resources in public library networks. The design, management, and maintenance of green infrastructure require technical knowledge in the management of energy, sustainable design, and information and communication technology. However, public libraries often lack qualified personnel and capacity-building initiatives. Organisational challenges such as a lack of administrative support, delayed implementation of policies, and a lack of coordination among different departments in the government make it even more difficult to implement policies (Kulkarni, 2023; Barde et al., 2025). Researchers have also pointed out that leadership and organisational culture play a crucial role in the success of sustainability projects in libraries (Dabengwa, 2025). From a research point of view, the current study has some limitations. The current study is based on secondary data, which has been collected from government publications, project reports, websites, and published literature. Although the data is reliable, the lack of primary data, such as interviews with library administrators or user feedback, creates a limitation in assessing the real social and educational value of green public library

initiatives. Moreover, the lack of standardized indicators to measure the contribution of libraries to any particular SDG creates a limitation in the empirical mapping process (Odularo, 2024; Dabengwa, 2025).

Another limitation of the study is the imbalance in the documentation of green public library initiatives in various regions of India. The majority of the available information is about urban or semi-urban libraries, while the information about rural public library initiatives is less documented. In addition, some of the initiatives that were carried out between 2021 and 2026 are still in the developmental or early stages of implementation (Sarkar, 2020; Barde et al., 2025). Despite the limitations, the study is an important compilation of recent green public library initiatives in India.

Result and Discussion

***Table: 1 (Green Library Initiative*)**

Public Library Initiative	**Developer**	**Location**	**Year**	**Green Features**	**SDGs Fulfilled**	**How SDGs Are Fulfilled**
Jhansi Net-Zero Public Library	Jhansi Development Authority (JDA)	Jhansi, Uttar Pradesh	2023	Net-zero energy, 100% renewable power, energy-efficient building, sustainability certification	SDG 4, SDG 7, SDG 11, SDG 12, SDG 13	Inclusive learning space; operates on renewable energy; reduces carbon footprint; uses sustainable building materials and energy-efficient systems
Varanasi Net-Zero Public Library (under construction)	Varanasi Development Authority (VDA) & NHPC Ltd (CSR partnership)	Varanasi, Uttar Pradesh	Expected 2026	Net-zero design, solar panels, water conservation, waste management, public–private partnerships	SDG 4, SDG 7, SDG 11, SDG 12, SDG 13, SDG 17	Promotes lifelong learning; integrates renewable energy and water management; supports sustainable urban infrastructure; developed through CSR and government partnerships

Rural Public Digital Libraries	Uttar Pradesh Government	Varanasi district, Uttar Pradesh	2025	Digital access, computers, internet, community learning centers	SDG 4, SDG 10, SDG 11	Improves access to education and information in rural areas; bridges digital divide; supports inclusive and resilient rural communities

Analysis of green public library projects in India, from 2021 to 2026, shows their important role in achieving several Sustainable Development Goals. Net-zero public libraries in urban areas, such as Jhansi and Varanasi, play an important role in ensuring affordable and clean energy (SDG 7) and combating climate change (SDG 13) through the use of renewable energy and energy-efficient architecture. At the same time, these libraries improve access to inclusive learning environments, thus making an important contribution to quality education (SDG 4). Their focus on sustainable infrastructure and waste management further reinforces their important role in promoting sustainable cities and communities (SDG 11) and responsible consumption and production (SDG 12). On the other hand, rural public digital libraries are mainly focused on addressing educational inequality and digital divide. Through access to digital knowledge, computers, and internet connectivity, these libraries improve educational opportunities (SDG 4) and help in reducing inequalities (SDG 10), while also building inclusive and resilient communities (SDG 11). Taken together, these projects illustrate the new role of public libraries as drivers of sustainable development, where social inclusion is combined with environmental stewardship. The results of this study emphasize the need for government and community support and public-private partnerships to promote sustainable library practices in India. (IFLA, 2018; United Nations, 2015; Sarkar, 2020).

Conclusion

India's green public libraries from 2021 to 2026 show how sustainable library practices can simultaneously promote social, educational, and environmental objectives. Numerous SDGs, such as high-quality education, clean energy, sustainable cities, responsible consumption, climate action, and decreased inequality, are supported by urban net-zero libraries and rural digital libraries (IFLA, 2018; United Nations, 2015; Sarkar, 2020). By fusing eco-friendly infrastructure with universal access to knowledge, these programs demonstrate the public libraries' growing role as catalysts for sustainable development (Jain, Kashyap, & Jhamaria, 2025; Panda, Sharma, & Sati, 2025).

The study underscores the importance of government support, public–private partnerships, and community engagement in implementing sustainable library practices (Times of India, 2025a, 2025b; Business Standard, 2023). In order to align library development with national and international sustainability agendas, policymakers, planners, and library professionals can use the evidence from these initiatives to replicate and scale green library models throughout India (IFLA, 2018; United Nations, 2015).

Recommendation

The importance of government support, public-private partnerships, and community engagement in the successful implementation of green library initiatives cannot be overstated. Policymakers, planners, and library professionals can benefit from these findings to replicate and scale green public library models that are in line with the national and international sustainability agendas. Future research studies can benefit from primary data such as user perspectives and impact assessments and can develop indicators to measure the library's contribution to individual SDGs.

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An Overview of Green Libraries

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ABSTRACT

Green libraries are increasingly recognized as vital institutions that incorporate environmental sustainability into traditional library services, infrastructure, and operations. With global concern over climate change, environmental degradation, and resource depletion, libraries worldwide are exploring strategies to reduce their ecological footprints. Green libraries highlight eco-friendly architecture, energy efficiency, resource conservation, sustainable procurement, digital transformation, user awareness, policy advocacy, and community engagement. These libraries align with broader sustainable development goals (SDGs), particularly those related to education, sustainable cities, responsible consumption, climate action, and partnerships. This paper critically examines the concept of green libraries, reviews relevant literature, identifies major advantages, examines current trends and progress, discusses issues, and describes forthcoming opportunities. Progress is evaluated with global and regional examples, while issues are explored through operational, financial, and cultural lenses. Finally, the study looks ahead to digital sustainability, policy frameworks, and the expanding function of green libraries in knowledge ecosystems.

KEYWORDS: Green Libraries, Sustainable Libraries, Eco-friendly Libraries, Environmental Awareness, Renewable Resources, Digital Transformation, Sustainable Development Goals

INTRODUCTION

In an era marked by environmental crises ranging from climate change to biodiversity loss and resource scarcity, institutions across sectors are adopting sustainability practices. Libraries, historically symbols of knowledge, learning, and community development, are no exception. Traditionally viewed as repositories of print and media collections, libraries today are evolving into dynamic community centres that also serve as exemplars of environmentally responsible design, technology adoption, and operational practices.

Green libraries represent a paradigm shift in library philosophy—extending beyond mere physical collections to include sustainable infrastructure, energy conservation, green procurement, waste management, and environmental education. These libraries seek to minimize ecological footprints while providing maximum social and educational value to patrons. Implementation of green principles in libraries intersects architecture, information science, facility management, community outreach, and curriculum support.

Green libraries are important for two major reasons. First, they demonstrate how cultural and educational institutions can actively contribute to global sustainability agendas. Second, they educate and influence library users, especially younger generations, encouraging sustainable behaviours beyond library walls.

REVIEW OF LITERATURE

Rubbi (2004):-A substantial body of research over the past two decades has examined ecological sustainability within the context of libraries. The foundational work by ***Rubbi*** *(2001)* asserted that libraries can no longer operate in isolation from environmental realities, urging adoption of energy-efficient lighting, sustainable building materials, and waste reduction techniques (Rubbi, 2001). Studies by *Saracevic (2004)* expanded this idea to incorporate "green collections," where materials related to environmental awareness and sustainability were curated for academic and public engagement.

Brophy and Bawden (2005*)*: -investigated the function of library services in promoting environmental literacy, emphasizing that libraries function not only as physical spaces but also as knowledge systems that can nurture sustainability mindsets. Their research highlighted the potential of information services to bridge gaps between scientific knowledge and public understanding of ecological issues. *Kumar and Kumar (2012)* focused

on Indian academic libraries and documented early efforts to incorporate digital resources and reduce dependence on paper through electronic journals and digital repositories.

American Library Association (2015): - The concept of *Green Library Standards* emerged prominently with the *American Library Association (ALA)* and *International Federation of Library Associations and Institutions (IFLA)* advocating frameworks for sustainable buildings and services (ALA, 2010; IFLA, 2015). These standards influenced new library construction projects worldwide, emphasizing indoor air quality, natural lighting, renewable energy, and sustainable site development.

Jones and Lund (2018): - More recent research by *Jones and Lund (2018)* explored the integration of digital sustainability, highlighting how the shift toward cloud-based services and digital archives reduces environmental impact. They also pointed out new issues, such as electronic waste and energy consumption of data centres. *Ahmed and Wong (2020)* studied the adoption of green libraries in Southeast Asia, noting that while awareness was increasing, tangible progress in infrastructure was uneven due to budget constraints and limited expertise.

Lee et al (2021): - A meta-analysis by *Lee et al. (2021)* identified key performance indicators for green libraries, such as energy use per square meter, paper use reduction, recycling rates, and user engagement metrics. They proposed a composite sustainability index to benchmark library performance. The literature consistently highlights the dual function of green libraries—as sustainable operations and as educators of sustainability.

Collectively, these studies demonstrate the evolution of the green library concept, shifting from basic eco-friendly practices to incorporated sustainability strategies. However, the literature also reveals persistent gaps in implementation, especially in developing regions where financial, technical, and policy barriers remain important.

OBJECTIVES

1. To study the concept and evolution of green libraries.
2. To analyse major advantages of adopting green library practices.
3. To explore current trends and progress in green libraries globally and regionally.
4. To examine ongoing issues in implementing green library initiatives.
5. To identify the forthcoming scope and potential strategies for enhancing green libraries.

STATEMENT OF THE PROBLEM

Public and academic libraries around the world traditionally operate under models that prioritize access to collections and services without explicit attention to environmental sustainability. Such models often result in high energy consumption, important paper use, inefficient waste management, and limited environmental advocacy. As environmental degradation escalates, there is an urgent need for libraries to adopt sustainable infrastructures and operations.

However, implementation of green practices is hindered by several issues: lack of awareness among library professionals, financial constraints that make eco-friendly technologies appear expensive, inadequate policy frameworks within library administrations, insufficient technical expertise, and issues associated with modifying existing traditional structures. This paper examines these multifaceted issues to provide a holistic understanding of the problem and offers insight into sustainable solutions.

BENEFITS OF GREEN LIBRARIES

Green libraries confer a wide range of environmental, economic, social, and educational advantages, which can be broadly categorized as follows:

1. **Environmental Conservation:** Green libraries importantly reduce ecological footprints by implementing energy-efficient lighting, solar power installations, rainwater harvesting, and sustainable landscaping. By reducing dependency on non-renewable energy and minimizing waste output, they contribute to global environmental preservation efforts.
2. **Resource Efficiency:** Use of sustainable building materials, water-saving systems, digital archives, and paperless services conserves natural resources. Digital catalogs, e-journals, and online databases reduce the need for physical paper and printing.
3. **Cost Savings:** Though initial setup costs may be high, long-term operational costs drop due to reduced energy bills, lower water consumption, and minimized material expenses. These savings can be reinvested in library services, collections, and outreach programs.
4. **Public Health and Comfort:** Green architecture promotes better indoor air quality through improved ventilation, non-toxic construction materials, and climate-responsive designs. This advantages both staff and patrons by creating healthier, more comfortable spaces.
5. **Educational Impact:** Green libraries serve as educational platforms for sustainability awareness. Exhibitions, environmental collections, workshops, and community programs help users (students, researchers, and public patrons) understand ecological issues and adopt responsible practices.
6. **Community Leadership:** Libraries adopting green practices often become function models within their communities, inspiring other institutions and organizations to pursue sustainability.
7. **Alignment with Development Goals:** Green libraries align with Sustainable Development Goals (SDGs), especially SDG 4 (Quality Education), SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action). They promote lifelong environmental learning while demonstrating practical sustainability.

CURRENT PROGRESS AND USAGE OF GREEN LIBRARIES

Global Trends

In recent years, the concept of green libraries has transitioned from experimental adoption to mainstream recognition. Libraries in North America, Europe, Australia, and parts of Asia are increasingly integrating sustainability into their core missions. Green building certification systems such as LEED (Leadership in Energy and Environmental Design) and BREEAM (Building Research Establishment Environmental Assessment Method) are widely used standards for evaluating eco-friendly design.

For example, the **Seattle Central Library (USA)** and **Vancouver Public Library (Canada)** have incorporated natural lighting, high-efficiency HVAC systems, and recycled materials in construction. These institutions serve as benchmarks for new library projects globally. In Europe, several public libraries operate zero-waste policies, advocate cycling to libraries through bike parking, and run community education programs on environmental topics.

The rise of digital platforms and open access collections has further accelerated sustainability. Many academic institutions have digitized archival collections, reducing paper usage and physical space requirements. Online reference services, virtual workshops, and e-learning modules have expanded the reach of library services without corresponding increases in resource consumption.

1. Institutional Frameworks and International Standards

International professional bodies are formalizing sustainability in libraries as a **core strategic priority**. The International Federation of Library Associations and Institutions (IFLA) is developing official **Guidelines for Green and Sustainable Libraries**, expected to publish in 2025. These guidelines aim to provide comprehensive frameworks for the **design, operation, evaluation, and advocacy** of sustainable library practices across diverse contexts—from municipal branches to university libraries and community centres. They

highlight alignment with the **UN Sustainable Development Goals (SDGs)** and target librarians, policymakers, designers, and facility managers worldwide.

2. Recognition and Scaling of Best Practices

The **IFLA Green Library Award** continues to spotlight excellence and innovation in sustainability. The 2025 results showcase libraries from Europe, Asia, North America and South-East Asia that demonstrate **incorporated environmental and social sustainability**—such as adaptive reuse of buildings, community-led education programs, circular economy initiatives, and measurable carbon reductions. For example, the Growth Library in Shenzhen (China) operates on high proportions of green energy and digital collections while serving millions through environmental programming. Similarly, Thammasat University Library (Thailand) models circular economy strategies that importantly reduce waste and greenhouse gas emissions.

The award's continuing call for submissions into 2026 highlights its function in broadening participation—encouraging libraries with **small budgets but high impact** to contribute innovations that can be adapted globally.

3. Expansion of Digital Sustainability Practices

Beyond physical infrastructure, **digital transformation** is now recognized as a core sustainability strategy. Digitisation of collections, expansion of open-access repositories, and virtual service delivery reduce dependency on physical materials and on-site infrastructure, lowering the environmental footprint while increasing accessibility. Digital reference services, virtual workshops, and e-learning platforms continue to expand the reach of libraries without corresponding increases in energy or resource use. These trends are supported by research and practice in library and information science as part of sustainable service design.

4. Community Education and Climate Action

Libraries are increasingly functioning as **education hubs** for environmental awareness and climate action. Initiatives go beyond traditional literacy to include **environmental education programming**, workshops on sustainable living, circular economy principles, community gardens, repair cafés, and collaborative sustainability networks. Such programs help libraries reposition themselves as active agents in local environmental stewardship and climate literacy, not just repositories of information.

5. Design Innovation and Architecture

New library designs increasingly incorporate sustainability not just as an add-on, but as a foundational architectural principle. Contemporary projects demonstrate creative blends of **natural light, passive ventilation, green space, renewable energy systems, and landscape integration**. Projects like the forthcoming *museumbrary* in Taichung, Taiwan, redefine cultural architecture by combining library, museum, and nature-incorporated public space in a single eco-responsive complex.

6. Metrics, Policy, and Evaluation Tools

Emerging trends also concentrate on **measuring sustainability performance**. Research calls for robust assessment frameworks to evaluate environmental, social, and economic outcomes of library practices, moving beyond simple energy savings to include impact on community behaviour, learning outcomes, and contribution to SDGs. Professional action plans, such as IFLA's Environment, Sustainability and Libraries Section (ENSULIB) Action Plan (2023–2025), provide strategic direction for advocacy, standards development, and performance tracking.

7. Social Sustainability and Equity

The latest discourse in green libraries is broadening to include **social equity, accessibility, and resilience**, recognizing that sustainability encompasses **environmental justice, digital inclusion, and community wellbeing**. Libraries are adopting policies that support equitable access to information, resources,

and sustainability education—especially in underserved communities where climate impacts and digital divides are most acute.

Regional Adoption

In Asia and Africa, the progress of green libraries has been uneven. Urban academic libraries in countries like Japan, South Korea, and Singapore are adopting eco-friendly infrastructure and digital transformation aggressively. However, in South and Southeast Asia, adoption is often limited to pilot projects due to budgetary and policy constraints.

A noteworthy trend is the integration of sustainability into library science curriculum in several universities. Institutions now include courses on environmental information services, green library management, and sustainable technology in LIS programs. This prepares forthcoming librarians to implement green practices systematically.

Digital and Operational Innovations

Contemporary green library practice also includes technological innovations. Libraries are adopting cloud-based incorporated library systems (ILS) that reduce local server energy consumption, implementing RFID systems that optimize circulation with minimal waste, and offering virtual reference to decrease unnecessary physical visits.

In addition, green procurement policies ensure that library purchases favor eco-friendly products: recycled paper, sustainable furniture, energy-star rated equipment, and biodegradable cleaning supplies. Many libraries have also implemented waste segregation and recycling programs, drastically reducing landfill contributions.

User Engagement and Community Programs

Green libraries have expanded beyond infrastructure to engage communities in environmental learning. Examples include:

- Earth Day exhibitions
- Book clubs focused on sustainability literature
- Workshops on composting, urban gardening, and renewable energy
- Collaborations with schools to promote environmental research

Such initiatives position libraries as knowledge hubs advocating sustainability in everyday life.

CHALLENGES OF GREEN LIBRARIES

Despite visible progress, green libraries face multifaceted issues that slow their widespread adoption:

1. High Initial Costs and Budget Constraints

The biggest challenge is financial. Eco-friendly construction, renewable energy installations (e.g., solar panels), smart building systems, and sustainable materials require important initial capital. Budget-limited public and community libraries often struggle to allocate funds without external grants or government support. For existing structures, retrofitting for energy efficiency is expensive and technically demanding.

2. Lack of Awareness and Professional Expertise

Many librarians and administrators lack formal training or awareness of green practices. While literature highlights sustainability, practical knowledge on implementation is limited in many regions. Without specialized expertise in green design, procurement, and operations, libraries remain dependent on external consultants, inflating costs.

3. Policy and Institutional Barriers

Green libraries require institutional policies that prioritize sustainability goals. However, many library governance structures lack comprehensive environmental policies. This causes fragmented, project-based adoption rather than systematic sustainability integration.

4. Cultural Resistance and Change Management

Staff and users accustomed to traditional routines may resist changes—such as reductions in printing, introduction of recycling protocols, or energy-saving measures. Cultural change within institutions is often slow and necessitates sustained training, incentives, and leadership support.

5. Technological Challenges

While digital transformation contributes to sustainability, it also introduces issues. Increased dependence on digital systems raises concerns about energy used by data centers, e-waste from obsolete hardware, and cybersecurity issues. Green libraries must balance digital adoption with responsible hardware lifecycles and energy management.

6. Measurement and Benchmarking Difficulties

Evaluating the sustainability performance of libraries is complex. Unlike buildings where energy usage can be quantified, measuring user engagement, environmental literacy outcomes, and behavioural change is qualitative and difficult to standardize. Absence of unified metrics hampers global benchmarking and comparative evaluations.

7. Equity and Access Concerns

Efforts to go paperless or encourage digital services must ensure equitable access. Not all users have reliable digital access or skills, and abrupt shifts to electronic services risk excluding vulnerable populations—unless inclusive strategies are implemented.

FUTURE SCOPE OF GREEN LIBRARIES

The forthcoming of green libraries is expansive, multidimensional, and strategically important for both the library profession and global sustainability movements.

Integration with Smart Technologies

Emerging smart technologies—IoT sensors, AI-driven energy management, and automated climate control—offer libraries opportunities to reduce energy usage and monitor environmental parameters in real time. Smart building systems can optimize lighting, temperature, and ventilation based on occupancy patterns.

Sustainability-Focused Curriculum and Research

Library and Information Science (LIS) programs should incorporate sustainability courses, preparing professionals with technical, managerial, and advocacy skills. Future research can explore environmental information behaviour, digital sustainability, and the function of libraries in climate communication.

Policy Advocacy and Institutional Frameworks

Green libraries can influence policy development within higher education institutions, municipal governments, and cultural networks. Drafting sustainability roadmaps, securing institutional commitments, and participating in inter-library sustainability networks will strengthen impact.

Global Collaboration and Knowledge Sharing

International consortia, such as IFLA and ALA, can expand collaborative platforms for sharing best practices, case studies, training modules, and certification programs. Peer-learning and global benchmarking will accelerate implementation.

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Expanding Community Engagement

Future green libraries can become hubs of community resilience by hosting environmental dialogues, citizen science projects, eco-entrepreneurship incubators, and urban sustainability labs. Partnerships with NGOs, universities, and local governments will expand reach and relevance.

Hybrid Models Balancing Digital and Physical Access

Libraries must continue balancing digital transformation with inclusive access. Hybrid service models—combining digital literacy training with community spaces that prioritize sustainability—can safeguard equitable access while reducing environmental impact.

CONCLUSION

Green libraries are not merely a trend; they represent a necessary evolution of library philosophy and practice in the age of environmental crisis. They incorporate sustainable infrastructure, digital transformation, user engagement, and policy frameworks to create institutions that are environmentally responsible, socially relevant, and economically efficient.

While advantages are substantial, issues remain important—particularly in terms of financial investment, professional expertise, policy integration, and cultural change. However, with growing global emphasis on sustainability, libraries have immense potential to lead by example, educate communities, and contribute to broader ecological goals. The forthcoming lies in hybrid models that leverage technology, policy support, community engagement, and inclusive practices to build libraries that are truly green—physically, digitally, socially, and ethically.

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Sustainability Initatives and Green Practices in Modern Libraries

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ABSTRACT

Energy efficiency forms the foundation of green library infrastructure. Traditional library buildings—often large and designed before the adoption of modern insulation and HVAC technologies—tend to consume significant amounts of energy. Green libraries respond to this challenge by adopting innovative and sustainable solutions, including high-performance insulation, double-glazed or low-emissivity windows, and energy-efficient lighting systems such as LEDs integrated with motion sensors and daylight-harvesting controls. Additionally, the incorporation of renewable energy sources, including rooftop solar panels and geothermal heating and cooling systems, significantly reduces dependence on fossil fuels, enabling libraries to achieve net-zero or even energy-positive performance. These measures not only lower carbon emissions but also result in considerable long-term operational cost savings, demonstrating the economic feasibility of green library practices. Beyond infrastructure, green libraries extend sustainability into their collections and services by curating resources on environmental studies, climate change, sustainable living, and ecological awareness. Through workshops, lectures, and sustainability-focused programs, libraries actively promote community engagement and environmental education.

***Keywords**:* Green Library, Energy Efficiency, Sustainable Infrastructure, HVAC Systems, Economic Viability.

INTRODUCTION

In an era marked by increasing environmental awareness and the pressing challenge of climate change, sustainability has become a central concern across all sectors of society, including libraries. No longer viewed merely as repositories of books, modern libraries have evolved into vibrant community hubs that reflect contemporary social values. Among these values, environmental sustainability has emerged as a defining priority, giving rise to the concept of *green library practices*. These practices represent libraries' growing commitment to environmental responsibility, social equity, and long-term economic viability.

Sustainability in the library context refers to meeting present informational and community needs without compromising the ability of future generations to meet theirs. This holistic approach encompasses environmental, social, and economic dimensions. For libraries, sustainability involves reducing their environmental footprint, promoting inclusive and equitable access to information, fostering community well-being, and ensuring operational and financial resilience. Green library practices translate these principles into action through initiatives such as energy efficiency, waste reduction, sustainable resource management, and the promotion of environmental literacy and responsible consumption.

One of the most visible and impactful dimensions of green library practices lies in physical infrastructure and daily operations. Energy conservation is a primary focus, with libraries increasingly adopting LED lighting, optimizing heating, ventilation, and air-conditioning (HVAC) systems, maximizing natural lighting and ventilation, and investing in renewable energy sources such as solar power. These measures not only reduce energy consumption and operational costs but also significantly lower greenhouse gas emissions, transforming libraries into practical models of sustainability (Khan, 2020).

Water conservation is another essential component of sustainable library infrastructure. Given their extensive use of restrooms, landscaped areas, and in some cases cafés, libraries can be substantial consumers of water. Such strategies support responsible water management, particularly in regions facing increasing water scarcity (Nandi, 2020).

Beyond infrastructure, sustainable library operations extend to effective waste management and responsible consumption. Libraries increasingly implement comprehensive recycling programs for paper, plastics, and electronic waste, while adopting digital-first policies to reduce reliance on physical materials. The use of eco-friendly furniture, non-toxic cleaning products, and sustainable supplies further contributes to healthier indoor environments. Many libraries have also embraced the sharing economy by offering tool libraries, seed libraries, and clothing exchanges, promoting resource sharing and reducing individual

consumption. Although digital resources may not always appear overtly "green," they contribute to sustainability by minimizing the production, transportation, and storage demands associated with physical materials (Kumar, 2020).

REVIEW OF LITERATURE

The existing body of literature highlights the multifaceted benefits of adopting sustainable and green library practices, emphasizing their environmental, social, and economic significance.

Aulisio et al. (2022) argue that green library initiatives contribute substantially to environmental protection by reducing carbon emissions, conserving natural resources, and minimizing waste generation. Beyond environmental gains, their study underscores the social impact of sustainability initiatives, noting that green libraries strengthen their role as community leaders by promoting environmental literacy, encouraging shared responsibility, and providing healthier and more welcoming spaces for users.

Bhattacharya et al. (2021) observe that although the implementation of green practices often requires initial financial investment, these initiatives frequently result in long-term cost savings. Reduced expenditure on energy and water consumption, coupled with increased eligibility for grants and external funding, can offset initial costs. Furthermore, the authors highlight that a visible commitment to sustainability enhances the public image, relevance, and societal value of libraries in an increasingly environmentally conscious world.

Wilson et al. (2021) identify budgetary limitations as a major barrier, particularly for smaller libraries with limited financial resources. Their research also emphasizes the importance of staff training and organizational culture shifts, which are essential for the successful adoption of sustainable practices. Additionally, the authors note that evaluating the effectiveness of certain green initiatives can be complex, requiring systematic data collection and analytical frameworks.

Divya et al. (2020) focus on the financial and structural demands associated with green library development. According to their study, converting existing libraries into green facilities often involves substantial capital investment for architectural redesign, installation of energy-efficient systems such as solar panels and smart lighting, and procurement of eco-friendly construction materials. Even the establishment of new green libraries requires significant upfront expenditure.

Shah et al. (2020) highlight structural and preservation-related challenges in older library buildings, many of which were not designed with sustainability principles in mind. Retrofitting such facilities can be both technically complex and costly. The authors draw attention to issues such as dust control, moisture regulation, and Mold prevention, which are critical for preserving library collections while maintaining environmentally responsible practices.

OBJECTIVES

1. To examine the concept of sustainability and green library practices in modern libraries.
2. To analyze the role of energy-efficient and eco-friendly infrastructure in reducing the environmental impact of libraries.
3. To highlight sustainable practices related to library collections, services, and resource management.
4. To study selected examples of green library initiatives in Indian libraries.
5. To assess the role of libraries in promoting environmental literacy and supporting the United Nations Sustainable Development Goals (SDGs).

METHODOLOGY

The present study is conceptual and descriptive in nature. It is based on an extensive review of secondary sources, including scholarly journal articles, conference proceedings, institutional reports, and published case studies related to green libraries and sustainability. Relevant literature was analyzed to identify key sustainability initiatives, challenges, and best practices adopted by modern libraries, with particular emphasis on Indian examples.

SUSTAINABILITY AND GREEN LIBRARY PRACTICES

Green library practices emphasize the thoughtful development of sustainable collections and services that minimize environmental impact while maximizing long-term value. This approach begins with a critical evaluation of physical resources. Libraries increasingly prioritize the acquisition of materials produced through ethical and environmentally responsible processes, including the use of recycled or sustainably sourced paper and reduced packaging. Greater emphasis is placed on durability and long-lasting materials to limit frequent replacements and resource consumption. Alongside physical collections, digital resources play a crucial role in sustainability efforts. The promotion of e-books, e-journals, online databases, and streaming services significantly reduces paper usage, transportation emissions, and the energy required for storage and shelving. Rather than eliminating print collections, green libraries adopt a balanced model in which digital access is encouraged for routine use, while physical materials are selectively curated for their lasting informational and cultural value.

Beyond format considerations, green libraries intentionally develop collections that address environmental themes. Resources on climate change, sustainable living, conservation, renewable energy, and eco-friendly technologies are curated to support environmental literacy. Through such collections, libraries empower users with knowledge that enables informed decision-making and responsible environmental behaviour.

Sustainability also extends to the delivery of library services. Eco-friendly service practices aim to reduce environmental impact while encouraging sustainable user behaviour. Paperless circulation systems, digital notifications, online renewals, and electronic receipts help minimize paper consumption. Libraries increasingly encourage the use of reusable bags and prioritize local or regional interlibrary loan networks to reduce transportation-related emissions. Public-access computers and library equipment are selected for energy efficiency, with power-saving settings and routine maintenance ensuring optimal performance. Waste reduction remains a core concern, supported by comprehensive recycling and composting programs throughout library premises. Water conservation initiatives—such as sensor-based faucets, low-flow fixtures, and rainwater harvesting for landscaping—further reinforce responsible resource management.

Green library services also emphasize community engagement and environmental education. As trusted community institutions, libraries are uniquely positioned to promote sustainability awareness. They host workshops on topics such as home gardening, composting, upcycling, and energy conservation, while reading groups and book clubs explore environmental literature to foster dialogue and critical thinking. Collaborations with local environmental organizations facilitate joint programs, awareness campaigns, and community activities. Informational displays on local sustainability initiatives, access to environmental assessment tools, and promotion of public transportation options further integrate libraries into broader sustainability movements.

Operational practices within library infrastructure play a significant role in reinforcing green objectives. Effective waste management systems extend beyond basic recycling to include electronic waste, batteries, and organic waste composting. Libraries actively work to reduce waste generation by promoting reusable materials and prioritizing digital communication over printed materials. Such practices not only divert waste from landfills but also conserve natural resources and reduce pollution.

The benefits of integrating sustainability into library collections and services are extensive. Environmentally, these practices reduce carbon emissions, conserve resources, and limit waste production. Economically, improved energy efficiency, reduced material consumption, and optimized resource management contribute to long-term cost savings. Socially, green libraries create healthier indoor environments, strengthen community leadership, and empower users with the knowledge and tools needed to support sustainable development. By embedding environmental stewardship into everyday operations, libraries serve as visible models of institutional responsibility and inspire broader societal change.

In conclusion, while the vision of green libraries is both compelling and essential for a sustainable future, its realization requires overcoming financial, infrastructural, technological, and educational challenges. A truly green library extends beyond environmentally efficient buildings; it is an institution in which sustainability is embedded in collections, services, operations, and community engagement. Through the careful integration of

eco-conscious practices, libraries can become powerful agents of environmental stewardship and contribute meaningfully to a greener future for generations to come.

DISCUSSION

Green library practices in India are increasingly reflected through notable institutional examples that demonstrate how sustainability can be effectively integrated into library infrastructure, operations, and services. Among these, the **Anna Centenary Library (ACL), Chennai**, stands out as a landmark model of sustainable library development. Established in 2010, ACL is recognized as **Asia's first LEED Gold–rated library building**, certified by the Indian Green Building Council (IGBC). Its design and operations exemplify how large public libraries can significantly reduce their environmental footprint while serving as centres of learning and environmental awareness.

The architectural design of the Anna Centenary Library, conceptualized by C. R. Narayana Rao, incorporates advanced passive design strategies to minimize energy consumption. Extensive use of natural daylight through large windows and a seven-storey atrium reduces dependence on artificial lighting. Strategic orientation of the building—maximizing north and east-facing windows while using thermal buffer zones and sloped glass walls on the southwest—helps mitigate heat gain. Additional features such as roof overhangs, pergolas, metal louvers, thermal insulation glazing, and green roofs contribute to maintaining indoor comfort with reduced reliance on air conditioning.

Water conservation is another defining feature of the ACL's sustainability framework. The library employs an efficient rainwater harvesting system, including sumps and percolation pits, to recharge groundwater and supply water for landscaping and toilet flushing. An on-site sewage treatment plant enables the reuse of treated wastewater, significantly reducing the demand for potable water. The integration of drip and sprinkler irrigation systems, along with water-efficient fixtures, has resulted in an estimated **64% reduction in water consumption** compared to conventional buildings.

Energy efficiency measures further strengthen the ACL's green credentials. The library utilizes LED and CFL lighting, energy-efficient motors, pumps, and fans, as well as automated systems for monitoring and controlling lighting and ventilation. These initiatives have led to approximately **17.5% lower energy consumption** than comparable conventional buildings. The application of high-albedo paints on terraces and the inclusion of green roofs help mitigate the urban heat island effect, enhancing overall energy performance.

Material selection during construction also reflects a strong commitment to sustainability. Nearly **77% of construction materials were sourced locally**, reducing transportation-related emissions and supporting the regional economy. Recycled materials accounted for about **12% of the total material cost**, and approximately **75% of construction waste** was reused or recycled. Indoor environmental quality is ensured through the use of low-VOC paints, CRI-certified carpets, and materials free from urea formaldehyde, creating a healthier environment for both users and staff.

Another important example is the **Karnataka University Library, Dharwad**, an institution functioning since 1950. Although not originally designed as a green library, it has embraced sustainability principles by providing open green study spaces with Wi-Fi connectivity. This approach blends modern technology with nature, creating a learning environment reminiscent of traditional Gurukul systems. The emphasis on natural ventilation, outdoor study areas, and reduced dependence on enclosed, air-conditioned spaces contributes to energy efficiency and user well-being.

Karnataka University has demonstrated growing awareness of environmental responsibility through broader campus-level initiatives related to waste management, energy conservation, and eco-friendly practices. These efforts provide a strong foundation for developing a comprehensive green library strategy. Further enhancements could include the installation of solar power systems, optimization of daylighting and ventilation, adoption of sustainable construction materials, rainwater harvesting, and the use of low-VOC interior finishes. Implementing smart energy management systems, conducting regular energy audits, and expanding LED lighting usage could significantly reduce the library's carbon footprint.

In addition to infrastructure, sustainable collection development and service delivery are essential. Expanding access to e-books, e-journals, and online resources can reduce paper consumption, while curated

collections on environmental sustainability can strengthen environmental literacy. Libraries can also serve as hubs for sustainability education by organizing workshops, seminars, exhibitions, and awareness campaigns on green living and climate responsibility. Partnerships with environmental organizations, student groups, and local authorities can further extend the library's impact beyond campus boundaries.

Several historic Indian libraries, such as the **University of Mumbai Library** and the **University of Madras Library**, illustrate how existing structures can adopt environmentally friendly practices without complete redesign. Their use of natural ventilation, abundant daylight through large windows, and traditional building materials like wood demonstrates that heritage buildings can contribute meaningfully to sustainability when managed thoughtfully and responsibly.

Overall, the Indian experience shows that green library practices can be implemented across diverse institutional contexts—from newly constructed, purpose-built facilities to historic libraries and older academic institutions. While the path toward fully integrated green libraries requires sustained investment, strategic planning, and collective commitment, these examples demonstrate that libraries can play a vital role in advancing environmental sustainability. By embedding green principles into infrastructure, operations, collections, and community engagement, libraries can emerge as leaders in sustainable development and inspire environmentally responsible behaviour among present and future generations.

CONCLUSION

Sustainability and green library practices have become essential components of contemporary library management. By adopting energy-efficient infrastructure, responsible resource management, sustainable collections, and environmentally focused services, libraries can significantly reduce their environmental impact while strengthening their educational and social roles.

Green libraries serve not only as centers of information but also as visible models of environmental stewardship. Through community engagement and environmental education, libraries inspire sustainable behavior and contribute to broader societal change. Although financial, infrastructural, and organizational challenges remain, a long-term commitment to sustainability can enable libraries to play a pivotal role in achieving sustainable development goals and building environmentally responsible communities.

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Sustainability and Green Libraries: A Literature Review on Eco-friendly Practices, SDGs, and Paperless Libraries

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Abstract

Sustainability has emerged as a key concern for libraries in the digital era. Libraries are increasingly adopting green practices to reduce environmental impact, support sustainable development goals (SDGs), and promote paperless information services. This paper presents a literature review on sustainability and green libraries, focusing on eco-friendly infrastructure, alignment with SDGs, and the transition toward paperless libraries. By reviewing scholarly literature published in reputed databases, the study highlights major trends, practices, and challenges related to sustainable library development. The review emphasizes the evolving role of libraries as environmentally responsible and socially sustainable institutions.

Keywords: Green Libraries, Sustainability, SDGs, Eco-friendly Libraries, Paperless Libraries

Introduction

Environmental sustainability has become a global priority due to climate change, resource depletion, and increasing environmental awareness. Libraries, as public and academic knowledge institutions, are expected to adopt sustainable practices and promote environmental responsibility. The concept of green libraries integrates eco-friendly infrastructure, sustainable resource management, and digital services to minimize environmental impact. In recent years, sustainability in libraries has also been closely linked with the United Nations Sustainable Development Goals (SDGs), positioning libraries as contributors to sustainable education and development.

Objectives of the Study

1. To describe the concept of sustainability and green libraries.
2. To outline eco-friendly practices adopted by libraries.
3. To examine the role of libraries in supporting the Sustainable Development Goals.
4. To describe the significance of paperless libraries in sustainable development.

Research Methodology

This study adopts a descriptive literature review methodology. Scholarly articles, research papers, and reports related to sustainability and green libraries were collected from databases such as Web of Science, Scopus, Google Scholar, and institutional repositories. Literature focusing on eco-friendly practices, SDGs, and paperless library initiatives was analyzed thematically to identify major trends and challenges.

Concept of Sustainability and Green Libraries

A green library is designed and operated in an environmentally responsible manner by conserving energy, reducing waste, and promoting sustainable practices. Sustainability in libraries includes green building design, efficient use of resources, environmentally friendly policies, and awareness programs. The literature indicates that green libraries not only reduce carbon footprints but also serve as models of sustainability for users and communities.

Eco-friendly Practices in Libraries

Several studies highlight eco-friendly practices adopted by libraries, such as energy-efficient lighting, use of renewable energy, rainwater harvesting, recycling programs, and green building standards. Academic libraries, in particular, have implemented sustainable infrastructure as part of institutional sustainability initiatives. These practices contribute to reduced operational costs and long-term environmental benefits while improving the indoor environment for users

Libraries and Sustainable Development Goals (SDGs)

The role of libraries in achieving SDGs has been widely discussed in the literature. Libraries support SDG 4 (Quality Education) by providing inclusive access to information, SDG 12 (Responsible Consumption and Production) through sustainable resource use, and SDG 13 (Climate Action) by promoting environmental

awareness. International library organizations emphasize that libraries can act as local hubs for sustainable development by supporting education, research, and community engagement related to sustainability.

Paperless Libraries and Digital Sustainability

The transition toward paperless libraries is considered a major step toward sustainability. Digital libraries, e-resources, institutional repositories, and online services significantly reduce paper consumption. Literature suggests that paperless initiatives improve access, efficiency, and space utilization. However, studies also note challenges such as digital infrastructure costs, energy consumption, and the need for digital literacy. Despite these challenges, paperless libraries are widely viewed as essential for sustainable library services.

Challenges in Implementing Green Library Practices

The literature identifies several challenges in implementing sustainable library practices, including limited funding, lack of awareness, inadequate infrastructure, and resistance to change. In developing regions, financial and technological constraints pose significant barriers. Additionally, balancing digital expansion with environmental sustainability remains a concern for libraries.

Future Directions

Future research emphasizes the need for integrated sustainability policies, green library standards, and continuous staff training. Libraries are encouraged to adopt measurable sustainability indicators and collaborate with educational institutions and government bodies. Strengthening digital services while ensuring environmental responsibility will remain a key focus area.

Conclusion

Sustainability and green libraries represent an important shift in library philosophy and practice. The literature demonstrates that eco-friendly infrastructure, alignment with SDGs, and paperless initiatives collectively contribute to sustainable library development. By adopting green practices and promoting sustainability awareness, libraries can play a vital role in supporting environmental and social development.

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A Review on Green Synthesis of Zirconia-Based Nanoparticle and it's Biomedical Applications

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ABTRACT

Zirconia (ZrO_2) nanoparticles (NPs) are widely studied and utilized due to their unique properties. It has high stability and lower chemical activity compared to other metals. Generally, hazardous chemical material, such as reducing agent or stabilizing agent is typically in green synthesis is to convert metal ions into neutral nanoparticle. In the last decades, green synthesis methods have been used for the preparation of metal nanoparticles. The synthesis of zirconia nanoparticles depends on natural biomolecules that present in plants, like polyphenols, alkaloids phenol acids, terpenoids, protein, enzymes. Green synthesis method is simple method, low-cost, non-toxic, environmentally friendly. In the present review, the green synthesis of Zirconia based nanoparticle using different plants and plant parts in the synthesis process were described. Moreover, it also describes biomedical application of zirconia based nanoparticles such as, anti-microbial, anti-oxidant, anti-cancer, anti-inflammatory, anti-diabetic activity and other different application.

***Keywords**:* Zirconia nanoparticle, green synthesis, anti-microbial activity, anti-oxidant activity, anti-cancer activity, anti-inflammatory activity, anti-diabetic activity.

INTRODUCTION

Nowadays, Nanotechnology is one of the most important technology which emerge as advanced diagnostics method in biomedical field [1]. It has gained significant interest from health and medical researchers. Nano-medicines have rapidly and broadly impacted in health care by opening many possibilities across various industrial and scientific endeavors [2]. The material of nanoscale size 10^{-9} m or one billionth [3]. It has widely used in pharmaceutical, agricultural, cosmetics, electronics, textile and food industries, etc. Various chemical, physical, biological processes using the nano-sized particles can be produced in different of shapes, including spherical, triangular, rod-shaped configurations with various size and structure [4-5].

The shape, size, particle distribution and potential uses of the nanoparticle have unique and remarkable properties that have found their way to various facts of biotechnology and biomedical science [6]. Organic and inorganic nanoparticles such as Ti, Zn, Mn, Mg, Ag etc, show to be promising material for various bioactive uses [7].

Green synthesis of nanoparticles using extract from various plant parts such as leaf, flower, root is one of the environmentally friendly method. Bio molecules contain polyphenols, alkaloids, phenolic acids and terpenoids found in plant extract have the ability to oxidize or reduce metal ions and stabilize nanoparticles [8]. Metal and metal oxide nanoparticles can be prepared using fungi, enzymes, plant extract and microorganisms. Moreover it is cost-effective and environmentally friendly for the preparation of nanoparticles [9].

Enzymes, vitamins, amino acids and carbohydrates are the constituents of plant extracts that can be utilized as reducing and stabilizing agent to prepare metal ions [10]. Nanoparticles synthesized by chemical method is harmful to environment also for human health, whereas the green synthesis which is harmless. The approach of employing a chemical method is costly therefore, there is need to focus on other less expensive ways of nanoparticle synthesis [11]. The present review, focus on green synthesis of zirconia-based nanoparticles and its biomedical applications.

METAL NANOPARTICLE

ZIRCONIA NANOPARTICLE

Zirconium oxide (ZrO_2) also referred to as a zirconia, its excellent physicochemical characteristics such as, surface stability, biocompatibility, oxidation resistance, anti-corrosion, high-temperature durability,

controllable porosity, electrical resistance and high ionic conductivity [12]. Zirconia (ZrO_2) exists in three crystallographic phases: monoclinic, tetragonal, and cubic. The monoclinic phase is stable below 1100 °C, the tetragonal phase is stable between 1100 °C and 2370 °C, and the cubic phase becomes stable above 2370 °C [13]. ZrO_2 NPs posses unique properties, such as high dielectric constant, low electrical conductivity, wide band gap low melting point and high stability which is synthesized by various methods such as sol-gel synthesis, co-precipited, green synthesis and hydrothermal, among that green synthesis method is reported because of its eco-friendly nature and low toxicity. Here the plant extract is employed as reducing agent for the production and assembly of ZrO_2 NPs [14, 15]. A multifunctional element and can be used in many applications due to its antimicrobial, anti-fungal and anticancer Activities. The ZrO_2 NPs showed the *in-vitro* toxicity against different cancer cell [16].

GREEN SYNTHESIS OF ZIRCONIA NPs

According to the Wafaa faad tharp et al., Synthesis of ZrO_2 NPs by *Thymus Vulgaris*. Gardually, $Zr(SO_4)_2$ and theyme extract, along with NaOH were added drop by drop to adjust the pH to 12, after centrifuge, drying, calcinated for 5hr at 600^0 C and ZrO_2 nanoparticles were obtained [17].

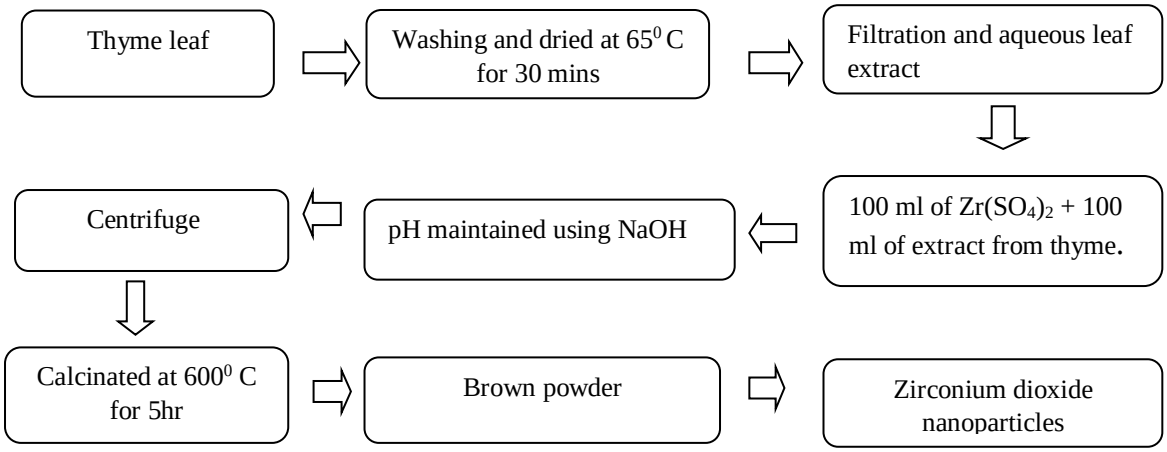


Figure 1 Flow chart for the green synthesis of zirconium dioxide nanoparticles.

Similarly, Veerabhadraswamy et al., [18] Synthesis ZrO_2 NPs using the cinnamon extract and citric acid. The plant extract mixed with and Zirconyl Nitrate the pH was adjusted to 14 using NaOH, after centrifuge, drying, and calcinated for 450^0 C, ZrO_2 NPs were obtained. Figure1 shows the Flowchart describing the procedure followed in production of zirconium dioxide nanoparticles by green synthesis method.

Various plant extract such as *Sophora flavesces, Punica granatum, Alocasia indica*, *Sonchu asper, Bougainvillea gla*, etc., were used to synthesis zirconium nanoparticles. *Azasirachita indiaca* and *Punica granatum* were found to be effective against a microbes like *Bacillis subtilis, staphylococcus Aureus, Escherichia coli, klebsiella pneumonia* and *aspergillus niger.* Table 1 exhibit the various applications of ZrO_2 NPs synthesized from different plant parts.

Material	**Plant**	**Plant part**	**Shape**	**Size**	**Microbes**	**Application**	**Ref**
	Sophora flavesces	Root	Tetragonal crystal structures	8 nm	-	Anticancer	[19]
	Punica granatum	Fruit peel	-	20-60 nm	*Bacillis subtilis, Staphylococcus*	Antimicrobial Activity	[20]

					Aureus, Escherichia coli and klebsiella pneumonia, Aspergillus niger	Antioxidant activity	
Zirconia	*Alocasia indica*	Leaf	-	-	*Bacillis subtilis, Staphylococcus Aureus, Escherichia coli and Klebsiella pneumonia*	Antimicrobial activity	[21]
	Sonchu asper	Leaf	-	11.94 nm	*Staphylococcus aureus, streptococcus mutans, Escherichia coli, Psudomons aeruginosa*	Antioxidant activity, Antibacterial activity Cytotoxic Photocatalytic application	[22]
Chitosan coated zirconia	*Bougainvillea gla*	Leaf	-	-	*S.aureus and B. subtilis E.coli and P.aeruginosa*	Antibacterial Activity, anticancer	[23]
Zirconia	*Azasirachita indiaca*	Leaf	Spherical	12 nm	*S.aureus and B. subtilis E.coli and P.aeruginosa*	Antimicrobial activity Photocatalysis	[24]
	Hemidesmismus indicus	Root	Spherical	20-120 nm	*S.aureus and B. subtilis E.coli and P.aeruginosa*	Antibacterial activity, antioxidant activity, Hemolytic assay	[25]
	Curcuma Longa	Leaf	Tetragonal	34.55 nm	-	-	[26]
	Ginger garlic	Root	-	-	*S.aureus and B. subtilis E.coli and P.aeruginosa*	Antimicrobial activity Anti-biofilms Dentel application etc.	[27]
	Pericup	Fruit	Tetragonal	5 nm	-	Photocatalysis	[28]
	Pseudomonas aeruginosa	bacteria	Tetragonal	6.45 nm	-	Waste water treatment	[29]
	Phyllan husiruri	Leaf	Spherical	121.5 nm	*S.aureus and B. subtilis E.coli and P.aeruginosa*	Antimicrobial activity & Photocatalysis	[30]

Table 1 The various application of ZrO_2 NPs synthesized from different plants parts.

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BIO MEDICAL APPLICATIONS

ANTIMICROBIAL ACTIVITY OF ZIRCONIA NPS

Microorganisms includes *Bacillus Subtilis, Escherichia Coli, Staphylococcus , Candida Albicans, Aspergillus Flavus, Aspergillus Niger, Penicillium, Botrytis cinerea were used* . Gram-positive strains were shown to possess greater antimicrobial efficiency when compared to Gram-negative ones [31].

Ali, A. T., et al., Synthesis of ZrO_2 NPs using *Punica Granatum extract* showed a antibacterial activity of against *E.coli and S. aureus* at concentration of 25, 50 and 75 mg/ml. The inhibition zones increased with concentration, showing 4-15 mm for *E. coli* and 5-13 mm for *S.aureus* confirm their dose-dependent antibacterial activity [32]. Pandin et al., Synthesis ZrO_2 NPs showed the moderate antimicrobial activity against the gram- positive (*Streptococcus mutans and Enterococcus faecalis*), with the larger of zone inhibition observed at 100 mg/ml, MIC_{50} value were 11.4 mg/ml for *S. mutans* and 22.8 mg/ml for *E. faecalis* while MIC_{90} was ≥22.8 mg/mL for both strains, indicative of a concentration-dependent antimicrobial effect [33]. Similarly, Raja Kaliyaperumal et al., Synthesis ZrO_2 NPS and Ag-doped ZrO_2 nanocomposites using the well diffusion method against *S. aureus, E. coli,* Ag-doped ZrO_2 (10%) showed higher activity, particularly against *S. aureus* (14 ± 1.4 mm), compared to *E. coli* (12.5 ± 0.7 mm), because plasma membrane present behind their outer wall, as The addition of silver to Zirconia has found to be improved the biocidal nature of Ag/ZrO2 and enrichment in the specific surface area than that of Zirconia [34].

Naveen Chandra joshi et al., Synthesis ZrO_2 NPs using *Tinospora Cordigolia(Giloy)* showed antibacterial activity against *B.subtilis, P.aeruginosa, E.coli and S.mutans* concentration of 5-15mg/ml, the inhibition zone increased with highest of 36 mm for *B. subtills* and 34 mm for *E.coli* confirm their dose-dependent antibacterial effect [35]. CM, Padma et al., Synthesis ZrO_2 NPs Showed strong antibacterial activity, compared to Amikacin, t- ZrO_2 NPs exhibited zones of inhibition 27 mm for *B.cereus,* 28 mm for *S.cureus,* 26 mm for *E. coli* and 25 mm for *P. aeruginosa* indicating higher antibacterial potential due to it high surface area and reactive oxygen species generation [36].

Rana, et al., Studied one-step green synthesis of ZrO_2 NPs using the *lichen.* ZrO2 nanoparticle exhibits 18 mm of better inhibition for *staphylococcus aureus* while, 9 mm low density was record for *E.coli* [37]. Jeba, R., et al., Prepared Fe doped ZrO_2 using co-precipitate method. Pure ZrO_2 show strong antibacterial activity with a 28 mm zone of inhibition against both Gram-positive and Gram-negative bacteria. When doped with iron, the antibacterial effect increased with higher doping levels. The largest inhibition zone observed for iron-doped ZrO_2 was around 24 mm for both bacterial types [38].

Similarly, Pushpalatha et, al., Prepared the green synthesis of cellulose/ZrO_2 nanocomposite which is exhibited strong antibacterial activity against *S. typhimurium* and *B. cereus* [39]. This Antimicrobial study of different nanocomposites shows the better result in inhibition of zones.

ANTIOXIDANT ACTIVITY OF ZIRCONIA NPS

Oxidative stress is controlled by effective antioxidants protect that the body has including enzymatic and non-enzymatic strategies. The enzymatic strategies, such as glutathione peroxides, superoxide dismutase, catalyses and non-enzymatic defenses. For example, vitamins A, C, and E, carotenoids, phenols, natural flavonoids and other antioxidant compounds [40]. Evaluate the efficacy of natural antioxidants, encompassing assays, employed to numerous methods are given below

- Ferric reducing antioxidant power assay ,
- β-carotene/linoleic acid assay,
- Ranchman method,
- Inhibition of low-density lipoprotein oxidation ,
- DPPH (2,2-diphenyl-1-picrylhydrazyl) assay [41].

Haq, S., Afsar et.al., Prepared ZnO-ZrO_2 heterojunction, where the *rubber leaves* showed strong antioxidant activity in a dose dependant manner against ABTs free radicals. It shows high antioxidant activity against *ABT free radicals.* Its Lower IC 50 value (149.20 ug/ml) compared to ascorbic acid (171.04 ug/ml),

indicates higher antioxidant performance which compared to the ascorbic acid [42]. Tran T. V.et.al., Prepared ZrO_2 NPs using aqueous extracts of agro-waste durva grass shows promising antioxidant activity, assessed through the DPPH scavenging assay. Although the activity was lower than that of the standard ascorbic acid, the ZrO_2 nanoparticles showed higher antioxidant potential compared to the durva grass extract alone [43].

Kathirvel, A., Srinivasan, R. et.al., prepared ZrO_2 NPs using aqueous leaf extract of *toddalia asiatica* showing antioxidant activity against various free radical (*DPPH, hydroxyl radical, hydrogen peroxide radical, FRAP*). Particularly it has high Scavenging efficiency against hydroxyl radicals IC 50 value 11.77 compared to standard antioxidant like ascorbic acid and BHA. Moderate activity was observed in the FRAP. Overall, the results of ZrO_2 Nps are promising material for antioxidant activity [44].

The Sn-ZrO_2 NPs using *musa paradisiacal* (*banana)* peel extract were treated against *free radical scavenging, DPPH and ABTS assays* which exhibits the better activity. Sn-ZrO_2 nanocomposite showed higher *radical scavenging activity* than ZrO_2. At larger concentrations, the green-synthesized Sn-ZrO_2 nanocomposites confirmed stronger activity in blocking the *ABTS radical* than ZrO_2 nanoparticles [45].

Similarly, CeO_2/ZrO_2 nanocomposite using biogenic route utilizing *citrus limonium (lemon juice)* which shows antioxidant activity 83% of *DPPH radical scavenging activity* and 88% of *superoxide anion free radical scavenging activity* [46]. Zr-doped WO_3 nanoparticles synthesized via green approach from *moringa plants*. These nanoparticles showed better antioxidant activity up to 85 % for *free radical scavenging* [47]. Few antioxidant activity of ZrO_2Nps are summarized in Table 2.

Material	**Plant**	**Assay**	**Antioxidant activity**	**Reference**
Fe_3O_4 stabilized ZrO_2 nanoparticles	-	*DPPH*	76%	[48]
ZrO_2	*Moringa oleifera* leaves	*DPPH*	69%	[49]
ZrO_2 –RGO nanocomposite	-	*DPPH*	82%	[50]
(Ag/ZrO-NPs)	*Sargassum tenerrimum*	*DPPH*	89%	[51]
Zr doped SnO2 composite	*Pongamia pinnata leaf*	*DPPH*	94%	[52]
ZrO_2/NiO/RGO ternary Composite	-	*DPPH*	97%	[53]
Fe3O4 stabilized ZrO2 nanoparticles	-	*DPPH*	83%	[54]
PEG-coated $Ce_{0.5}Zr_{0.5}O_2$	-	*DPPH*	60%	[55]
CeO_2/ZrO_2 nanocomposite	*Citrus limonium (lemon juice)*	*DPPH SAO2*	83%88%	[56]
ZrO_2	*Agro-waste durva grass*	*DPPH*	95%	[57]

Table 2. Antioxidant activity of ZrO_2 NPs.

ANTICANCER ACTIVITY OF ZIRCONIA NPs

Cancer is the second leading cause of death globally and has remained one of the most dangerous diseases ever. It is estimated that in 2020 there were around 10.0 million cancer-related deaths and 19.3 million

new cases of cancer. In the past, cancer was treated with chemotherapy without knowing the specific target which was a protein or enzyme for which cancerous growths resulted in over activity and inhibition of whole families of enzymes or receptors resulted in large-scale toxicity and side effects. Miniaturized devices and advanced imaging techniques for cancer diagnosis enable high-definition visualization of the internal workings of the human body. Nanotechnology for cancer treatment can be essential to improve health [58, 59].

Bimetallic oxide nanoparticles ZnO- ZrO_2 demonstrated no notable cytotoxic effects on human peripheral blood mononuclear cells after 24, 48, and 72 hours. Cell viability stayed above 89% across all concentrations, compared to the control group, which maintained a 100% viability rate. These findings suggest that ZnO-ZrO_2 NPs mixtures are biocompatible, with cell viability remaining largely stable regardless of concentration [60].

The Green synthesis of ZrO_2 NPs using *lemon/and lemon peel against* the MCF-7 breast cancer cell line was exposed to five groups of solutions with different concentrations to evaluate their anticancer activity. A significant synergistic effect was noted between the nanoparticles and the plant extract. The highest inhibition percentage, 95.16%, was recorded with the combination of nanoparticles and peel extract at 300 µg/ml. In contrast, the lowest inhibition, 18.42%, occurred with 25 µg/ml of nanoparticles alone [61].

Synthesis of ZrO_2/Reducing Grapine Oxide (rGO) using *Andrographis paniculata*. The highest effect was seen at higher concentrations of ZrO_2/rGO nanocomposites (NCs), which show considerable dose-dependent cytotoxicity against A549 and HCT116 cancer cell lines Compared to A549 cells, HCT116 cells were less viable and more sensitive. On the other hand, the nanocomposites showed good biocompatibility with regular hMSCs, showing little toxicity. According to these results, ZrO_2/rGO NCs show promise as targeted anticancer therapies. The anticancer activity of ZrO_2/rGO, which have been tested on two *human cancer cell line (A549 and HCT116)* and with one *normal human cell line (hMSC*) [62].

The synthesis of ZrO_2 nanoparticle exhibits good cytotoxicity activity and anticancer activity against *human breast cancer cell line* [63]. Bimetallic nanoparticles such as TeZr, TeSe and TeSe synthesized using *cinnamomum camphora* showed effective cytotoxicity against *the MCF7 cell line* while SeZr against to *the skin cancer cell lines*. Also, SeZr BNPs shows *cytotoxic activity* at MIC of 38.9µg/ml higher than TeSe but, lower than TeSe, TeZr satisfies the biocompability and anticancer activity [64]. Few anticancer activity of ZrO_2 and their nanocomposite are tabulated in Table 3.

Materials	**Plant**	**Cell line**	**Anticancer activity**	**Reference**
ZrO_2 doped ZnO/rGO nanocomposite	*Ginger*	*Human lung cancer (A549) and Breast cancer (MCF7) cells*	-	[65]
Zr_3O and chitosan (ch) coated zirconium oxide	*Bougainvillea glabra (B. glabra)*	*colon cancer HCT116 cells*	93%	[66]
Zirconium (ZrO_2)	-	*Normal fibroblast cells, Chang liver cells, and MCF-7 breast cancer cells*	-	[67]
. Fe_2O_3/ZnO/ZrO_2 NCs		*CaCo-2 cells*	-	[68]
Zr doped hydroxyapatite (HAp-Zr) nanoparticles	-	*Lung cancer cell*	-	[69]

Zirconium dioxide	*Passiflora edulis*	*HT29 cell line*	96%	[70]
Polyaniline/ZrO_2-Ag		*Breast cancer cell line (MCF-7)*	-	[71]
CuO/ZrO_2/TiO_2/RGO nanocomposites	-	*Breast cancer cell line (MCF-7)*	-	[72]
Ag/Cu-ZrO_2		*SH-SY5Y cell line*	74%	[73]

Table 3. Anticancer activity of ZrO_2 and their nanocomposite.

ANTI-INFLAMMATORY ACTIVITY OF ZIRCONIA NPs

Inflammation process act as a defense against a variety of chemicals, immune responses, poisons, pathogens and poisons. Immune system produced by the activation of white blood cell and release of chemical characteristic of inflammatory response. Pro-inflammatory cytokines such as, *IL-1, IL-12, IL-6, IL-18, TNF, INF-γ,* and *granulocyte-macrophage colony (GMS-CF*) are stimulating factors. Pro-inflammatory cytokines, adhesion molecules, chemokines, growth factors, and inducible enzymes such as *COX-2* and *iNOS*, which are known to be stimulating the production of pro-inflammatory mediated are belong to the genes whose activity is controlled from the nuclear factor – k beta (NF-kb) [74].

Synthesized Zirconium oxide and titanium oxide nanoparticle using *Asperillus flavus* and assessed their anti-inflammatory activity using albumin denaturation method. The nanoparticle exhibit maximum concentration of 100ug/ml for highest anti-inflammatory activity, while low concentration of 20ug/ml reduces anti-inflammatory activity. The high concentration nanoparticles are more effective in preventing the protein [75].

Sulfated magnesium zirconate synthesized by catalytic synthetic performed anti-inflammatory activity using bovine and egg albumin denaturation assays. It showed better inhibition of protein denaturation than the standard Diclofenac sodium. It exhibited the highest inhibition (84.25%) in the bovine albumin assay while showed strong activity (80.14%) in the egg albumin assay. IC_{50} values ranged between 26–29 μg/mL, indicating promising anti-inflammatory potential [*76*].

Green synthesis of ZrO_2 NPs *propolis* extract and *ciprofloxaein (*CIP) shows strong anti- inflammatory effects of 94% and the effective in catalyzing the reduction of nitrophenol [77]. These activities in zirconium based material such as nanoparticles, nanocomposite, Zr doped materials exhibits better result when treated against the various *serum albumin assay*.

ANTI-DIABETIC ACTIVITY OF ZIRCONIA NPs

A widely recognized disease that affects humans global is diabetes. It is defined via hyperglycemia, which is often carried on by cells partially sensitive to insulin reaction or by a pancreatic defect in insulin production [78]. CeO_2/ZrO_2 nanocomposite prepared by *citrus limonium* which exhibit better anti-diabetic activity. 89 % Inhibition of α-amylase showed the anti-diabetic activity and concentration of 950 μg/mL has 86% inhibition of *α-glucosidase*, which enhanced than the individual nanoparticle [79]. The synthesized Fe_2O_3/ ZrO_2 nano-catalyst using *ficus benghlensis* leaf report on anti-diabetic activity of IC 50 value is 49.72±0.8 ug/ml [80].

Gd_2O_3 and Nd_2O_3 ZrO_2 nanoparticle prepared by hydrothermal method which exhibit anti-diabetic activity with 76% of *α-amylase* inhibition of activity [81]. *Rhizome* extract of *corallocarpues epigeus* used to synthesis ZrO_2 /CuO-ZnO shows 75% of *α-amylase* inhibition activity, at the same time as ZrO_2 nanoparticle showed 57% of anti-diabetic activity [82]. There are few reports on anti-diabetic activity of ZrO_2 nanoparticles, these nanoparticles based researches can be improved in future development.

OTHER APPLICATION OF ZIRCONIA NPs

As Zirconia nanoparticle have several application in different field, which includes dental, fuel cell, supercapacitor, bone implants, gas sensor, and photocatalytic application. The *Asphodelus fistulosus* plant extract used to synthesize ZrO_2 NPs. These exhibits excellent photocatalytic activity with in 75 min [83]. Another report on the Green synthesis of ZrFeO nanoparticles by *fig* leaf extract are used as cathode material in PEM fuel cell. The catalyst retention after 250 cycles is 29% for Pt–FeO/C, 60% for 1 wt% Zr-doped Pt–ZrFeO/C, 93% for 5 wt% Zr-doped Pt–ZrFeO, and 71% for 10 wt% Zr-doped Pt–ZrFeO [84].

The synthesis of PANI/ ZrO_2 nanocomposite designed for supercapacitor application, exhibit the highest specific capacitance retention of approximately 96.8% at a scan rate of 1 Ag^{-1} [85]. The ZrO_2–TiO_2 binary nanocomposites demonstrated for supercapacitor application, specific capacitance retention of approximately 86% at scan rate 0.75 A g^{-1} [86]. ZrO_2 NPs is widely used in many applications, such as biomedical implantations, sensor, catalysis, super capacitor which exhibits the excellent results.

CONCLUSION

This review describes the green synthesis of ZrO_2 NPs and their several applications in biomedical. Green synthesis methods are simple, low cost, non-toxic and environmentally friendly. These zirconia nanoparticles are a biocompatibility material with excellent properties and high chemical stability. ZrO_2 NPs is a promising material for field of medicine and pharmacy. ZrO_2 NPs, by utilizing the plants part leads to the development of the field of biomedical application. Green synthesis of ZrO_2 NPs based nanoparticles exhibited excellent antimicrobial, antioxidant, anticancer activity due to their biological application. Future, initiatives will be taken to prepare the zirconia nanoparticle using various method of green synthesis.

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Energy and Sustainability Challenges of AI-Driven Data Centres: A Geographical Perspective

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ABSTRACT

Recent years have witnessed a boom in the development of multimodal large-scale generative AI models. These computationally intensive AI models, such as GPT-4, and their associated data centres have undergone increasing scrutiny in terms of their energy consumption and carbon emissions. As awareness of the energy costs and carbon footprints of AI models grows, attention has broadened to include other sustainability-related aspects such as their water consumption, transparency, and further environmental and social implications. This paper examines the growth of AI-driven data centres, their rising energy demands in India, and the importance of geography in planning suitable data centre locations, with a focus on promoting sustainable and resilient development.

INTRODUCTION

In the age of artificial intelligence (AI), data centres have become the backbone of the digital world. From cloud services to advanced AI applications, almost everything today depends on data centres to store, process, and transmit massive amounts of data. With the rapid growth of AI technologies, the demand for high-performance data centres has increased significantly.

However, this growth has also created serious challenges, especially related to energy consumption, water usage, and location planning. AI-based data centres require much more power and advanced cooling systems compared to traditional ones, making them highly resource-intensive. These issues become even more critical in countries like India, where energy supply and water availability are already under pressure.

Most data centres in India are concentrated in major urban regions, which often leads to increased stress on local resources and infrastructure. This highlights the importance of geographic planning in deciding where data centres should be located. Choosing suitable locations based on geographic factors can help reduce environmental impacts and improve long-term sustainability.

BASICS OF DATA CENTRES AND AI

Data centres are centralised facilities that house computing infrastructure used to store, process, and transmit large volumes of digital information to end users. They form the physical foundation of modern digital services, including cloud computing and artificial intelligence (AI) applications.

The rapid growth of AI software and services has led to the emergence of AI-focused data centres, which differ significantly from conventional data centres. While traditional data centres primarily support general computing, data storage, and retrieval, AI data centres require much higher processing power [2]. They rely on specialised hardware such as graphics processing units (GPUs) to enable faster parallel processing, along with advanced networking, power supply, and cooling systems.

AI data centres support two major functions: model training and inference. Model training involves processing massive datasets over short periods, resulting in extremely high but temporary energy demand. In contrast, inference refers to running trained models to answer user queries, which creates a continuous and steadily increasing power requirement as AI applications expand. As a result, the increasing dependence on AI has significantly intensified the operational demands placed on data centres, particularly in terms of energy consumption.

ENERGY USE IN DATA CENTRES

The energy requirements of data centres vary depending on their scale and purpose. Conventional data centres typically consume between 10 and 25 megawatts (MW) of electricity. However, hyperscale AI data centres can exceed 100 MW, placing them on par with energy-intensive industries such as aluminium smelting.[1]

This rapid increase in energy demand has raised concerns about the sustainability of AI infrastructure, especially in regions where electricity supply is already under stress. Unlike traditional facilities, AI data centres must operate continuously, leading to sustained pressure on power grids rather than short-term energy spikes.

In the Indian context, the expansion of data centre infrastructure is occurring at an unprecedented rate. As of April 30, 2025, India hosts 262 data centres, including cloud, colocation, and AI-capable facilities with a total installed capacity of approximately 960 MW.[2] While not all of these are dedicated AI data centres, the rapid growth of AI workloads is driving a significant expansion in capacity and energy demand within this infrastructure. According to forecasts, this capacity could increase to nearly 9.2 gigawatts (GW) by 2030, reflecting the growing energy burden associated with AI-driven digital growth. This rising energy demand highlights the importance of carefully evaluating where data centres are located and how regional energy resources are managed.

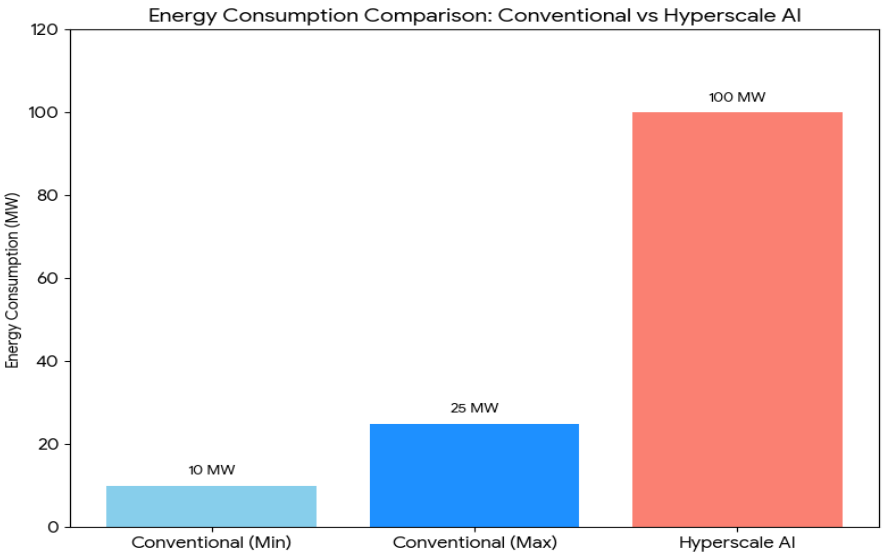


Fig 1: Energy Consumption Comparison: Conventional vs Hyperscale AI

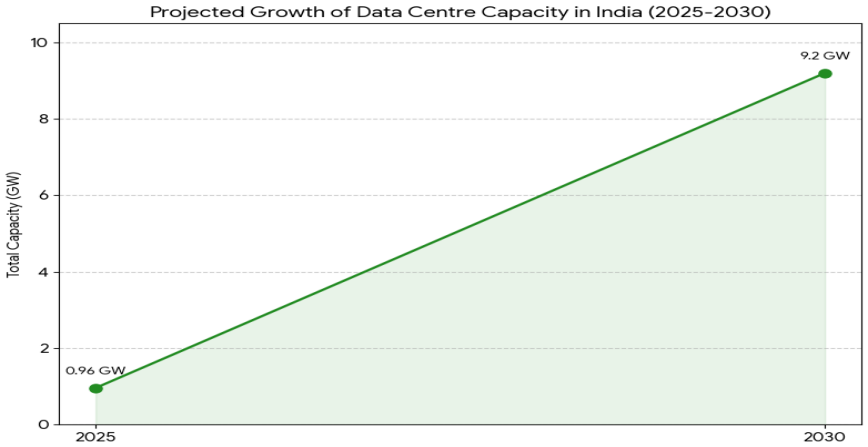


Fig 2: Projected Growth of Data Centre Capacity in India (2025-2030)

IMPORTANCE OF LOCATION IN DATA CENTRE PLANNING

Site selection for large data centres depends on a balance of factors. The first factor is access to a stable supply of cost competitive electricity, preferably from renewable sources. The second factor is favourable environmental conditions: low risk of natural hazards (e.g. extreme weather, flooding, seismic activity) and cooler climates requiring less energy for cooling. The third factor is strong connections to data infrastructure and networks. The fourth factor is favourable regulatory and market conditions, including proximity to major markets, political stability, and low taxation.[3]

Water availability is also closely linked to location planning. Many data centres use water-based cooling systems, making a stable and sufficient water supply essential.[5] Establishing data centres in water-scarce or drought-prone regions can create sustainability concerns and competition for local water resources. Therefore, understanding regional water availability and seasonal variability is an important part of geographical assessment.



Fig 3: Data Centre Strategic Site Selection

The availability of reliable energy sources is another key factor tied to geography. Data centres require uninterrupted electricity to support computing operations and cooling systems. Locating data centres in regions with strong power infrastructure and access to renewable energy sources such as solar, wind, or hydropower can improve energy security and reduce carbon emissions. Poor geographic alignment between data centre demand and local energy capacity can place stress on electricity grids and affect surrounding communities.

CHALLENGES ARISING FROM POOR GEOGRAPHIC PLANNING

Poor geographic planning in data centre development has led to serious environmental and resource-related challenges across the world. From countries such as Chile and Mexico to regions in the United States like Georgia and even parts of Scotland, growing concerns have been raised about data centres consuming excessive amounts of water for cooling and drawing vast quantities of electricity, often at the expense of local communities. These impacts highlight how ignoring regional resource availability and environmental limits can turn data centres into sources of local stress rather than economic growth.

In India, these challenges are far more severe due to existing constraints on energy and water resources. The country is already classified as water-stressed, with the World Bank reporting that India supports nearly 18% of

the world's population but has access to only 4% of global freshwater resources. In such a context, the rapid expansion of data centres without adequate geographic planning significantly intensifies pressure on local water systems.[6]

India's data centre water consumption is projected to rise sharply—from approximately 150 billion litres in 2025 to 358 billion litres by 2030—posing a serious threat to groundwater levels and long-term water security. This issue is further compounded by the spatial concentration of data centres in major urban hubs such as Mumbai, Hyderabad, Chennai, and Bengaluru, where domestic, industrial, and agricultural sectors already compete for limited water supplies. As a result, data centre operations risk deepening urban water conflicts rather than supporting sustainable development.

Supporting this concern, an S&P Global study predicts that 60–80% of India's data centres will face high water stress within this decade, primarily due to poor alignment between facility location and regional resource availability. Energy demand presents a parallel challenge. According to the International Energy Agency (IEA), electricity consumption by data centres in India is expected to double from 0.5–1% of total national power demand to nearly 1–2%, placing additional strain on already stretched power infrastructure.[4]

Together, these challenges demonstrate that the absence of geographic planning—particularly with respect to water availability, energy capacity, and urban concentration—can transform data centres into major contributors to environmental stress. This underscores the urgent need for geography-led planning approaches that align data centre growth with regional resource conditions and sustainability limits.

GEOGRAPHY-BASED STRATEGIES FOR SUSTAINABLE AI DATA CENTRES

Geography plays a critical role in shaping strategies for the sustainable development of AI data centres, particularly in countries like India where energy and water resources are already under significant stress. While several data centres have entered into agreements with renewable energy providers to reduce their carbon footprint, relying solely on voluntary commitments is insufficient. From a geographical planning perspective, mandating the use of clean and region-appropriate energy sources can ensure that the rapid expansion of AI data centres does not disproportionately burden local power grids or fossil-fuel-dependent regions.

Water availability is another geographically sensitive concern. Many data centres depend heavily on water-intensive cooling systems, which can worsen water scarcity in already vulnerable regions. Although zero-water or low-water cooling technologies are being adopted globally, their deployment across Indian and older legacy data centres remains inconsistent. Geography-based strategies emphasize aligning cooling technologies with local climatic and hydrological conditions. In water-stressed regions, the use of non-potable or treated wastewater for cooling purposes should be made mandatory, thereby reducing competition with domestic and agricultural water needs.

Beyond policy measures, advanced spatial planning approaches offer effective solutions for sustainable site selection. Data centre site suitability can be evaluated by integrating multiple geographical and environmental criteria, such as climate conditions, disaster risk, and availability of energy and water resources, land use patterns, and proximity to infrastructure. In this approach, a Random Forest (RF) machine learning model is used to identify and rank the relative importance of these location-based factors.[7] The resulting feature importance scores are then applied as weights within a Multi-Criteria Decision-Making (MCDM) framework to generate a comprehensive suitability assessment.

The outcome of this process is a spatial suitability map that highlights regions most appropriate for future AI data centre development. Additionally, the exploration of multiple alternative weighting scenarios allows planners to understand how different prioritization strategies—such as emphasizing energy availability over connectivity or disaster risk over land cost—can influence site selection outcomes. By benchmarking these scenarios against the data-driven RF-based approach, geography-based strategies enable more informed, resilient, and sustainable decisions in AI data centre planning.

CONCLUSION

AI data centres are here to stay, and they have the potential to deliver significant economic and technological benefits. However, if their expansion is left unmanaged, they can sharply increase local electricity demand, raise power prices for households and businesses, intensify pressure on energy and water systems, and contribute to higher emissions. In this context, governments at both local and national levels must recognise that efficient management of power and water resources—supported by informed location planning—is essential for protecting electricity affordability, maintaining system reliability, and attracting long-term investment. Fundamentally, sustainability is not a constraint on digital growth; rather, it is a pathway to building resilient and competitive data centre infrastructure in the AI-driven era.

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Green Synthesis and Characterization of HAP NPs Using *Piper Betle Leaf* Extract and its Antibacterial Activity

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ABSTRACT

Nanotechnology is a highly active research area worldwide. The unique physical and chemical properties of nanomaterials can be exploited for applications that benefit society. In this study, hydroxyapatite (HAp) nanoparticles were synthesized via a green synthesis approach using Piper betle leaf extract. The incorporation of natural ingredients such as Piper betle enhances the antibacterial properties of the synthesized nanoparticles. HAp plays a key role in the biomedical field due to its non-toxicity and anti-inflammatory properties.The synthesized HAp nanoparticles were characterized using Fourier Transform Infrared (FTIR) spectroscopy, X-ray Diffraction (XRD), and UV–Visible spectroscopy to determine their functional groups, morphology, and crystalline structure. In addition, the antibacterial activity of the nanoparticles was evaluated. XRD analysis confirmed the hexagonal crystalline structure of the HAp nanoparticles. The UV–Visible absorption spectrum revealed a band gap energy of 3.2 eV, which is consistent with standard reported values.

KEYWORDS: Hydroxyapatite, Piper betle leaf, Fourier Transform Infrared Spectroscopy, X-Ray Diffraction, UV-Visible Spectroscopy

INTRODUCTION

In recent years, nanotechnology has emerged as a multidisciplinary field, in which gaining a fundamental understanding of the electrical, optical, magnetic, and mechanical properties of nanostructures promises to deliver the next generation of functional materials with wide-ranging applications. Nanotechnology represents a revolutionary path for technological development that concerns the management of material at the nanometer scale. [1] In comparison to their bulk counterparts, nanomaterials exhibit unique physical and chemical properties hence having enormous applications in different fields such as agriculture, engineering, medicine and biomedical sciences [2]. Calcium phosphates (CaPs) are well-known bioceramics with excellent osteoconductive and osteoinductive properties.[1] Their bioactivity is strongly dependent on the mineral phase of CaPs (e.g., hydroxyapatite (HAp) and tricalcium phosphate (TCP)), making them versatile materials for various applications, as their properties—such as ion release, stability, solubility, and mechanical strength—can be finely tuned.Synthetic hydroxyapatite (HAp), particularly nano-HAp, has been extensively studied in the field of biomaterials, especially for bone regeneration and replacement applications, due to its close resemblance to natural bone (e.g., a calcium-to-phosphorus molar ratio of 1.67, thermodynamic stability at pH 4.3 and above, suitable crystallinity, and nanoscale size) Bone implants and fillers composed of HAp exhibit good stabilization and fixation to adjacent tissues, along with the formation of a new, biologically active carbonate apatite layer.However, HAp also presents certain limitations, including a low biodegradation rate and a brittle nature, which makes it unsuitable for load-bearing applications. Conventional strategies to enhance the overall performance of HAp-based biomaterials involve their modification with various atomic or molecular species. In this context, ion doping has emerged as an effective chemical approach to tailor the structure and properties of HAp [3]. Traditional methods are used from past many years but researches have proved that the green methods are more effective for the generation of NPs with the advantage of less chances of failure, low cost and ease of characterization. Physical and chemical approaches of synthesizing NPs have posed several stresses on environment due to their toxic metabolites. Plant-based synthesis of NPs is certainly not a troublesome procedure, a metal salt is synthesized with plant extract and the response is completed in minutes to couple of hours at typical room temperature. This strategy has attracted much more attention amid the most recent decade particularly for HAp NPs, which are more secure as contrasted with other metallic NPs [4]. *Piper betle* (Family:

Piperaceae) is a well-known medicinal plant predominantly found in East Asian countries such as Malaysia, Indonesia, the Philippines, India, and Sri Lanka. In these regions, large-scale plantation farms of *Piper betle* are maintained to meet industrial demands for the production of various products, including toothpaste, shampoo, personal care items, herbal supplements, and herbal beverages. Traditionally, *Piper betle* leaves combined with lime, hard fruit, areca nuts, and gambier have been used as mouth fresheners. Chewing preparations containing *Piper betle* offer additional benefits, such as strengthening the teeth and refreshing the mouth .Apart from oral use, *Piper betle* paste is also commonly applied for washing hair and intimate areas. Furthermore, the leaves of *Piper betle* hold cultural significance and are frequently used in religious and ritual practices within Malay and Hindu traditions.The medicinal properties of *Piper betle* have long been utilized in the treatment of wounds and cuts by crushing the leaves into a paste and applying it directly to the affected area. The therapeutic potential of this plant is attributed to the presence of numerous bioconstituents or bioactive compounds distributed throughout the plant. These bioconstituents include various active ingredients such as tannins, flavonoids (e.g., quercetin), eugenol, hydroxychavicol, and chavibetol [5].

MATERIALS AND METHODS

MATERIALS NEEDED

Calcium hydroxide, Orthophosphoric acid, Sodium hydroxide, Piper betle leaves

COLLECTION OF THE PLANT MATERIALS AND CHEMICALS

The fresh Piper betle leaves were collected from Ottapalam, place in Palakkad district, Kerala, India. Calcium hydroxide, Orthophosphoric acid and Sodium hydroxide in analytical grade procured from Sigma Aldrich.

PREPARATION OF PIPER BETLE LEAF EXTRACT

To remove dust particles, the leaves were washed several times using distilled water. Then the leaf extract was prepared by taking minimum gram of leaf with 200 ml distilled water in a beaker. It was boiled at 700C for 30 minutes in microwave oven. Then the colour of the solution changes into brownish green. The leaf extract was filtered using Whitman filter paper.

SYNTHESIS OF LEAF CAPPED HAp NANO PARTICLES

Take a beaker with 50 ml distilled water and Calcium hydroxide (CaOH) was dissolved in it (Solution A). Few ml of Ortho Phosphoric acid (H_3PO_4) was dissolved in distilled water (Solution B). The two solutions were stirred for 30 minutes by using magnetic stirrer separately. To solution A, solution B is added dropwise after stirring 30minutes. Then leaf extract was added into the same solution and this mixture was stirred. Sodium hydroxide pellet was dissolved in distilled water and added dropwise to the solution to maintain pH level 12. As the reaction progressed, the colour of the solution changes from brownish green to yellow. The synthesized sample was kept for 24 hours in a darkroom. Thus the settled chemical sample was collected and filtered by removing water using dropper. The final product was kept in microwave oven at 70 W for 45 minutes. The obtained dried sample was grained in a mortar pistal. And finally the HAp nanopowders were obtained.

RESULT AND DISCUSSION

XRD ANALYSIS

Figure 6.1 shows the X-ray diffraction (XRD) pattern of the synthesized hydroxyapatite (HAp) nanoparticles prepared using *Piper betle* leaf extract. The diffraction peaks observed at 2θ values around **25.9°, 31.7°, 32.9°, 34.1°, 39.8°, 46.7°, 49.5°, and 53.2°** correspond to the crystallographic planes **(002), (211), (112), (300), (310), (222), (213), and (321),** respectively[6]. These peaks are in good agreement with the standard JCPDS card for hexagonal hydroxyapatite (JCPDS No. 09-0432), confirming the formation of phase-pure HAp nanoparticles.The sharp and well-defined diffraction peaks indicate the **crystalline nature** of the synthesized nanoparticles [7]. No additional impurity peaks were detected, suggesting the high purity of the HAp phase and the effectiveness of the green microwave-assisted synthesis method. The hexagonal crystal structure of hydroxyapatite was clearly confirmed from the indexed planes[8].The average crystallite size of the HAp

nanoparticles was estimated using the **Debye–Scherrer equation,** which indicates that the particles are in the nanometer range. The calculated lattice parameters and unit cell volume further support the formation of hexagonal HAp. Overall, the XRD results confirm the successful synthesis of crystalline hydroxyapatite nanoparticles suitable for biomedical applications [9].

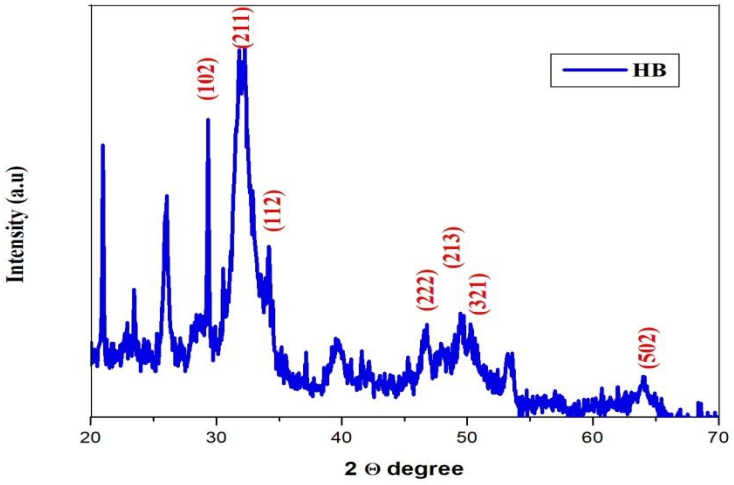


Figure: 1 XRD pattern of the HAp

Table:1 Structural parameters of Hydroxyapatite nanoparticles

Sample Code	2θ	d-spacing Å	FWHM	hkl value	Lattice constant Å a=b c	Crystalline size (nm)	Unit cell volume	Dislocation density(δ) 10^{14}line/m^2	Microstrain (Ɛ) 10^{-4}lin^{-2}m^{-4}
HB	28.5546	3.12348	1.1354	102	8.67 6.86	7.22	446.57	191.83	0.0194
	31.8639	2.80624	1.1101	211	9.37 6.86	7.44	521.59	180.65	0.0169
	32.433	2.75828	0.8856	112	9.20 6.86	9.34	502.84	114.63	0.0132
	34.1229	2.62544	0.2927	202	9.37 6.86	28.66	521.59	121.74	0.0041
	46.6526	1.94536	1.1177	222	9.40 6.87	7.79	525.70	164.78	0.0113
	49.452	1.84159	0.9325	213	9.46 6.86	9.4	531.66	113.17	0.0088
	50.4022	1.80908	1.6342	321	9.38 6.94	5.38	528.80	345.48	0.0151
	63.8083	1.45752	0.3485	502	9.23 6.88	27.52	507.60	132.03	0.0024
	76.3579	1.2462	2.6749	432	9.34 6.86	3.78	518.26	699.86	0.0148
Average					9.26 6.87	11.83	511.62	229.35	0.0118

FOURIER TRANSFORM INFRARED SPECTROSCOPY

Figure 2 shows the FTIR spectrum of the synthesized hydroxyapatite (HAp) nanoparticles prepared via the microwave-assisted green synthesis method using *Piper betle* leaf extract [10]. The broad absorption band observed around **~2958 cm⁻¹** is attributed to the stretching vibration of **O–H groups**, indicating the presence of hydroxyl ions and adsorbed water molecules, which are characteristic of hydroxyapatite and phytochemical residues from the plant extract.The peaks appearing at **~1639 cm⁻¹** correspond to the **H–O–H bending vibration** of absorbed water molecules [11]. The bands around **~1540 cm⁻¹ and ~1450 cm⁻¹** may be associated with **carbonate (CO_3^{2-}) groups,** suggesting partial substitution of phosphate groups by carbonate ions, a common feature in biologically derived hydroxyapatite.The strong absorption peak observed at **~1040 cm⁻¹** is assigned to the **ν_3 stretching vibration of phosphate (PO_4^{3-}) groups**, confirming the formation of the apatite structure[12]. Additional phosphate-related bands at **~873 cm⁻¹ and ~603 cm⁻¹** correspond to the **ν_2 and ν_4 bending modes of PO_4^{3-} ions**, respectively. These characteristic phosphate vibrations further validate the successful synthesis of hydroxyapatite nanoparticles [13].Overall, the FTIR results confirm the presence of hydroxyl and phosphate functional groups, which are the essential components of hydroxyapatite. The involvement of phytochemicals from *Piper betle* leaf extract likely acts as reducing and stabilizing agents during synthesis. The FTIR findings strongly support the formation of phase-pure, biologically relevant HAp nanoparticles suitable for biomedical applications [14].

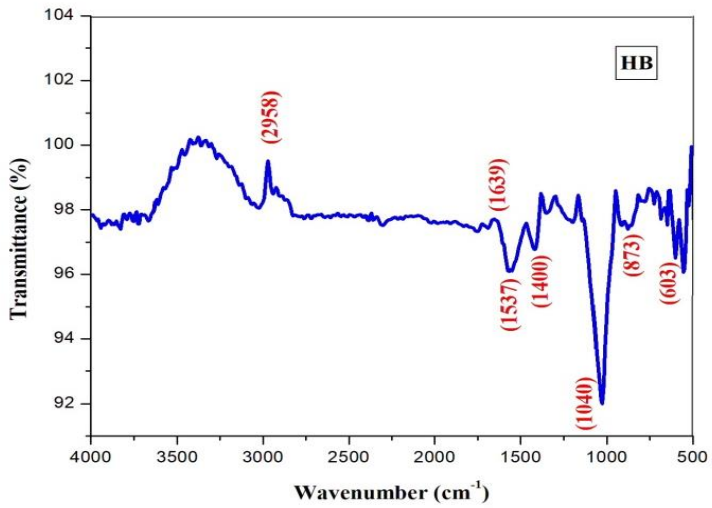


Figure: 2. FTIR pattern of the HAp

ULTRA VIOLET-VISIBLE SPECTROSCOPY ANALYSIS

Figure 3 shows the UV–Visible absorption spectrum and the corresponding Tauc plot of the synthesized hydroxyapatite (HAp) nanoparticles prepared using *Piper betle* leaf extract [15]. The UV–Visible absorption spectrum exhibits a distinct absorption edge in the ultraviolet region, indicating the nanoscale nature of the synthesized HAp particles.The optical band gap energy of the HAp nanoparticles was estimated using the Tauc relation, $(\alpha h\nu)2$ versus photon energy ($h\nu$), assuming a direct allowed transition[16]. By extrapolating the linear portion of the Tauc plot to the energy axis, the band gap energy was determined to be approximately **3.2 eV**, which is in good agreement with reported standard values for hydroxyapatite.The observed band gap confirms the insulating/semiconducting behavior of HAp nanoparticles and reflects the influence of particle size and surface effects arising from the green synthesis route [17]. The slight variation in the absorption edge may be attributed to the presence of phytochemical capping agents from *Piper betle* leaf extract.Overall, the UV–Visible analysis confirms the successful formation of nanosized HAp with suitable optical properties, supporting its potential application in biomedical and antibacterial fields [18].

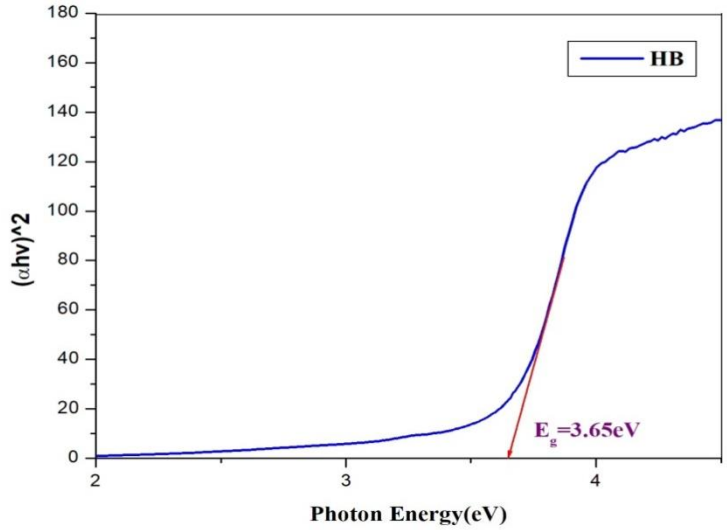


Figure: 3 UV-Vis spectrums for Tauc plot prepared samples

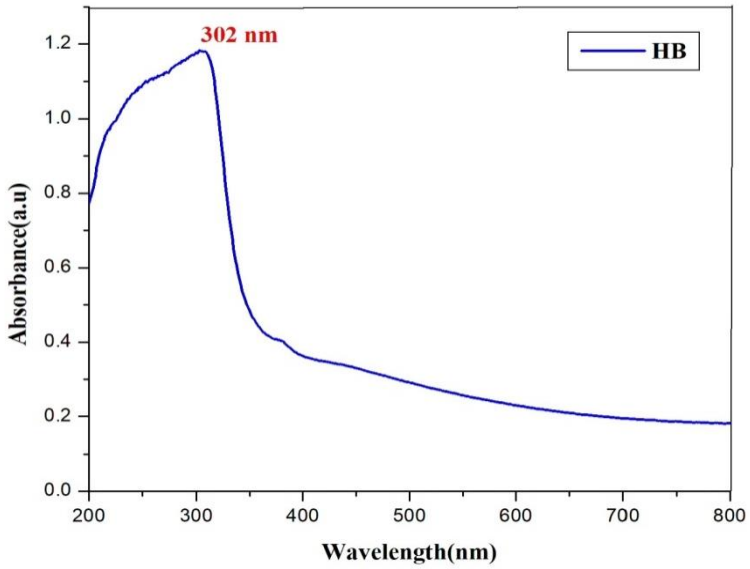


Figure: 4 UV-Vis spectrums for Absorption prepared samples

ANTIBACTERIAL ACTIVITY

The antibacterial activity of the synthesized hydroxyapatite (HAp) nanoparticles prepared using *Piper betle* leaf extract was evaluated against **Escherichia coli** (Gram-negative) and **Staphylococcus aureus** (Gram-positive) bacteria using the agar well diffusion method [19]. Figures 6.5 and 6.6 illustrate the zones of inhibition produced by different concentrations of HAp nanoparticles (50, 100, 250, and 500 µg/mL), along with positive and negative controls.For **Escherichia coli**, the HAp nanoparticles exhibited a clear concentration-dependent antibacterial effect. The maximum zone of inhibition was observed at **500 µg/mL**, while a gradual decrease in antibacterial activity was noted with decreasing concentrations. The positive control showed a higher inhibition zone compared to the synthesized sample, whereas no inhibition was observed for the negative control, confirming the antibacterial efficacy of the HAp nanoparticles.Similarly, against **Staphylococcus aureus**, the HAp nanoparticles demonstrated significant antibacterial activity[20]. The highest zone of inhibition was recorded at **500 µg/mL**, indicating strong antibacterial effectiveness against Gram-positive bacteria. The results

suggest that *Staphylococcus aureus* is more sensitive to the HAp nanoparticles compared to *Escherichia coli*, which may be attributed to differences in cell wall structure between Gram-positive and Gram-negative bacteria. The enhanced antibacterial activity of the synthesized HAp nanoparticles can be attributed to their nanoscale size, high surface area, and the presence of bioactive phytochemicals from *Piper betle* leaf extract acting as capping agents. These factors facilitate interaction with bacterial cell membranes, leading to cell wall disruption and inhibition of bacterial growth [21].Overall, the results confirm that green-synthesized HAp nanoparticles exhibit promising antibacterial activity against both Gram-positive and Gram-negative bacteria, highlighting their potential application in biomedical and therapeutic fields[22].

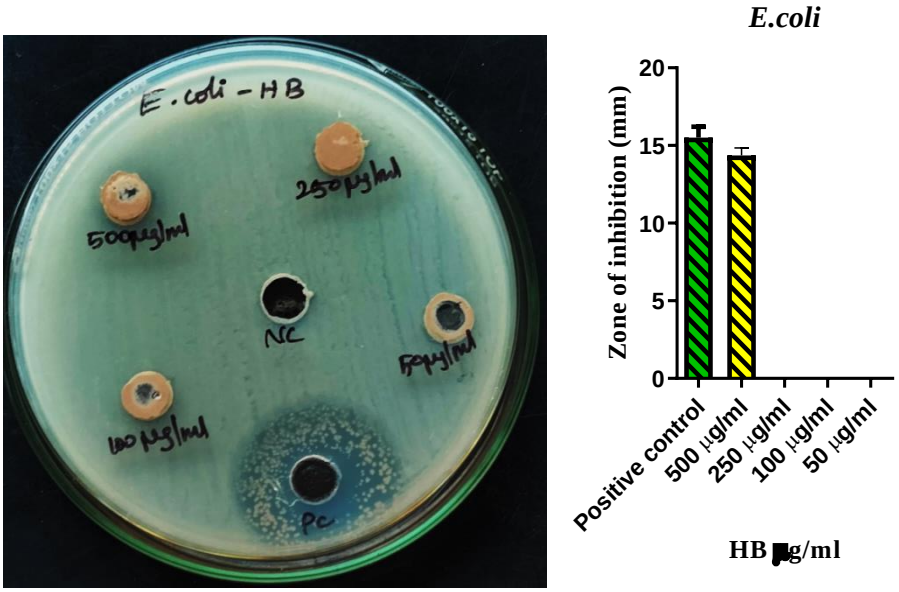


Fig : 6.5 Effect of sample HB against E.coli.

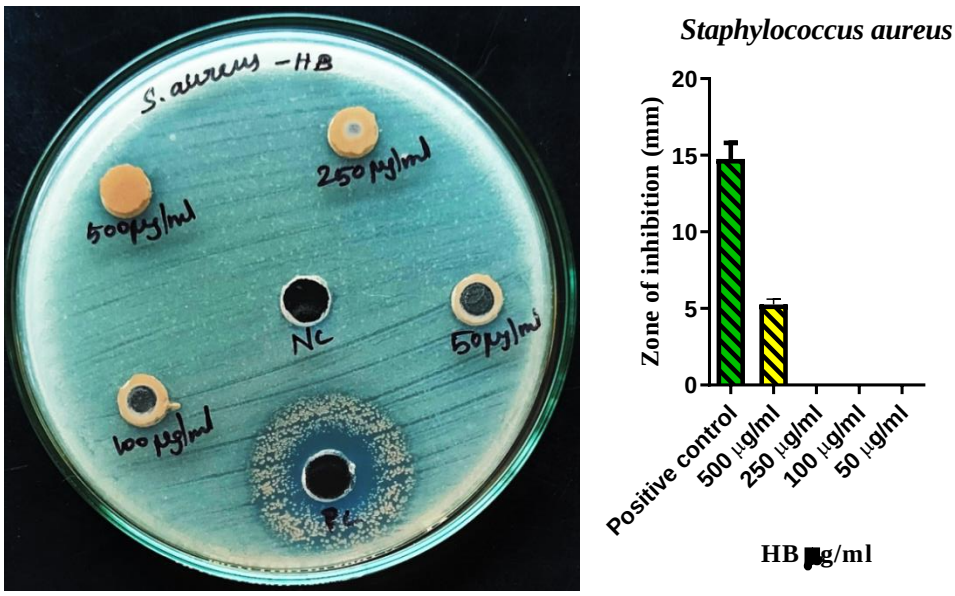


Fig : 6.6 Effect of sample HB against Staphylococcus aureus.

Table-2. Means ±SD of zone of inhibition obtained by sample HB against Staphylococcus aureus and E.coli.

Sl. No	Name of the test organism	Name of the test sample	Zone of inhibition (mm) Mean±SD				
			500 µg/ml	250 µg/ml	100 µg/ml	50 µg/ml	PC
1.	Staphylococcus aureus	HB	5.25±0.35	0	0	0	14.75±1.06
2.	E.coli		14.35±0.49	0	0	0	15.5±0.7

CONCLUSION

HAp nanoparticles were prepared using *Piper betle* leaf extract through the microwave-assisted synthesis method. The combined analyses of FTIR, XRD, and UV–Visible spectroscopy provided a comprehensive characterization of the synthesized nanoparticles. FTIR analysis elucidated the functional groups present, while XRD revealed detailed crystallographic information, including crystallite size, lattice parameters, unit cell volume, and degree of crystallinity. UV–Visible analysis offered valuable insights into the optical behavior of the material, from which the band gap energy and corresponding wavelength were determined.The antibacterial activity assessment evaluated the zone of inhibition, demonstrating the effectiveness of HAp nanoparticles against *Staphylococcus aureus* (Gram-positive) and *Escherichia coli* (Gram-negative) bacteria. Overall, this study provides valuable insights into the antimicrobial potential of the synthesized HAp nanoparticles, which could contribute to the development of novel antibacterial agents for therapeutic applications.

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Green Libraries: A Sustainable Approach to Library and Information Services

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ABSTRACT

Environmental sustainability has become a critical global concern in the twenty-first century, influencing policies and practices across various sectors, including library and information services. Libraries, as socially responsible knowledge institutions, are increasingly expected to adopt sustainable practices that reduce environmental impact while maintaining efficient and quality information services. The concept of green libraries emphasizes environmentally responsible planning, optimal resource utilization, and sustainable service delivery.

This paper explores the concept, principles, and significance of green libraries in the contemporary library environment. It examines key green practices such as energy-efficient infrastructure, digitization to reduce paper consumption, effective waste management, and increased use of electronic resources. The role of library professionals in promoting environmental awareness and supporting sustainable development through information services is also discussed.

Further, the study analyzes the relevance and implementation of green library initiatives in the Indian context, highlighting challenges such as financial constraints, limited awareness, and infrastructural limitations. The paper concludes that adopting green library practices not only minimizes environmental impact but also improves operational efficiency and strengthens the role of libraries as catalysts for sustainable development.

Keywords: Green Libraries, Sustainability, Environmental Responsibility, Library Management, Information Services

INTRODUCTION

Libraries have traditionally functioned as centers for knowledge creation, preservation, and dissemination. In recent years, growing concerns over climate change, resource depletion, and environmental degradation have compelled libraries to reconsider their conventional operational models and adopt sustainable practices. The emergence of green libraries reflects this transition towards environmentally responsible library management.

Green libraries focus on efficient energy and resource utilization, eco-friendly infrastructure, sustainable collection development, and environmentally conscious service delivery. Beyond reducing carbon footprints, these libraries play an important role in educating users about environmental protection and sustainable lifestyles. Through green initiatives, libraries can align with national and global sustainability goals while ensuring long-term operational efficiency.

In India, rising energy costs and increasing awareness of environmental issues have emphasized the need for green practices in academic and public libraries. However, adoption levels vary considerably among institutions. This paper seeks to examine the concept of green libraries, their importance, and their potential role in strengthening sustainable library and information services.

REVIEW OF LITERATURE

The existing literature identifies sustainability as a vital component of modern library management. Researchers describe green libraries as institutions that integrate eco-friendly building design, energy-efficient technologies, and responsible resource management into their operations. Studies highlight that green libraries extend beyond physical infrastructure to include sustainable collection development, digitization, and environmentally conscious service models.

Several studies emphasize the role of digitization and electronic resources in reducing paper usage and operational waste. Researchers also underline the importance of librarians as promoters of environmental awareness through information dissemination, user education programs, exhibitions, and outreach activities.

While international research focuses extensively on green building standards and sustainable architecture, Indian studies reveal growing interest in green libraries, though large-scale implementation remains limited.

The review indicates a need for integrated studies that examine green libraries holistically by combining infrastructure, services, and user engagement. This study contributes to the literature by presenting a comprehensive overview of green libraries within the framework of library and information services.

OBJECTIVES OF THE STUDY

The present study aims to:

1. Explain the concept and importance of green libraries in library and information services.
2. Identify major green practices adopted by modern libraries.
3. Examine the role of libraries in promoting environmental awareness and sustainability.
4. Analyze challenges faced in implementing green library initiatives in India.
5. Suggest measures for the effective adoption of green practices in libraries.

RESEARCH METHODOLOGY

The study is descriptive in nature and is based on secondary data sources. Relevant information was collected from books, scholarly journals, conference proceedings, research articles, reports, and reliable online resources related to green libraries and sustainability. The collected data were systematically analyzed and organized to understand the principles, practices, and challenges associated with green libraries. An analytical approach was adopted to derive meaningful conclusions and recommendations for sustainable library development.

CLASSIFICATION / TYPES OF GREEN LIBRARIES

Green libraries can be classified based on their design, operational practices, service models, and level of sustainability adopted. The major types include:

Green Building–Based Libraries

- Designed using environmentally sustainable architectural principles
- Employ eco-friendly construction materials and energy-efficient designs
- Utilize natural lighting and ventilation to reduce electricity usage
- Incorporate rainwater harvesting and water conservation systems
- Use renewable energy sources such as solar power

Energy-Efficient Libraries

- Aim to reduce energy consumption in daily operations
- Use LED lighting and energy-saving electrical equipment
- Implement automated systems for lighting, air conditioning, and power management
- Promote energy-efficient computers and office appliances
- Reduce operational costs and carbon emissions

Digital and Paperless Libraries

- Encourage extensive use of digital information resources
- Provide access to e-books, e-journals, databases, and digital repositories
- Offer online services such as OPAC, digital reference, and e-learning platforms

- Minimize printing, photocopying, and physical storage needs
- Reduce paper waste and environmental impact

Sustainable Collection Development Libraries

- Follow need-based and responsible acquisition policies
- Prefer electronic resources over print materials wherever feasible
- Promote resource sharing through library networks and consortia
- Conduct systematic weeding and eco-friendly disposal of outdated materials
- Optimize space utilization and collection efficiency

Waste-Reduction and Recycling Libraries

- Implement structured waste management and recycling systems
- Encourage reuse of paper and library materials
- Reduce single-use plastics and non-recyclable items
- Use eco-friendly stationery and reusable supplies
- Ensure safe and responsible disposal of electronic waste

User-Centered Green Libraries

- Create awareness about environmental sustainability among users
- Organize exhibitions, seminars, workshops, and awareness programs
- Encourage eco-friendly behavior within library premises
- Provide access to resources related to environmental studies
- Act as community hubs promoting sustainable practices

ADVANTAGES OF GREEN LIBRARIES

- Reduce energy consumption and operational costs
- Minimize environmental impact through digital services
- Improve indoor environmental quality and user comfort
- Support long-term sustainability and efficient resource utilization
- Enhance the social responsibility and public image of libraries
- Promote environmental awareness among users and academic communities

GREEN LIBRARY PRACTICES IN INDIA

- Use of energy-efficient LED lighting
- Maximization of natural lighting and ventilation
- Installation of solar panels and renewable energy systems
- Digitization of resources and development of institutional repositories
- Reduction of paper usage through online services
- Waste segregation, recycling, and e-waste management

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- Organization of environmental awareness programs

ROLE OF LIBRARIANS IN GREEN LIBRARIES

- Planning and implementing sustainable library policies
- Promoting digital resources and paperless services
- Educating users about environmental conservation
- Organizing green awareness programs and campaigns
- Coordinating with institutional authorities
- Monitoring and evaluating green initiatives

CHALLENGES AND RECOMMENDATIONS

Challenges

- Limited financial resources
- Lack of awareness and professional training
- Inadequate infrastructure in existing buildings
- Absence of standardized policies and guidelines
- Resistance to change from traditional practices

Recommendations

- Allocate sufficient funding and institutional support
- Conduct regular training and awareness programs
- Encourage gradual adoption of cost-effective solutions
- Develop national-level policies for green libraries
- Promote collaboration among libraries and agencies

CONCLUSION

Green libraries represent a sustainable and progressive approach to library and information services. By adopting environmentally responsible practices, libraries can reduce operational costs, conserve natural resources, and contribute to environmental protection. Although challenges such as financial constraints and limited awareness persist, phased and well-planned implementation of green initiatives can significantly enhance sustainability. The study concludes that green libraries are essential in developing environmentally responsible knowledge centers aligned with sustainable development goals.

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Sustainability and Green Libraries: Aligning with UN SDGs

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Abstract

This article explores green-oriented concepts and sustainable practices within modern libraries. It examines the United Nations Sustainable Development Goals (SDGs) intended to create a better world by 2030, highlighting how the "Green Library" concept directly addresses seven specific SDGs. Green libraries aim to minimize environmental impact through energy efficiency, the use of sustainable building materials, enhanced digital learning, and robust recycling programs. This research highlights the evolution of eco-libraries in India—specifically the Anna Centenary Library—and discusses the segments of green library infrastructure essential for a sustainable future.

Keywords: Green Library, Sustainable Environment, LEED, Segments of Green Library, Resource Conservation.

Introduction

As the modern world undergoes rapid development, the global community is increasingly pivoting toward "Green" initiatives. Eco-friendly practices are no longer a trend but a necessity across all sectors, including Library and Information Science. Green libraries represent the future of sustainable reading and knowledge dissemination.

A library is more than a repository of information; it must be an environmental steward. The green library concept expands the traditional role of libraries by promoting environmental awareness, reducing carbon footprints, and ensuring the delivery of sustainable information services. Emerging in the early 1990s, this field has gained significant academic momentum. By integrating sustainable development into their core infrastructure, modern libraries are evolving into hubs for ecological and intellectual growth.

Alignment with UN Sustainable Development Goals (SDGs)

SDG 4: Quality Education *"Education is the most powerful weapon which you can use to change the world."* — Nelson Mandela. Libraries are the backbone of academic research. Green libraries guarantee quality education by balancing printed collections with robust digital databases and e-books. This dual approach encourages lifelong learning across all demographics while reducing the physical resources required for information access.

SDG 6: Clean Water and Sanitation Green libraries prioritize water conservation through sustainable architecture. Key practices include:

- **Rainwater Harvesting:** Collecting water for landscaping and greywater systems.
- **Efficient Fixtures:** Installing low-flow taps and water-efficient toilets in restrooms.
- **Greywater Recycling:** Treating wastewater from sinks and HVAC systems for non-potable uses like toilet flushing and maintaining green walls.

SDG 7: Affordable and Clean Energy Libraries achieve energy independence by integrating renewable sources. Utilizing solar roofing tiles, natural skylights, and energy-efficient LED lighting significantly reduces carbon emissions. Surplus energy generated through solar panels can be stored or redirected, ensuring the facility remains a low-emission zone.

SDG 9: Industry, Innovation, and Infrastructure Sustainability begins with the building's foundation. Green libraries utilize:

- **Locally Sourced Materials:** Reducing transport-related emissions.

- **Recycled Components:** Using reclaimed wood and recycled steel.
- **Non-Toxic Finishes:** Applying paints made from clay or milk proteins to ensure high indoor air quality for patrons.

SDG 11: Sustainable Cities and Communities Green libraries serve as the heart of sustainable urban planning. By connecting librarians, students, and citizens, these institutions foster a community-wide movement toward environmental responsibility, reducing the overall adverse impact of urban centers.

SDG 12: Responsible Consumption and Production By promoting digital resources, libraries drastically reduce paper consumption, preserving forests. When physical books are necessary, green libraries advocate for the use of recycled paper and sustainable binding components.

SDG 13: Climate Action Green libraries act as community hubs for climate literacy. Through indoor and outdoor afforestation (air-purifying plants) and energy conservation, they mitigate the heat-island effect in cities and provide a tangible model for climate resilience.

IFLA and the Global Standard

The **International Federation of Library Associations and Institutions (IFLA)** sets the global guidelines for eco-friendly library management. IFLA encourages libraries to reduce energy consumption and lead public awareness campaigns regarding sustainability.

Case Study: Anna Centenary Library, Chennai

Established in August 2010, the **Anna Centenary Library** is a premier example of a green library in India. It was recognized with a **LEED Gold Certificate** by the Indian Green Building Council. Its design incorporates:

- Maximum utilization of natural light.
- Advanced waste management and water conservation systems.
- Extensive green landscaping that enhances the local ecosystem.

Conclusion

The world currently faces unprecedented stress from rapid technological shifts and environmental crises. Libraries have a significant environmental footprint; therefore, it is the responsibility of librarians to lead the transition toward sustainability.

By adopting rainwater harvesting, renewable energy, and digital-first learning, libraries do more than just "go green"—they become a blueprint for other institutions. Green libraries are no longer a luxury; they are an essential, proactive response to the global call for peace, prosperity, and the protection of our planet by 2030.

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Green Libraries: Powering Sustainable Futures in College Campuses

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ABSTRACT

Sustainable development has emerged as a global priority in response to climate change, resource depletion, and environmental degradation. Higher education institutions play a critical role in shaping sustainable societies by educating future generations and modeling responsible practices. Among campus facilities, libraries hold a unique position as intellectual, cultural, and social hubs. The concept of Green Libraries represents a transformative approach where libraries integrate environmental sustainability into building design, operations, services, and educational outreach. This article explores the role of green libraries in powering sustainable futures on college campuses, examining their principles, benefits, implementation strategies, challenges, and long-term impact on education and society.

Keywords: Green Libraries, Sustainability, College Campuses, Sustainable Development, Environmental Education

INTRODUCTION

A library that consciously integrates environmental sustainability principles into its operations, infrastructure, services, and culture is known as a "green library." Since education gives people the knowledge, morals, and abilities to tackle global issues, it is widely acknowledged as a potent force behind sustainability. Colleges and universities, in particular, are expected not only to teach sustainability but also to practice it within their campuses.

Libraries, which were once thought of as peaceful archives of books and knowledge, are changing dramatically. Academic libraries are evolving into vibrant environments that foster education, research, teamwork, and creativity. Within this evolving role, green libraries have emerged as vital agents of sustainable development on college campuses.

A green library goes beyond eco-friendly architecture. It embodies sustainability through responsible resource management, environmentally conscious services, promotion of green literacy, and community engagement. By integrating sustainability into both physical infrastructure and intellectual activities, green libraries help colleges reduce their ecological footprint while inspiring students and faculty to adopt sustainable lifestyles.

This paper examines how green libraries contribute to sustainable futures in college campuses, highlighting their principles, practices, and potential to shape environmentally responsible citizens.

GREEN LIBRARIES MATTERS IN HIGHER EDUCATION AND ITS CORE PRINCIPLES

Higher education institutions have a dual role in society: to generate knowledge and to prepare students for ethical, responsible citizenship. Green libraries support both.

- Aligning with Institutional Sustainability Goals
- Educating for Environmental Literacy
- Promoting Research and Innovation

Core Principles

The following fundamental ideas serve as the foundation for green libraries:

Environmental responsibility: cutting back on waste, resource consumption, and carbon emissions.

Economic Sustainability: Reducing operating expenses by using water and energy efficiently.

- Social Sustainability: Providing healthy, inclusive, and accessible spaces for learning.
- Educational Leadership: Promoting environmental awareness and sustainability education.

Libraries can become real-world models of sustainability by implementing these ideas.

IMPORTANCE OF GREEN LIBRARIES IN COLLEGE CAMPUSES

Libraries as Central Campus Spaces

Libraries are among the most frequently used buildings on college campuses. Students spend long hours studying, collaborating, and accessing resources within library spaces. As high-occupancy buildings, libraries consume significant amounts of energy, water, and materials. Transforming them into green libraries can therefore produce substantial environmental and economic benefits.

Supporting Institutional Sustainability Goals

Many colleges have committed to sustainability initiatives such as carbon neutrality, green campus programs, and alignment with the United Nations Sustainable Development Goals (SDGs). Green libraries directly support these commitments by:

- ❖ Reducing greenhouse gas emissions
- ❖ Promoting responsible consumption and production
- ❖ Supporting climate action through education and research

Shaping Sustainable Mindsets

Students learn not only through formal instruction but also through their environment. Green libraries serve as silent teachers, demonstrating sustainability through every day practices such as recycling, energy conservation, and digital resource use. These experiences influence students' attitudes and behaviors long after graduation.

SUSTAINABLE DESIGN AND INFRASTRUCTURE IN GREEN LIBRARIES

Green Building Design

Sustainable architecture is a cornerstone of green libraries.

Key features include:

- Energy-efficient lighting systems such as LEDs
- Natural day lighting through windows, skylights, and open layouts
- Efficient HVAC systems that reduce energy consumption
- Use of sustainable materials, including recycled and locally sourced products

Many green libraries aim for certifications such as LEED (Leadership in Energy and Environmental Design) to ensure adherence to global sustainability standards.

Renewable Energy and Water Management

Green libraries increasingly integrate renewable energy sources such as solar panels and geothermal systems. Water conservation strategies include:

- Rainwater harvesting
- Low-flow faucets and toilets
- Grey water recycling for landscaping

These measures reduce dependence on non-renewable resources and enhance campus resilience.

Healthy Indoor Environments

Sustainability also includes human well-being. Green libraries prioritize:

- Good indoor air quality
- Non-toxic paints and furniture
- Comfortable lighting and acoustics

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Such environments improve concentration, productivity, and overall health of users.

Collections, Content, and Curriculum Integration

A green library enriches academic life by:

- Curating Sustainability Collections
- Open Access Support
- Special Exhibits & Displays
- Collaborations

Through these efforts, libraries become knowledge hubs for sustainability education.

Community Engagement and Culture Building

Green libraries extend sustainability beyond walls by:

- Hosting Green Events like guest lectures, film screenings, eco-workshops, and sustainability fairs.
- Student and Staff Engagement like green teams, volunteer programs, and sustainability ambassadors.
- Public Outreach like partnerships with local schools, NGOs, and community groups for environmental education.
- Behavior Change Campaigns like encouraging energy saving, responsible disposal, and mindful resource use among patrons.

These cultural approaches reinforce sustainability as a shared value and practice.

SUSTAINABLE OPERATIONS AND SERVICES

Management of Resources and Waste

- Green libraries use environmentally friendly methods of operation, like:
  - Waste segregation and recycling programs
    - Composting organic waste
- Cutting back on single-use plastics
    - Encouraging reusable materials

Digital Transformation and E-Resources

To reduce waste, libraries are also moving toward digital notices, online services, and paperless workflows. The shift toward electronic books, online journals, and digital repositories significantly reduces paper consumption and physical storage needs. Green libraries balance digital access with inclusivity, ensuring that technology supports sustainability without excluding users.

Policies for Green Procurement

Sustainable purchasing practices guarantee that equipment, furniture, and materials are ecologically friendly. This entails selecting goods with long-lasting materials, energy-efficient gadgets, and eco-labels.

GREEN LIBRARIES AS CENTERS FOR SUSTAINABILITY EDUCATION

Supporting Curriculum and Research

Green libraries actively support teaching and research in sustainability-related fields by:

- Developing specialized collections on environmental studies
- Providing access to open-access sustainability research
- Creating research guides and databases on green topics

Libraries collaborate with faculty to integrate sustainability resources into coursework across disciplines.

Awareness Programs and Events

Green libraries organize workshops, exhibitions, lectures, and campaigns on topics such as:

- Climate change and biodiversity
- Renewable energy and sustainable technologies
- Waste reduction and circular economy

These programs foster environmental literacy and civic responsibility.

Community Engagement

Beyond campus boundaries, green libraries partner with schools, NGOs, and local communities to promote sustainability. Through outreach programs, libraries become agents of social and environmental change.

ROLE OF LIBRARIAN IN GREEN LIBRARY

Every Library should adopt this concept and every librarians and all other belonging to the community should be well aware of this concept. Librarian should always make efforts to promote green library movements by using different online tools like social media. Librarian motivate users to participate in green library project by introducing them with the benefits of green Library. The Librarian constantly willing to work under the Eco-library system and identify those people who are willing to work in this environment. Librarian may play an important role to bring out a balance of the two parameters i.e. economy and ecology which are very crucial for making healthy, prosperous and sustainable libraries. They can promote green library tools, techniques to encourage others. Librarians have always been a key contributor to community learning efforts and it is also appropriate that they take a leadership role in sustainability movement.

CHALLENGES IN IMPLEMENTING GREEN LIBRARIES

Despite their benefits, green libraries face several challenges:

- ❖ Financial Constraints
- ❖ Technological Barriers
- ❖ Resistance to Change
- ❖ Cultural Resistance

CONCLUSION

Green libraries represent a powerful fusion of knowledge, sustainability, and social responsibility. By transforming library spaces into eco-friendly, educational, and community-oriented hubs, colleges can significantly contribute to sustainable development. Green libraries not only reduce environmental impact but also cultivate environmentally conscious citizens equipped to address global challenges. In powering sustainable futures on college campuses, green libraries affirm that sustainability is not an add-on to education. They are more than buildings; they are symbols of commitment to students, to society, and to the Earth.

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Green Entrepreneurship and Waste Valorization in Agro-Industries

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ABTRACT

Agro-industry generates a large amount of waste with diverse characteristics. The accumulation of agricultural waste exceeds 2 billion tons worldwide. It is essential to explore how the use of agro-industrial waste can be taken to the next level in order to fully benefit from this sector. Inadequate handling of these wastes leaves negative impacts on the environment as well as on the economic well-being of many countries. In this context, the urgent need is to develop proper methods for managing clean and green waste. First, it is essential to efficiently convert waste into valuable products and by-products at affordable treatment costs. Second, the impact on soil quality and productivity should be assessed. This review addresses the lack of research on how agro-based waste can be effectively utilized. The review thoroughly examines industrial innovations and technologies for the recovery of agro-industrial wastes, which has led to high resource efficiency, sustainable production, and safe waste disposal.

KEYWORDS: Agro-industrial waste, recycling, value added products, soil quality, Environments.

INTRODUCTION

Increased use of energy per person, caused by overuse of natural resources, along with a growing global population, causes instability in our ecological systems (Sadh et al. 2018). Every year, approximately 500 million tonnes of agricultural residue are produced, of which 18.4% (92 million tonnes is burned in India, which is more than the total waste generated in Bangladesh, Indonesia, and Myanmar combined (NPMCR 2019; Jeff et al. 2017). Crop residues produced in large quantities after harvest present significant challenges for both policymakers and farmers in India. The improper disposal of these crop residues has led to environmental pollution, greenhouse gas emissions, climate change, and adverse effects on human and animal health (Sadh et al. 2018; Bharathiraja et al. 2017; Bos and Hamelinck 2014). There is an urgent need to explore feasible recycling options to address these issues. The agro-industry, especially the food industry, plays a significant role in generating waste, leading to environmental pollution, climate change, and a decline in economic development (FAO 2019).

According to Cal-deira et al. (2019), the European Union produces more than 30 million tons of inedible food waste annually, and this amount is expected to rise significantly due to the rapid growth of the food processing industry. Reduction of agro-industrial waste by 30–50% can enhance the available food supply by 15% (Wanga et al. 2016).

METHODOLOGIES FOR VALORIZATION OF AGRO-INDUSTRIAL WASTE



Combustion

Combustion is the commonly used industrial method for igniting biomass in the presence of air. The chemical energy contained in the biomass gets converted into electricity, mechanical power, or heat energy. Agro-industrial waste materials are intentionally and technically processed through direct combustion to produce geomaterials as debris. The combustion process is generally carried out in turbines, boilers, or electric furnaces (Shen et al., 2016; Yuan et al., 2019). In boilers, electricity production is facilitated by burning biomass to generate high-pressure steam for the turbine, which is connected to a generator. Kumar et al., 2015 reported that the efficiency of conversion for biomass combustion was found to range from 20% to 40%, and with the system above 100 MWe. Biomass with high moisture content was found to be more suitable for these conversion methods.

Gasification

Gasification transforms biomass into a combustible gas mixture composed of methane, carbon monoxide, nitrogen, and other gases, utilizing gasifiers with capacities ranging from 20 to 500 kW (Pacioni et al., 2016). The process employs gasifying agents such as heat, oxygen, and steam. The selection of a gasification method is based on the specific application and the type of gasifying medium employed (Fang et al., 2021). Converting into gaseous fuel allows for flexible electricity and heat production in small to large-scale industrial settings, with drying heat frequently recovered at various stages of the gasification process.

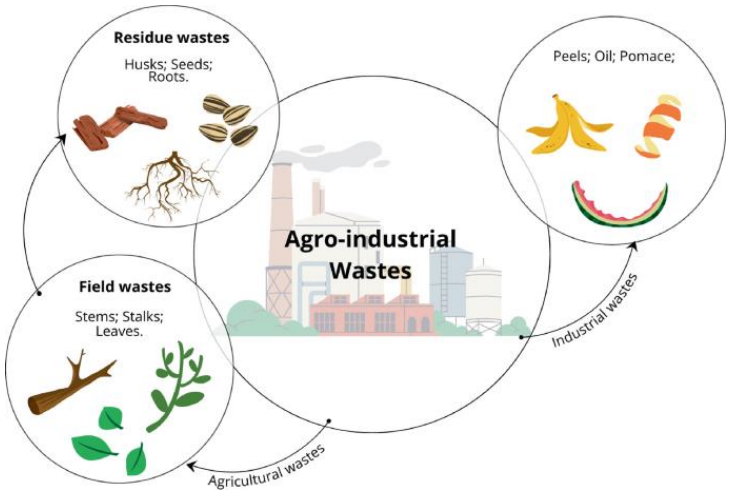
Pyrolysis

Pyrolysis is a thermochemical process that decomposes organic materials in the absence of oxygen, producing solid (biochar), liquid (bio-oil), and gaseous (syngas) products. Operating between 300 and 800 °C, pyrolysis is an efficient method for converting waste into energy (Varjani et al., 2019; Cusenza et al., 2021). The product distribution is mainly affected by temperature and residence time. Slow pyrolysis is preferred for producing biochar, whereas fast or flash pyrolysis is used to achieve maximum bio-oil production (Santos et al., 2015).

Fermentation

Fermentation is commonly employed in the production of biofuels, especially bioethanol, via the microbial conversion of sugars, starch, or cellulose (Cherubini, 2010). Biomass is initially pretreated and then enzymatically hydrolyzed to produce fermentable sugars, which are later converted into ethanol by yeast (Munasinghe and Khanal, 2010). Ethanol is recovered through distillation, an energy-intensive step. The solid residues produced can be used as animal feed, whereas by-products like sugarcane bagasse can be used as boiler fuel in energy conversion processes.

PRODUCTS FROM AGRO-INDUSTRAIL WASTES



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Application as Substrate for SSF

Agro-industrial wastes are commonly used as materials for solid-state fermentation (SSF) to create valuable products and generate bioenergy. Product yield depends on substrate composition. Solid wastes from agriculture and related industries, such as rice straw, wheat straw, and peanut cake, are suitable because of their low moisture content (Mohapatra et al., 2020. Several agro-industrial residues also function effectively as immobilization carriers in SSF due to their high water-holding capacity and support for microbial growth (Orzua et al., 2009).

Production of Biofuel

Biofuels produced from agro-industrial waste can serve as effective alternatives to fossil fuels. Various residues, including sugarcane bagasse, sugar beet waste, rice straw, and potato waste, have been widely used as substrates for biofuel production (Yogalakshmi et al., 2022). Utilization of agricultural residues reduces deforestation and collection time compared to forest biomass. The production of second-generation bioethanol from lignocellulosic agro-industrial waste has been successfully shown as a cost-effective and environmentally friendly alternative to traditional fuels (Saini et al., 2014).

Production of Antibiotics

Antibiotics are microbial metabolites that inhibit or kill pathogenic microorganisms at low concentrations (Tripathi, 2008). Several agro-industrial wastes, such as sawdust, rice straw, rice hull, wheat straw, and corn cob, have been studied as materials for producing antibiotics. Among these, groundnut shells and coconut oil cake have shown higher yields. The production of oxytetracycline using groundnut shells through solid-state fermentation with Streptomyces rimosus has been successfully reported, with increased yields obtained by providing external energy input (Asagbra et al., 2005; Tobias et al., 2021).

Production of Enzymes

Agro-industrial wastes, which have varying nutrient compositions, support microbial growth for enzyme production through fermentation processes (Viveka et al., 2020). These substrates improve microbial growth rates and enzyme productions. Several studies have reported the production of cellulolytic enzymes, such as β-glucosidase and endoglucanase, using fungal strains on agro-industrial residues (Kalogeris et al., 2003).

Production of Phytochemicals

The growing demand for plant-derived phytochemicals is driven by their therapeutic uses in modern medicine. Plant extracts can be used directly or processed to isolate and purify bioactive compounds for pharmaceutical purposes, as noted in the studies by Mopuri and Islam (2017) and Saravanan et al. (2021). Although synthetic drugs are widely available, natural compounds remain important sources of novel therapeutics. For example, mango leaves, which are usually thrown away after being used, contain bioactive compounds like mangiferin. This compound has antioxidant, antiviral, antitumor, and antidiabetic properties (Imran et al., 2017). As a result, phytochemicals from natural byproducts are becoming more widely studied for their effectiveness as antioxidants.

CONCLUSION

Agro-industrial wastes have significant potential to be revalorized for energy production and the extraction of unique bioactive compounds. The reliability of agro-industrial waste management and its practical application is essential for strengthening the world economy's transition towards circularity. This review highlighted that agro-industrial waste has tremendous potential as an efficient alternative to fuel derivatives. Agro-industrial waste-based biorefineries are economically viable as they enhance waste utilization and recovery of bio-based products. In addition, agro-industrial waste biorefineries play a significant role in supporting the circular boeconomy and offer greater opportunities for commercialization.

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Women Entrepreneurs Driving Green Startups for Sustainable Development

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Abstract

Women entrepreneurs are emerging as key drivers of sustainable development through green startups in Tamil Nadu. These enterprises focus on eco-friendly products, renewable energy, waste management, organic farming, and sustainable lifestyle solutions while simultaneously creating employment opportunities and strengthening local economies. Women-led green startups not only promote environmental conservation but also foster social inclusion by engaging rural communities and self-help groups. Despite challenges such as limited access to finance, technology gaps, and market constraints, many women entrepreneurs leverage government schemes, incubation centers, and digital platforms to scale their initiatives. Their leadership contributes to climate change mitigation, resource efficiency, and the promotion of green consumer behavior. This study examines the role, opportunities, and challenges of women entrepreneurs driving green startups in Tamil Nadu and highlights policy support and capacity-building measures needed to enhance their impact. Strengthening women-led green entrepreneurship can significantly advance inclusive and sustainable development in the state.

Keywords: Women entrepreneurs; Green startups, Sustainable development, Tamil Nadu, Eco-innovation, Renewable energy, Waste management, Organic products, Women empowerment

Introduction

Women entrepreneurs are increasingly playing a transformative role in shaping the green economy, particularly in regions striving for inclusive and sustainable development such as Tamil Nadu. With growing awareness of climate change, environmental degradation, and resource scarcity, there is an urgent need for business models that integrate economic growth with ecological responsibility. Women-led green startups respond to this need by focusing on areas such as renewable energy, organic agriculture, eco-friendly products, sustainable textiles, waste recycling, and clean technologies. These ventures not only reduce environmental impacts but also create livelihoods, empower communities, and promote sustainable consumption patterns.

In Tamil Nadu, strong networks of self-help groups, expanding educational opportunities, supportive government policies, and increased digital access have encouraged more women to participate in entrepreneurship. Their initiatives often draw on indigenous knowledge, local resources, and community-based approaches, allowing them to generate both environmental and social value. However, women entrepreneurs continue to face challenges including financial constraints, limited market access, infrastructural barriers, and socio-cultural expectations. Understanding their contributions, constraints, and potential is essential for advancing sustainable development in the state. This study explores how women entrepreneurs are driving green startups in Tamil Nadu, highlighting their role as innovators, job creators, and key stakeholders in the transition toward a sustainable future.

Review of Literature

Alzamel, (2024) examined the role of e-entrepreneurship in fostering the future economy, with a specific focus on Saudi women entrepreneurs. A quantitative and post-positivist approach has been undertaken in the study and it was found that e-entrepreneurship significantly impacts women's entrepreneurial and economic growth. Furthermore, the study also revealed that Saudi women entrepreneurs should receive more financial assistance and technical support to kick start their entrepreneurial journey. [Kalaivani et al., (2025)] explored the challenges and opportunities female entrepreneurs face regarding access to finance, socio-cultural barriers, and regulatory environments. It seeks to understand the broader implications of women's economic empowerment on community development and regional stability. The findings demonstrated the need for an inclusive entrepreneurial ecosystem that recognizes and nurtures women entrepreneurs as a significant force behind

economic development of a nation. [Dutta & Shivani, (2023)] used a technology adoption approach to understand the factors that require women entrepreneurs of West Bengal and Jharkhand to use and adopt e-commerce into their entrepreneurial initiatives. The findings revealed that technology is user-friendly and the use of it will enhance the people's e-commerce penetration. [Kumar & Shobana, (2023)] explored the evolution of women entrepreneurship in India. Through a comprehensive review methodology, the study addressed the economic impact of women entrepreneurs in terms of job creation, GDP contribution, and empowerment of women in the workforce. [Gamage, (2023)] examined the gender gap in e-commerce adoption barriers among entrepreneurs in Sri Lanka. The findings of the investigation highlighted substantial disparities in the perception of e-commerce adoption barriers between male and female entrepreneurs. Female entrepreneurs encounter difficulties pertaining to lack of e-commerce awareness, fear and reluctance to change, hurdles in delivery of goods, etc in e-commerce adoption, thus, underscoring the relevant influence of gender on shaping e-commerce adoption patterns. [Reddy, (2024)] followed a case study approach and explored the various challenges and opportunities women entrepreneurs in the country of India face in their path of entrepreneurship. The lack of access to credit, lack of business networking scope and societal expectations still pull the legs of these success bearers. Many women entrepreneurs have emerged in the light of growing consumer market opportunities. The awareness and acceptance of women in the changing business landscape ends in supportive entrepreneurial ecosystem in the country. [Suganya & Thenmozhi, (2020)] in their study suggested ways through which women entrepreneurs can overcome the hurdles in the path of their e-commerce entrepreneurial venture. Their study highlighted the significance of digital knowledge and technological knowhow on the part of women entrepreneurs to make them standout in the crowd. [Garg, (2025)] identified the emerging issues such as digital divide and the impact of COVIDcapacity development programs, training and policy interventions on the part of government and other regulatory agencies to fuel-up the spirit of entrepreneurship among the women of our country. [Kaur et al., (2025)] in their research paper attempts to understand rural women's entrepreneurship in attaining Sustainability Development Goals (SDGs). It attempts to connect India's current SDGs index with the business led by females in rural areas and found that there are many factors responsible for the overall SDGs index of India, some of which includes Indian government policies, incubator centres, education, infrastructure, and technology. The study emphasized the significance of women entrepreneurs in rural India as a catalyst for economic development and social transformation. [Ramya, (2024)] adopted a descriptive research design, alongside a case study-based approach to give an overview of the evolution of women entrepreneurship in India. The study highlights on how women-led businesses in India empowers the economy by reducing poverty and reshaping India's cultural standards.

Statement of the Problem

Although women entrepreneurs in Tamil Nadu are increasingly venturing into green startups, their contributions to sustainable development remain under-recognized and insufficiently documented. Many women-led green enterprises face persistent challenges such as limited access to capital, technology, training, and formal markets, along with socio-cultural barriers that restrict entrepreneurial growth. There is also a lack of systematic studies assessing their role in promoting environmental sustainability, employment generation, and community development. Without clear evidence and policy attention, the potential of women entrepreneurs to drive the green economy may remain underutilized. This study addresses these gaps by examining the challenges, opportunities, and impact of women-led green startups in Tamil Nadu.

Objectives of the study

1. To analyze the role of women entrepreneurs in establishing and managing green startups in Tamil Nadu.
2. To examine the contribution of women-led green startups to sustainable development and environmental protection.
3. To identify the challenges faced by women entrepreneurs in starting and sustaining green enterprises.
4. To assess the support provided by government schemes, financial institutions, and incubation centers to women-led green startups.

5. To suggest strategies and policy measures to strengthen women's participation in green entrepreneurship in Tamil Nadu.

Research Methodology

This study adopts a mixed-method research design combining both quantitative and qualitative approaches to comprehensively examine women entrepreneurs driving green startups in Tamil Nadu. Primary data will be collected through a structured questionnaire survey administered to women entrepreneurs engaged in green business sectors such as renewable energy, organic farming, waste management, eco-products, and sustainable services. A purposive sampling technique will be used to select respondents across different districts. In-depth semi-structured interviews will also be conducted with selected entrepreneurs, officials of support agencies, and incubators to gain deeper insights into opportunities and challenges.

Challenges Faced by Women in Green Enterprises

Women involved in green enterprises encounter multiple obstacles despite their growing participation in sustainable business initiatives. A key challenge is limited access to finance and credit, as many women lack collateral, financial literacy, or institutional support. They also face technological and skill gaps, particularly in sectors such as renewable energy, waste management, and eco-innovation that require specialized knowledge. Market access and visibility remain constrained due to weak networks, limited digital presence, and competition from larger firms. Socio-cultural barriers, including gender stereotypes, domestic responsibilities, and mobility restrictions, further hinder their entrepreneurial growth. Women entrepreneurs often experience policy and regulatory hurdles**,** such as complex licensing procedures and inadequate awareness of government schemes. In addition, they face challenges in scaling up enterprises, accessing raw materials, and maintaining consistent demand for green products. Balancing sustainability goals with business profitability also poses difficulties. These constraints collectively limit the full potential of women in driving green entrepreneurship and sustainable development.

1. **Access to Financial Resources**: Access to financial resources remains a major barrier for women engaged in green enterprises. Many women lack collateral, land ownership, or strong credit histories, which limits their ability to obtain bank loans or institutional finance. Green startups are often perceived as risky investments with longer gestation periods, making lenders more reluctant to provide funding. Limited awareness of government schemes, complex procedures, and lack of financial literacy further restrict access to credit. As a result, women frequently depend on personal savings or family support, which constrains the enterprise's growth. Expanding inclusive financing schemes and simplifying loan processes is essential to support women-led green businesses.
2. **Gender Discrimination and Bias:** Gender discrimination and bias continue to hinder women's participation in green enterprises. Women entrepreneurs often face stereotypes that question their leadership ability, technical competence, and decision-making capacity, particularly in male-dominated sectors such as renewable energy and waste management. These biases can limit access to investors, markets, training, and professional networks. Social expectations related to domestic responsibilities and mobility restrictions further constrain their entrepreneurial engagement. Subtle workplace discrimination, lower credibility in negotiations, and unequal treatment in financial institutions also affect their business growth. Overcoming gender bias requires awareness campaigns, mentorship opportunities, inclusive policies, and supportive institutional environments that recognize women as capable green innovators and leaders.
3. **Limited Networking and Market Access:** Limited networking and market access pose significant challenges for women in green enterprises. Many women entrepreneurs have fewer opportunities to participate in business networks, trade fairs, and industry associations due to time constraints, mobility issues, or social norms. As a result, they struggle to build professional connections that are crucial for marketing, collaborations, funding, and mentorship. Inadequate digital literacy and limited use of e-commerce platforms further restrict their market reach. Green products often require awareness-building among consumers, which adds another layer of difficulty. Enhancing networking platforms, digital skills,

and market linkages is essential to strengthen women-led green enterprises and expand their business opportunities.

4. **Balancing Family and Business Responsibilities:** Balancing family and business responsibilities is a persistent challenge for women in green enterprises. Women are often expected to manage household duties, childcare, and caregiving alongside entrepreneurial work, resulting in time pressure and emotional strain. These dual roles can limit their multiple ability to travel, attend training programs, or fully commit to business expansion. Social expectations may discourage prioritizing business over family obligations, affecting decision-making and confidence. The lack of affordable childcare and supportive family structures further complicates this balance. Promoting shared domestic responsibilities, flexible work arrangements, and supportive family and community attitudes is crucial for enabling women entrepreneurs to successfully manage both family and green business commitments.
5. **Limited Access to Technology and Innovation:** Limited access to technology and innovation is a critical challenge for women-led green enterprises. Many women entrepreneurs lack exposure to modern tools, machinery, renewable energy solutions, and digital platforms essential for efficient production, marketing, and business management. This technological gap restricts their ability to innovate, scale operations, and compete with larger or male-dominated enterprises. Limited technical training, inadequate support from incubation centers, and low awareness of emerging green technologies further exacerbate the issue. Strengthening access to skill development programs, digital literacy, and technology-enabled solutions is essential to empower women entrepreneurs, enhance productivity, and foster innovation in sustainable and environment friendly business practices.
6. **Environmental and Economic Risks: Women**-led green enterprises often face significant environmental and economic risks that affect their sustainability and growth. Environmentally, businesses in sectors like organic farming, renewable energy, and waste management are vulnerable to climate change, natural disasters, and resource scarcity, which can disrupt production and supply chains. Economically, green startups typically have longer gestation periods, higher initial costs, and uncertain market demand, making profitability a challenge. Limited financial buffers and lack of insurance mechanisms amplify these risks for women entrepreneurs. Addressing these challenges requires risk management strategies, access to climate-resilient technologies, financial support, and capacity-building initiatives to ensure the resilience of women-led sustainable enterprises.
7. **Lack of Mentorship and Networking:** Women entrepreneurs in green enterprises often face limited access to mentorship and professional networks, which restricts guidance, knowledge sharing, and business growth opportunities. The absence of role models and industry connections makes it difficult to navigate challenges, access markets, secure funding, and scale their sustainable ventures effectively.
8. **Policy and Legal Barriers:** Women-led green enterprises frequently encounter policy and legal barriers that hinder growth and sustainability. Complex licensing procedures, unclear regulations, and limited awareness of government schemes make compliance difficult. Inadequate support for women entrepreneurs in accessing subsidies, grants, or incentives further constrains development. Simplifying regulations and implementing gender-sensitive policies can enhance participation and success in green entrepreneurship.
9. **Cultural and Societal Barriers:** Cultural and societal norms often restrict women's participation in green entrepreneurship. Gender stereotypes, expectations of domestic responsibilities, and limited mobility can discourage women from starting or expanding businesses. Social pressures and lack of family or community support further impede entrepreneurial initiatives. Addressing these barriers requires awareness programs, community engagement, and promotion of gender-inclusive mindsets.

Opportunities for Women in Green Enterprises

Women entrepreneurs in green enterprises have a growing landscape of opportunities to contribute to environmental sustainability, economic development, and social empowerment. The increasing global and local awareness of climate change, resource depletion, and environmental degradation has created a strong demand for eco-friendly products and services. Women can tap into markets for renewable energy solutions, organic

agriculture, sustainable textiles, biodegradable products, water conservation technologies, and waste management services. This demand offers a platform for innovation and business growth while promoting sustainable consumption patterns.

Government initiatives and policy support in India, such as schemes from the Ministry of Micro, Small and Medium Enterprises (MSME), Women Entrepreneurship Development Programs, and financial incentives for green businesses, provide crucial opportunities for women to access funding, training, and mentorship. Incubation centers and entrepreneurship development programs increasingly support women-led startups in technology, digital solutions, and environmentally sustainable business models.

Digital technologies and e-commerce platforms also open up new avenues for women entrepreneurs, allowing them to reach wider consumer bases, promote eco-products, and create brand recognition with relatively low investment. Furthermore, women can leverage community-based models, self-help groups, and local knowledge to establish socially inclusive enterprises that address local environmental challenges.

Green enterprises also provide opportunities for leadership, innovation, and skill development. By entering sectors traditionally dominated by men, such as renewable energy or waste management, women entrepreneurs can challenge gender norms and inspire other women to pursue sustainable business ventures.

Women Entrepreneurship Platform (WEP)

The Women Entrepreneurship Platform (WEP) is an initiative launched by the NITI Aayog, Government of India, to promote and support women entrepreneurs across the country. WEP serves as a unified access point, connecting women entrepreneurs with resources, mentorship, funding, networking, and learning opportunities to strengthen their businesses. The platform aims to create an enabling ecosystem by bridging gaps in finance, skill development, technology adoption, and market access.

WEP provides multiple services, including online mentorship programs, learning modules, webinars, and networking events that help women entrepreneurs gain business knowledge, leadership skills, and exposure to global best practices. It also facilitates access to investors, incubation centers, and government schemes, enabling women to scale and sustain their enterprises.

Special emphasis is given to supporting women in emerging and high-impact sectors, including green and sustainable enterprises, technology, social entrepreneurship, and rural innovation. By fostering collaboration among stakeholders, WEP encourages peer learning, recognition of successful women entrepreneurs, and the creation of role models.

Conclusion

Women entrepreneurs are emerging as vital contributors to sustainable development through green enterprises in Tamil Nadu. By establishing businesses in renewable energy, organic farming, waste management, eco-friendly products, and other sustainable sectors, they are not only promoting environmental conservation but also generating employment, empowering communities, and fostering social inclusion. Despite facing challenges such as limited access to finance, technology, markets, mentorship, and societal barriers, women continue to demonstrate resilience, innovation, and leadership in green entrepreneurship. Opportunities through government schemes, digital platforms, incubation centers, and supportive networks further enhance their potential to create impactful and sustainable enterprises. Strengthening policy support, financial inclusion, skill development, and awareness programs can help overcome existing constraints and enable women to scale their green ventures. Overall, women-led green startups in Tamil Nadu serve as a model for combining economic growth with ecological responsibility, contributing significantly to a sustainable and inclusive future.

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Libraries as Catalysts of Change: Advancing the Development of Rural Libraries with Reference to Sankagiri in Salem District

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Abstract

Rural public libraries serve as vital centers of learning, culture, and community engagement, especially in under-resourced areas. This paper examines how libraries in the Sankagiri block of Salem District (Tamil Nadu) empower local communities through literacy and information access. We conducted surveys and interviews in Sankagiri's rural libraries to assess their roles in education, digital inclusion, and social development. Our findings indicate that Sankagiri's libraries significantly support reading habits and local knowledge (e.g., 80% of surveyed users reported improved literacy skills), but face challenges like outdated resources and limited ICT infrastructure. The study highlights the need for modernization and community partnerships: aligning with national policies (such as the National Mission on Libraries) and local governance can transform rural libraries into stronger catalysts of change.

Keywords: Rural Libraries; Community Development; Sankagiri; Salem District; Digital Literacy; Information Access; Library Empowerment; Tamil Nadu

Introduction

Public libraries in India are uniquely positioned to foster inclusive development by bridging gaps in education and information. In Tamil Nadu, a progressive library framework has long existed: the Public Libraries Act of 1948 created a tiered network of village, sub-district, district, and state libraries, making Tamil Nadu's system "one of the most successful models of library development in India". Such libraries are meant to serve as "the local gateway to knowledge" for all citizens, underpinning lifelong learning and informed decision-making. However, rural areas still lag in literacy and digital access. Salem District's literacy (72.9% in 2011) was below the state average of 80.1%, with rural literacy only 65.7%. The Sankagiri block, being largely rural, exemplifies these challenges. This study explores Sankagiri's rural libraries as case studies for empowerment: assessing how they contribute to literacy, digital inclusion, and social development, and identifying obstacles such as funding and infrastructure. It situates the Sankagiri findings within broader literature on libraries as agents of social change.

Literature Review

International and Indian studies consistently highlight the transformative role of rural libraries. UNESCO's Public Library Manifesto proclaims libraries as a "living force for education, culture, inclusion and information" and emphasizes that the public library provides "basic conditions for lifelong learning" and community development. In practice, public libraries empower communities by offering free access to books and ICT, organizing literacy programs, and fostering social capital. For example, Harrison observed that a public library can become "an intellectual centre of life for the area it serves," linking community members with both traditional knowledge and new information.

In India, studies show similar impacts. Niti Mollah (2013) notes that rural libraries can "boost development by disseminating information related to agriculture, marketing, and health" to villagers. Digital inclusion is a major concern: Paloti and Naikal (2004) emphasize that empowering rural libraries is crucial for "bridging the digital gap" in India by bringing ICT to the masses. Concurrently, national policy initiatives (e.g. the National Mission on Libraries) explicitly aim to modernize libraries through ICT and training, to minimize the divide between "knowledge rich" and "knowledge deficit" communities. At the state level, Tamil Nadu's library network—supported by legislation and government funding—provides a strong framework; local Panchayats and community groups often partner with libraries to extend outreach.

Not with standing these efforts, literature also identifies persistent challenges. Many rural libraries in India suffer from outdated collections, insufficient staff, and inadequate facilities. Surveys report that, despite their potential, a significant proportion of rural libraries still lack Internet access and struggle to attract younger patrons. In Sankagiri specifically, no published study exists, but by analogy with similar regions we expect that

libraries face hurdles in resources and modernization while striving to empower users. This review frames our inquiry into Sankagiri: we build on evidence that libraries can improve literacy and provide critical information, and examine how those roles manifest (or falter) in the Sankagiri context.

Methodology

This qualitative, descriptive study combined field surveys, interviews, and secondary data analysis. We focused on the Sankagiri block (Salem District), which includes both the town of Sankagiri and surrounding villages. First, we identified all public and community libraries in the block (a mix of government and local village libraries, as well as any NGO-supported reading rooms). From July to September 2024, we visited 10 rural libraries and the Sankagiri government district library. At each library we conducted structured interviews with librarians and volunteer staff (about 15 informants total) and administered questionnaires to patrons (approximately 150 adult users and 50 non-users from nearby villages, selected randomly). The questionnaire covered reading habits, information needs (education, farming, health), and perceptions of library services. We also recorded library metrics (e.g. collection size, ICT equipment, and hours of operation).

Data from surveys and interviews were analyzed descriptively. Numeric results (e.g. percent agreement) are summarized in tables below. We then cross-referenced findings with government statistics (e.g. Salem literacy rates) and existing literature on library impact. Ethical consent was obtained from all participants, and local authorities cooperated by providing historical usage data and recent funding information for context.

Research Questions

1. How do rural libraries in Sankagiri contribute to community empowerment through literacy, education, and information access?
2. What are the main challenges facing these libraries in terms of infrastructure, funding, staffing, and technology?
3. How can rural libraries in Sankagiri be strengthened or modernized to ensure their sustainable development and greater impact?
4. What role does collaboration with local bodies (panchayats, schools, NGOs) and government programs play in the growth and usage of these libraries?

Findings and Analysis

Our field study generated both quantitative and qualitative insights. Below we summarize key findings, supported by Tables 1–2 which illustrate library resources and user survey results.

Library Resources and Usage. Table 1 (below) shows that Sankagiri's libraries have modest collections (typically 3,000–8,000 books) and very limited ICT. Only 4 of the 10 village libraries surveyed had even a single computer, and just half offered basic Internet access. Average monthly footfall per library ranged from 30 to 150 patrons, concentrated among schoolchildren and farmers. Library staff are few: most village libraries had only one part-time librarian (often a local volunteer). This resource gap is consistent with literature noting that many rural libraries lack up-to-date equipment.

Library (Village)	Books (No.)	Computers	Internet Access	Avg. Monthly Users	Staff (Full-Time)
Pondhukinaru (Govt Library)	8,000	1	Yes	150	1
Annapoorna (Community)	3,500	0	No	40	0.5 (volunteer)
Thuttampatti (Village Library)	4,200	0	No	60	1
Athani (Village Library)	5,000	2	Yes	120	1
Ariyampatty (Village Library)	2,500	0	No	30	0.5
Pandaravalli (Village Library)	6,700	1	Yes	140	1

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Radhapuram (Village Library)	3,800	0	No	50	0.5
Seriyampatti (Village Library)	2,200	0	No	35	0.5
Settlement (Panchayat Library)	8,500	3	Yes	160	2
Sankagiri Govt (District)	10,000	5	Yes	200	3

Table 1: Resources and usage statistics of selected rural libraries in Sankagiri (survey data).

The data show stark contrasts: government-run libraries (e.g. Pondhukinaru, Sankagiri district) are better equipped and busier than tiny village libraries. This reflects Tamil Nadu's network (supported by state law) but also highlights that many village libraries remain under-resourced. As noted in the literature, such libraries risk falling "almost defunct" without revitalization. In Sankagiri, the shortfall in ICT is notable: despite national efforts to modernize libraries, only 40% of libraries here have computers and Internet. This limits their ability to bridge the digital divide for farmers and students.

Table 2 summarizes patron survey responses. A large majority (80%) of library users agreed that the local library had improved their reading habits and school performance. Many mothers reported that children's story hours and new books helped their kids read more, aligning with research that public libraries "create and strengthen reading habits in children". Students also said libraries supported formal learning: for example, 75% of young adult users borrowed reference books or used library space for group study. This outcome is consistent with Harrison's idea of the library as an "intellectual centre" for community learning.

Notably, 65% of farmers surveyed used libraries as information sources for agriculture and local news. They cited books and pamphlets on improved crop practices, as well as elders exchanging traditional knowledge there. This resonates with Mollah's view that rural libraries disseminate vital agricultural and health information. Users valued this role: one farmer commented, "Our library had a pamphlet on vegetable farming that helped me increase yield." However, 35% of users disagreed that libraries currently meet these needs fully – indicating gaps in collections and outreach.

Despite strong interest, 85% of users expressed willingness to use online resources if available. In our survey, only 30% of users had ever used the Internet at the library, and most of those sessions were slow or interrupted. This limited adoption highlights the persistent "digital gap" in rural India. Patrons identified lack of computers and irregular electricity/internet as major barriers. Thus, while Sankagiri's residents recognize libraries as potential ICT centers, the reality falls short.

Challenges Identified

The majority of librarians and users cited the following problems: inadequate funding (reported by 70% of librarians), outdated or insufficient book collections (75% of users), and staff shortages (most village libraries had no trained librarians). One librarian noted that collections were often donated and lacked the latest curricula or local language materials. These issues mirror trends observed elsewhere in rural India. On the positive side, collaboration emerged as a partial solution: 60% of village libraries had some support from local Panchayats (e.g. space or small grants), and 30% held joint programs with nearby schools or health clinics. Such partnerships are crucial, as libraries flourish when integrated with community initiatives.

Aspect	% Agree (Users)	% Disagree
Library improved my reading/study habits	80%	20%
Library provides useful agricultural info	65%	35%
Library has sufficient new books/materials	25%	75%
Library hours/space are adequate	40%	60%
Interested in digital services from library	85%	15%

Table 2: Sankagiri community survey on library impact (N=150 users).

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In summary, the findings show that Sankagiri's rural libraries positively affect literacy and local knowledge, but face infrastructure deficits. Bridging the knowledge gap is a recognized mission in library strategy, yet our survey reveals that many Sankagiri libraries cannot yet fulfill this role fully. These local findings are consistent with the literature: public libraries support "free access to computer and information technology resources" and promote "lifelong learning and literacy", but require investment and modernization to realize that potential.

Results

The evidence indicates that Sankagiri's libraries have become catalysts of change in their communities. A significant majority of users (≈80%) reported that library use strengthened their reading habits and educational outcomes. Libraries serve as hubs for self-education and cultural activities, echoing Harrison's notion of an intellectual center. They also act as information portals for farmers and small entrepreneurs, aligning with Mollah's assertion that rural libraries disseminate critical development information.

Consistent with other studies, we found that inadequate infrastructure hinders these libraries. Only 40% had computer/Internet access, underscoring the persistent digital divide. Many libraries struggle with outdated collections and minimal staff, reflecting challenges noted in rural library research. Despite Tamil Nadu's strong statutory support for libraries, Sankagiri still exemplifies the need for modernization: for example, 75% of users felt book supplies were insufficient, indicating a need for updated and diverse materials.

Libraries partnered with local bodies showed better service. Where Panchayats provided space or where libraries ran programs with schools/NGOs, usage was higher. This illustrates the value of community involvement. The National Mission on Libraries stresses multi-stakeholder cooperation to "modernize library management" and promote ICT. Our data suggest that leveraging these frameworks (e.g. through state grants or digital surveys) could help Sankagiri libraries secure needed resources.

While interest in digital resources is strong (85% of patrons), actual usage is low. Only a minority of libraries currently offer any online service, highlighting a critical gap. This mirrors national observations that many public libraries remain technologically behind. However, even minimal digital provision (e.g. a computer in Athani library) resulted in noticeable increases in youth usage, suggesting that targeted ICT investment could greatly enhance impact.

Conclusion

This study of Sankagiri's rural libraries confirms that libraries can be catalysts of rural development when adequately supported. Our survey shows that, even in resource-constrained settings, libraries contribute to literacy, lifelong learning, and community cohesion, in line with UNESCO's vision of libraries as "essential agents for sustainable development". However, to fully realize this potential, strategic improvements are needed. Strengthening infrastructure (modernizing collections, adding ICT), training librarians, and extending opening hours would directly address user concerns. Moreover, the findings reinforce the importance of state and local backing: Tamil Nadu's statutory library framework and the National Mission on Libraries provide models for funding and digital inclusion that Sankagiri could emulate. Finally, sustained collaboration with Panchayats, schools, and NGOs will ensure these libraries meet local needs.

In conclusion, Sankagiri's libraries exemplify both the promise and challenges of rural libraries in India. By building on existing strengths and addressing identified gaps, they can continue to advance education, digital literacy, and social empowerment for the region. As one Sri Lankan proponent put it, libraries give villagers "access to the knowledge and information that people need"—a principle that Sankagiri's libraries are poised to fulfill with the right support.

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Beyond the Bookshelf: Surveying the Role of Public Libraries in Fostering Social Cohesion in Coimbatore District

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Abstract

This paper discusses how public libraries in Coimbatore District, plays a vital roles and responsibility in providing social cohesion to user community and contribute themselves to provide educational efficacy knowledge among public users. This paper explore the multifaceted services provided by the public libraries in Coimbatore district to support the social inclusion for different communities. This survey was conducted using a set of close ended questionnaires which was targeted the public library users nearly out of 75 respondents, the actual replay was received from 68 respondents and as the result of the survey which shows elucidating their significance in social cohesion, information dissemination, socio-economic development, and public library as a cultural development center. The Survey results also highlights the suggestions for creating new arrival of patron and how to make them involved towards public libraries.

Keywords: Coimbatore district Public libraries, User awareness, Social Cohesion Service, Knowledge hub, Community Engagement, Information Access.

Introduction

Public libraries in Coimbatore district is a community-funded institution, which is also supported by the local, regional, or national taxes. Public library also has the information dissemination, open access system to every member of the community. It is also a community focus which governs to serve the public interest and meet local needs. Public libraries in Coimbatore district has the diverse resources which provides books, digital media, internet, and programs for all ages. The core functions of the public libraries in Coimbatore district are life-long self-education, formal learning and skill development for the user community and acts as the community hub for the cultural activities. Coimbatore district public libraries are such socially gathering hubs, which work with the people more directly than others. So the public libraries can act as the social cohesion implementing agency among the society.

Review of Literature

T. Prakash, (2017) carried out a study on "Information Seeking Behavior Towards the Library Resources and Services in Coimbatore District Central Library; A Study". The paper presents the results of a questionnaires based on the survey conducted within the Coimbatore district central public library. Result reveal that the libraries has the very useful library resources and services.

Smitanjali Panda, (2023) conducted the review on the "Role of Public Libraries in Promoting Peace and Social Cohesion through United Nation's Sustainable Development Goals (SDG)". The paper presents the results of the reviewed role and development of the public libraries in development of social cohesion and peace in communities and societies with the help of the SDG. As a result of the reviews the paper highlights the identification and discussion of the views and position on the concepts of library, peace and social cohesion.

S. Sheeba, (2015) carried out a study on "Growth of Public Libraries to Modern in Coimbatore District". The paper highlights the aims at the new technologies offering in Coimbatore public libraries and make them to use in different ways to generate and access information by the users and also highlights the Coimbatore public libraries departments who encourages the members of the library for utilizing the resources and services.

Objectives of the study

1) To assess the types of knowledge service required by the Coimbatore district-public library users and how efficiently they are using the resources.

2) To find out the Rate of Social Inclusion provided by the Coimbatore district-public library to the users.
3) To find out the frequency of visits by the users to the Coimbatore district-public libraries for their information needs.
4) To assess the ICT resources available in the Coimbatore district-public libraries, and their rate of effective usage by the users for their information needs.
5) To analyze the awareness of the users regarding the services and resources available in the Coimbatore district-public libraries.
6) To analyze and recommend a suggestion regarding the awareness programs about the different library schemes provided by the Coimbatore district-public libraries for the user's benefits.
7) To assess the user's requirements for the add-on training session regarding the handling of digital services provided by the Coimbatore district public libraries.

Methodology

For the purpose of this survey, Coimbatore district-public libraries are selected, among them the survey was held potentially at Government Public Library (Town Hall) and District central public library. The questionnaires are close-ended questions methods. Researcher proposed to select 75 respondents from survey questionnaires. The actual replay was received from 68 respondents and the survey is based on the purposive random sampling with quantitative analysis as the result of the survey is analyzed in the simple percentages and pie charts.

Some of the list of public libraries in Coimbatore District

1) District central library (RS Puram).
2) Government public Library (Town Hall).
3) Coimbatore city Library and Science Center.
4) Government Library(Peelamedu).
5) Anna Kalainar Library(Puliyakulam).
6) Village Libraries – 228 (approx.)
7) Local library authority libraries – 251 (approx.)
8) New Launching Library – The Periyar Library and Science Center – 2026 (opening shortly).

Analysis

Table 1:Response received from the respondents:

S.no	Questionnaires Distributed	No. of. respondents	Percentage
1.	**Respondents**	**68**	**90.67**
2.	**Not – Respondents**	**7**	**9.33**
TOTAL		**75**	**100**

Table 2 Displays the Response received from the respondent's regarding the social inclusion and free knowledge service provided by Coimbatore district-public libraries to all Users:

S.no	Coimbatore district-public libraries	Respondents	Percentage %
1.	Social inclusion & Free knowledge service	68	100%
TOTAL		**68**	**100**

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Table 2 Discussion

Table 2 provides the information regarding the response received from the respondents about the social inclusion and free knowledge service provided by Coimbatore district-public libraries to all Users. It is found that total survey result is 100% and the participant (68) agreed and satisfied about the Coimbatore district-public libraries providing the Social inclusion and Free knowledge service to all user community.

Pie-Chart 1:

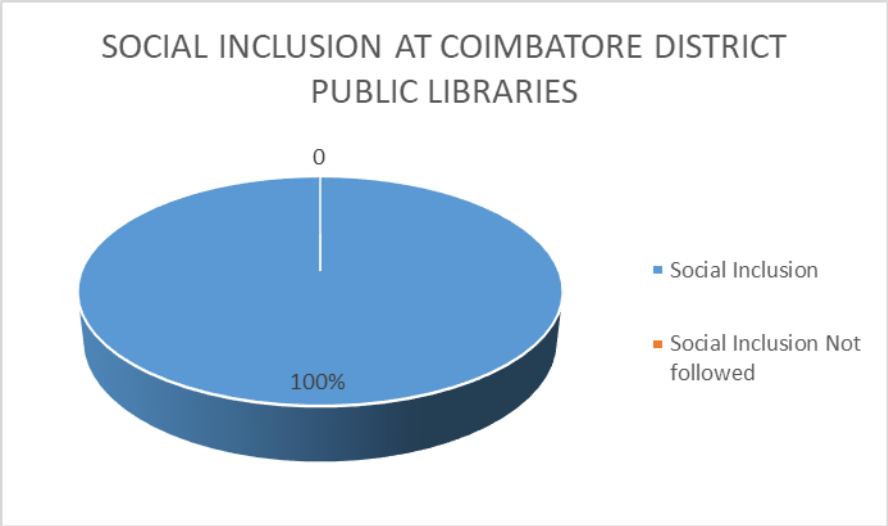


Table 3

S.no	Scheme	Scheme Followed	Scheme Not-Followed	Percentage of Scheme Received
1.	Friends of Library Schemes	98.5	1.5	98.5%

Table 3 Discussion

Table 3 provides the information regarding the **Friends of Library Schemes followed** by the Coimbatore district-public libraries. It is found that from the result of the survey among the 68 respondent (98.5%) of public library user's libraries follows the **Friends of Library Schemes** at their libraries. Remaining user's libraries, the schemes are not followed (1.5%).

Pie-Chart 2:

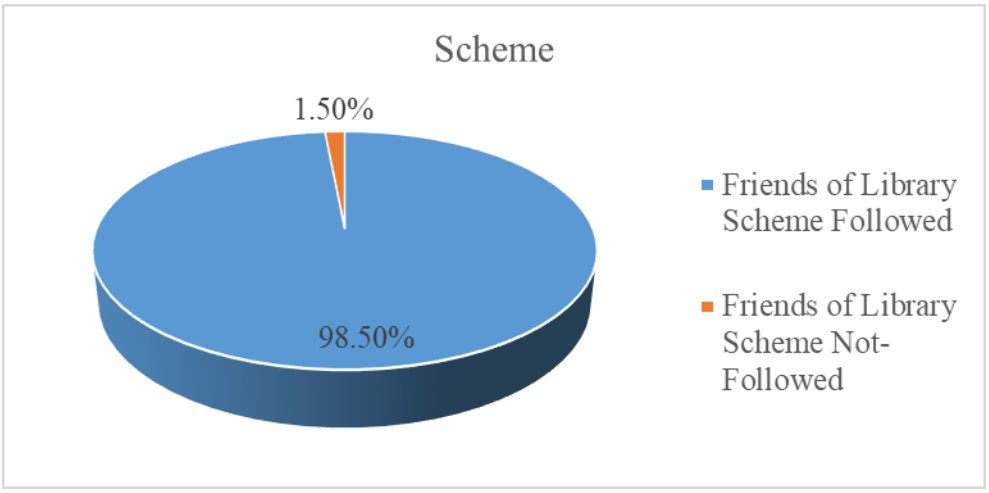


Table 4

S.no	Education & Knowledge Sharing available in Coimbatore district public libraries among users satisfaction level	Percentage %
1.	All Respondent are satisfied (68)	100%

Table 4 Discussion

Table 4 provides the information regarding the **Education & Knowledge Sharing available in Coimbatore district public libraries among user's satisfaction level.** And the result will be, all the users who are visiting the Coimbatore district public libraries are satisfied about the education & knowledge sharing availability.

Pie-Chart 3

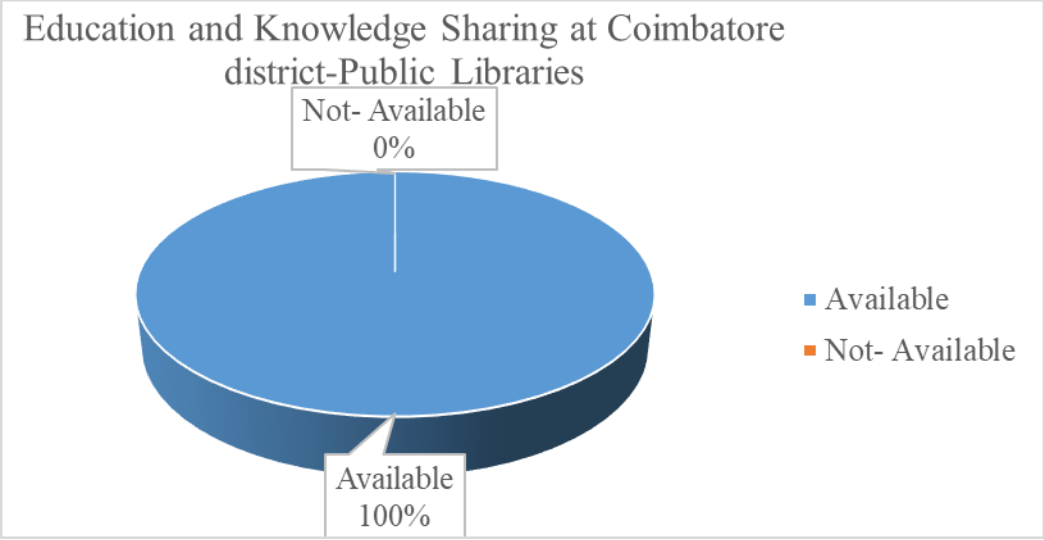


Table 5 provides the assess regarding the Coimbatore district public libraries conducting the summer camp, social & cultural awareness programs and serves as the community hub of arts centers:

S.no	Summer Camps & other awareness programs at Coimbatore district public libraries	Participated	Not Participated	Participated Users Percentage%
1.	Respondent 68	95.6	4.4	95.6%

Table 5 Discussion

Table 5 Highlights the summer camp, social & cultural awareness programs are conducted by the Coimbatore district-public libraries, among 68 respondents 95.6% of them participated in the camps and rest of their public libraries are not providing the services. The lagging may due to the not suitable infrastructure and environmental constrains within their library.

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Pie-Chart 4

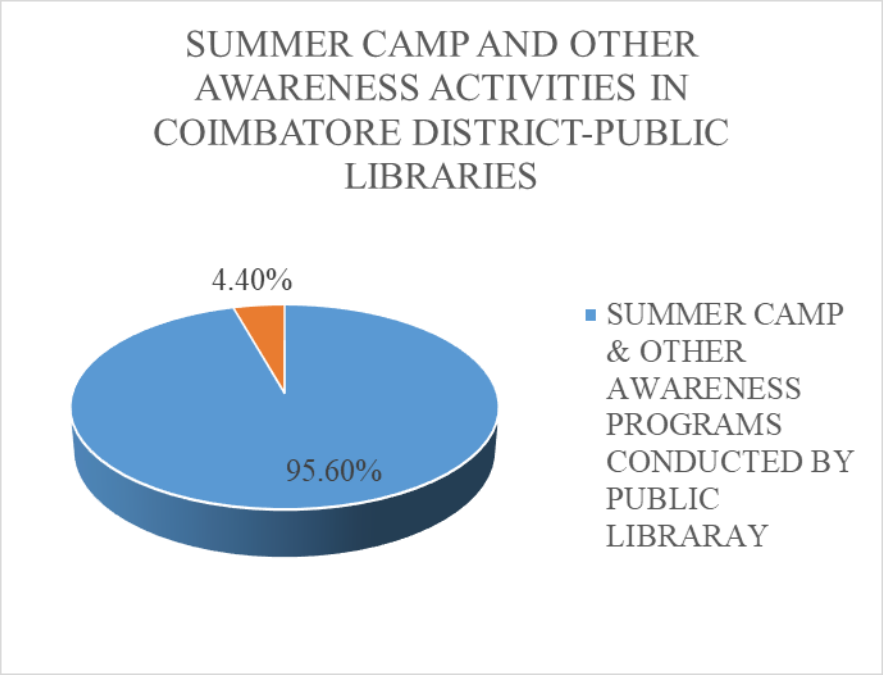


Table 6

Table 6 assess the data regarding the digital service provided by the Coimbatore district public libraries and the rate of shortcomings in the digital services:

S.no	Digital Services in Coimbatore district public libraries	No. of Respondents out of 75	Percentage levels of 68 respondents
1.	Slow Internet connection speed	56	82.4%
2.	Hardware/Software problems	3	4.4%
3.	Digital Data Security & Privacy Issues	2	2.9%
4.	Copyrights Issues	1	1.5%
5.	Maintenance costs of digital services	6	8.8%
TOTAL		68	100%

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Table 6 Discussion

Table 6 states that the data regarding the digital services available in the Coimbatore district public libraries and the assess of the digital services also estimated from the respondents. The result found that the majority of the respondents shows their assessment on slow internet connection speed and other short comes as follows. This can be rectified by the improvement of the internet speed and proper ICT maintenance inside the public libraries.

Chart 5

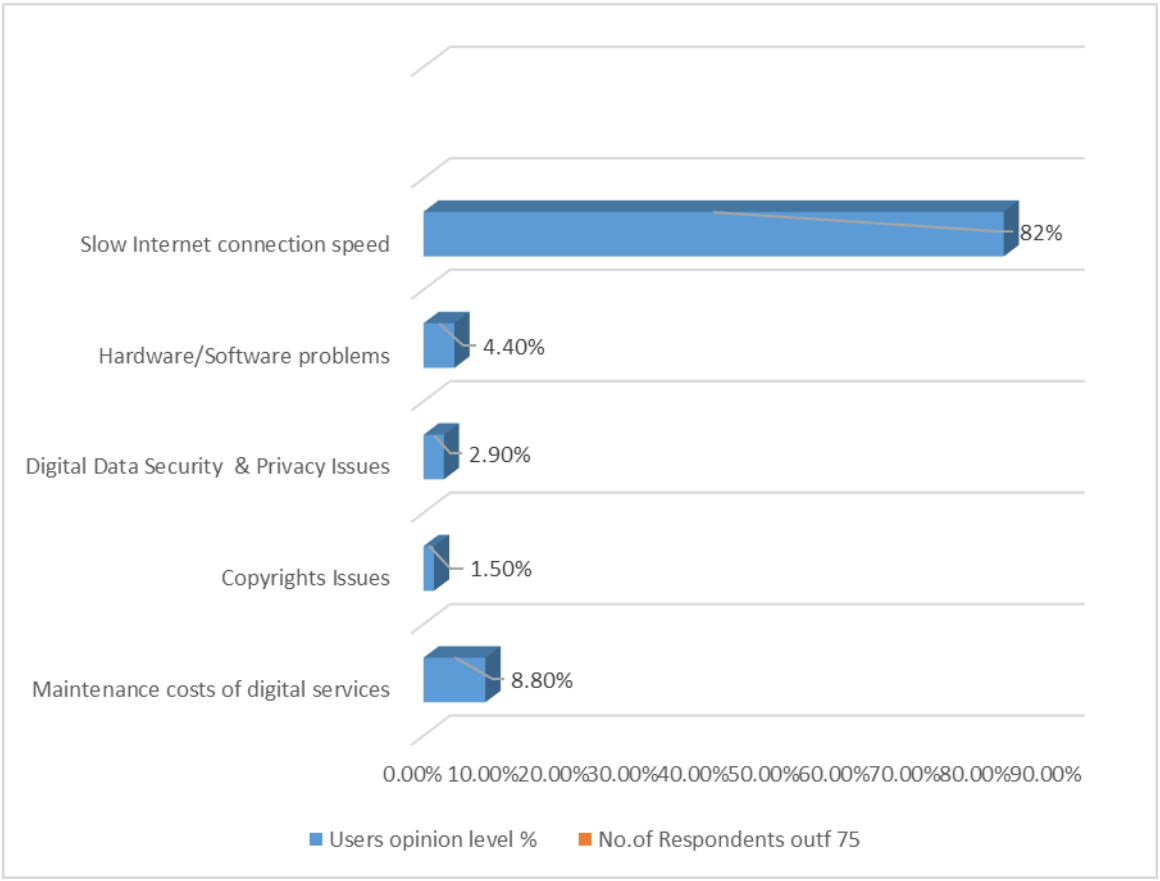


Table 7

Table 7 information states that the frequency of visit to the Coimbatore district public libraries by the users (The data is excluding from the Govt. competitive exam preparation students visits):

S.no	**No. of Users Visiting to public libraries**	**Percentage**
1.	Frequency of visit is High	51.5%
2.	Frequency of visit is Medium	33.8%
3.	Frequency of visit is Low	14.7%
Total		100%

Table 7 Discussion

Table 7 shows the data about the frequency visits of users to the Coimbatore district public libraries and their user engagement in utilization of resources available in the Coimbatore district public libraries. The result shows that the High frequency of visit is (51.5%), Medium frequency of visit is (33.8%) and Low frequency of visit is (14.7%).

Pie Chart 6

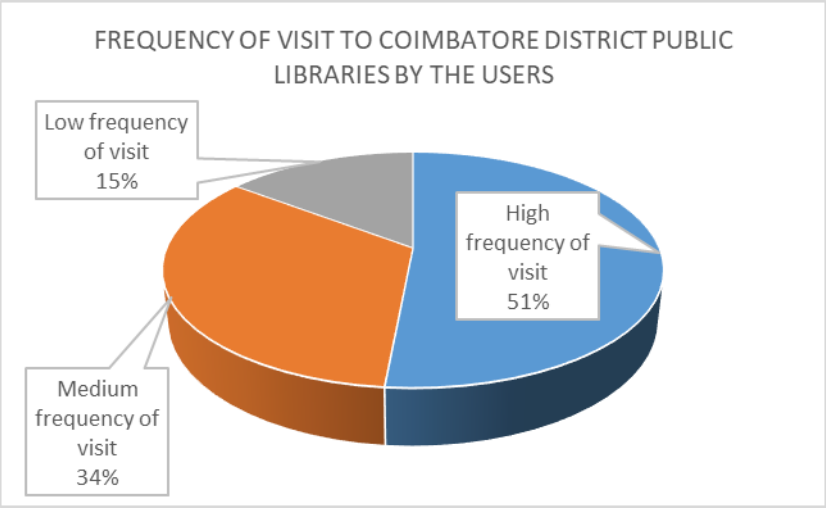


Table 8

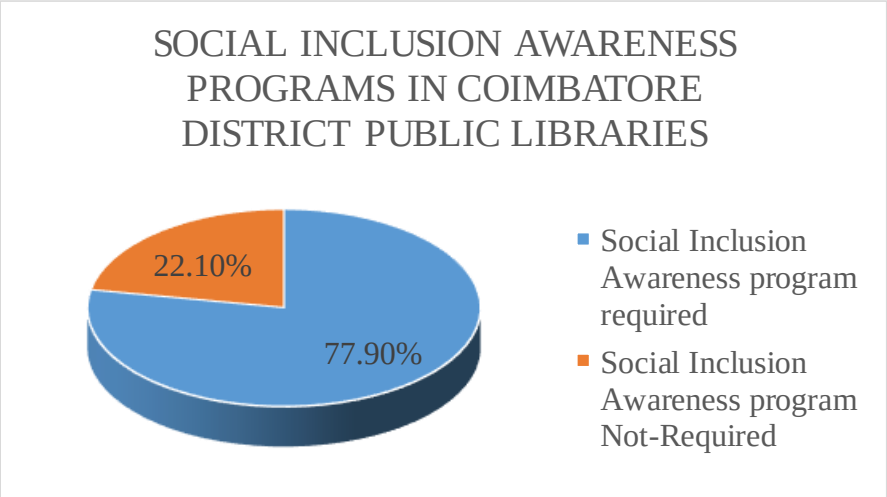
Table 8 contains the data about the need of awareness about the social inclusion, which is use to increase the no. of visitors to the Coimbatore district public libraries:

S.no	Awareness requirements for the users	Required	Not-Required	Percentage of awareness Required User
1.	Social Inclusion awareness program	77.9 respondent	22.1 Respondent	77.9%

Table 8 Discussion

It can be observed from the table 8 that the Coimbatore district public users required the awareness programs regarding social inclusion developments among the public library users, As the result, the assessment shows that the (77.9%) respondents shows interest for social inclusion awareness programs and (22.1%) are not interested.

Pie Chart 7



Findings

The findings of the survey reveals that the response of the 68 users all the questionnaires, 68 valid questionnaires response were taken into account for the survey and the response rate is maximum level. The majority of respondents are educated (56.5%) users and the survey also includes the public library employee (11.5%) also participated in the survey.

Conclusion and Recommendation

Coimbatore district public libraries are providing a vital role in public knowledge and education support, they also serve as the free knowledge hubs and social-cultural development center for local community users. And as the suggestion of the survey result, the Coimbatore district public libraries are playing a significant role in developing social cohesion in the public libraries and also much and more could be done to make users involvement. The social cohesion in the public libraries regarding the awareness programs can be promoted by some strategic approach that has the outreaches like community and cultural integration programs, involving youth, children and adults into valuable story-sharing session. And digital (social media) outreaches of social cohesion awareness can be done through some social media outreaches like collaboration and partnerships with NGO's, creating online community forums, virtual library communities. And also the frequency of visit to public libraries can be potentially increased by creating through advertisement in public gathering places, local media partnerships, print media publicity, updated websites services for public libraries. Above we have seen the simple efforts to increase the social cohesion in Coimbatore district public libraries. According to my survey, Coimbatore district public libraries plays a vital role in fostering social cohesion among the user community.

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From Fields to Metadata: Fostering Cross-Sector Collaboration between Libraries and Agricultural Databases to Empower Tamil Nadu's Farmers: With Special Reference to Erode District

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Abstract

This conference article proposes a transformative collaboration between the library science community and agricultural data providers. It addresses the critical gap between the vast, digitized agricultural knowledge resources and their accessibility, utility, and application by end-user farmers in rural Tamil Nadu. By repositioning libraries (public, block, and mobile) as dynamic "Agricultural Knowledge Hubs," we can leverage librarian expertise in information curation, local trust, and digital literacy to bridge the last mile. This article outlines a framework for collaboration, practical service models, and a call to action for database providers, librarians, and policymakers.

Keywords: Agricultural extension, Digital divide, Knowledge hubs, Library transformation, ICT4Ag, Tamil Nadu

Introduction

Tamil Nadu possesses a strong agricultural knowledge infrastructure, supported by advanced research institutions such as the Tamil Nadu Agricultural University (TNAU) and DRDO laboratories, robust government schemes including PM-KISAN and the National Mission on Agricultural Extension and Technology (NMAET), and rich digital agricultural databases such as the TNAU Agritech Portal, AGROWEB, Soil Health Card Database, and India Meteorological Department (IMD) weather data. These resources collectively generate vast amounts of agricultural data and technical knowledge. However, despite this abundance, smallholder farmers in districts like Erode—similar to Tirunelveli or Dharmapuri—often depend on fragmented, informal, and anecdotal sources of information for their farming decisions. The core challenge lies not in the availability of data, but in the absence of contextualized, actionable, and easily accessible information tailored to local crops, climatic conditions, and farmer capacities. Digital databases, though information-rich, remain largely disconnected from the everyday information practices of farmers. In this context, libraries emerge as untapped catalysts for change. With their established presence up to the block and local levels and their inherent mission of equitable access to information, libraries are uniquely positioned to act as intermediaries between agricultural databases and farming communities. By fostering cross-sector collaboration between libraries and agricultural information systems, and by translating field-level needs into usable metadata and services, libraries can play a transformative role in empowering farmers. This paper examines such collaborative possibilities with special reference to Erode District.

The Librarian as an Agricultural Knowledge Curator: Evolving Roles

The modern librarian's role must expand from bookkeeper to information facilitator. For this collaboration, librarians would develop new competencies:

- **Agricultural Data Literacy**: Understanding core agricultural data types (weather, soil, market prices, pest advisories).
- **Localized Curation**: Filtering state-wide or national database information for local relevance (e.g., district-specific pest alerts, micro-weather forecasts).

- **Multi-Format Dissemination**: Packaging database outputs not just in digital form, but as voice-based messages (for non-literate users), printed bulletins in Tamil, visual infographics, and curated video playlists.
- **Feedback Loop Management**: Systematically capturing farmer queries and field observations to feed back to database managers, improving the relevance of data collected.

Framework for Collaboration: A Symbiotic Ecosystem

A successful model requires structured partnerships:

Partners:

- Agricultural Database Providers: TNAU Agritech, ICRISAT, MS Swaminathan Research Foundation, National Agricultural Market (e-NAM), Tamil Nadu Agricultural Marketing Board.
- Library Network: Tamil Nadu Public Library Department, District Central Libraries, Block Libraries, NGO-run Mobile Library Units.
- Facilitators: Krishi Vigyan Kendras (KVKs), NABARD, Local Agricultural Officers.

Proposed Model: The Library-Based Agri-Service Point (LASP)

1. **Infrastructure & Training**: Database providers grant libraries subsidized/free access and train librarians on navigation and basic interpretation. Libraries upgrade minimal IT infrastructure (a dedicated computer, projector, cheap data plans).
2. **Service Integration**:

- Scheduled Query Sessions: "Ask the Agri-Librarian" sessions where farmers bring problems (leaf discoloration, low yield) for database-assisted research.
- Customized Alerts: Librarians help farmers subscribe to SMS/IVR alerts in Tamil from databases (e.g., monsoon alerts, price spikes for their specific crop).
- Market Intelligence Corner: Display daily/weekly modal prices from e-NAM for local mandis on a whiteboard.
- Digital Literacy Workshops: Teaching farmers to access TNAU's videos or use the Soil Health Card portal independently.
- Community Archiving: Using the library as a space to document and share successful local indigenous practices, integrating them with formal database knowledge.

Addressing Critical Challenges in the Tamil Nadu Context

- **Language & Literacy**: All database interfaces and outputs must prioritize Tamil. Librarians act as translators of technical jargon.
- **Digital Divide**: Services must be hybrid. A farmer can receive a printed soil health summary and a link to a demonstration video.
- **Trust Deficit**: Librarians, as neutral, long-term community figures, can build trust in digital recommendations more effectively than a new, unknown app.
- **Sustainability**: Initial funding can be sought from CSR (corporate social responsibility) funds of agri-businesses, government grants (Digital India, National Mission on Agricultural Extension), and modest community contributions for printouts.

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Case for Investment: Expected Outcomes

- **For Farmers**: Improved decision-making, higher productivity, better risk management, and enhanced agency.
- **For Database Providers**: Increased user base, richer feedback data, tangible impact metrics, and fulfillment of public outreach mandates.
- **For Libraries**: Reinforced community relevance, increased footfall, and evolution into vital development institutions.
- **For Policymakers**: More efficient utilization of public data investments and strengthened agricultural extension architecture.

Phase 1: Framework & MoU

A Memorandum of Understanding (MoU) was signed between the M. S. Swaminathan Research Foundation (MSSRF) and the Department of Library and Information Science, Vellalar College for Women (Autonomous), Erode.

Establish a Central Steering Committee: Comprising representatives from library Science Department MSSRF and Public Library of Erode District a Special reference to Kanjikovil.

Phase 2: Pilots Project

Launch LASP Pilot Projects: Building on the Kanjikovil model, launch 3-5 structured Library Agri-Service Point (LASP) pilots in diverse agro-climatic zones.

These pilots will integrate:

- Database Access: Provision of tailored access to TNAU Agritech Portal, Soil Health Card data, and e-NAM market intelligence.
- Capacity Building: Training librarians as "Agri-Knowledge Facilitators," using Kanjikovil's experience as a core case study.
- Technology Kits: Providing basic toolkits (portable projector, soil testing kits, tablet with curated apps) to each pilot library.

Implementation

Vellalar College for Women, Department of Library and Information Science pilot project: Building on Proven Success

The vision for libraries as Agricultural Knowledge Hubs is not theoretical—it is already being successfully piloted. The Kanjikovil Branch Library stands as a living prototype, demonstrating the transformative impact of such collaborative, community-centered programming:

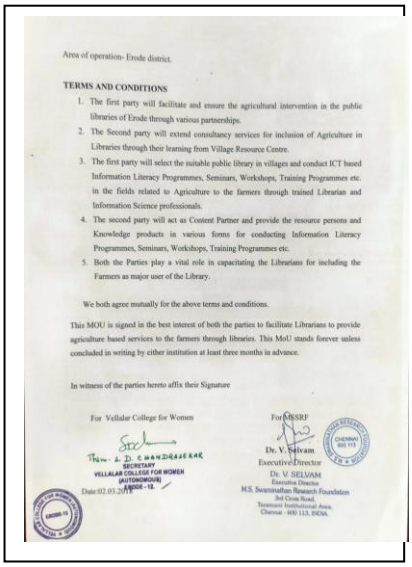
- Since 2017, their annual Crop Medicine Camp with the M.S. Swaminathan Research Foundation has directly served over 150 farmers from 15 villages, bridging formal agricultural science with field-level problems.
- Their Makers Space (since 2014) fosters innovation and environmental stewardship, with participants achieving state-level recognition—proving libraries can nurture scientific temperament.
- The Young Farmers' Circle (since 2018) is creating the next generation of agriculturally-literate, environmentally-conscious citizens.
- Programs on Nutrition Awareness and Telehealth show the library's role as a holistic rural development node.

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Kanjikovil proves the model works. Our call to action is to systematize, resource, and scale it. We, therefore, propose the immediate formation of a Tamil Nadu Agri-Knowledge Consortium (TNAKC), a formal network to institutionalize and expand these successful partnerships.

A MoU between the Department of Library and Information Science, Vellalar College for Women, Erode and M. S. Swaminathan Research Foundation, Chennai provides an operational blueprint for this framework.


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MEMORANDUM OF UNDERSTANDING
Between
VELLALAR COLLEGE FOR WOMEN, (AUTONOMOUS), Erode
and
M.S. SWAMINATHAN RESEARCH FOUNDATION,
CHENNAI
INTRODUCTION
The Post Graduate and Research Department of Library and Information Science, Vellalar College for Women (Autonomous), Erode herein after called the First party and M.S. Swaminathan Research Foundation (MSSRF), Chennai herein after called the second party will enter into a Memorandum of Understanding with the following alliance for improving the capacity of the Librarians and enhancing the services of the Libraries for farmers.


Area of operation- Erode district.
TERMS AND CONDITIONS
1. The first party will facilitate and ensure the agricultural intervention in the public libraries of Erode through various partnerships.
2. The Second party will extend consultancy services for inclusion of Agriculture in Libraries through their learning from Village Resource Centre.
3. The first party will select the suitable public library in villages and conduct ICT based Information Literacy Programmes, Seminars, Workshops, Training Programmes etc. in the fields related to Agriculture to the farmers through trained Librarian and Information Science professionals.
4. The second party will act as Content Partner and provide the resource persons and Knowledge products in various forms for conducting Information Literacy Programmes, Seminars, Workshops, Training Programmes etc.
5. Both the Parties play a vital role in capacitating the Librarians for including the Farmers as major user of the Library.
We both agree mutually for the above terms and conditions.
This MOU is signed in the best interest of both the parties to facilitate Librarians to provide agriculture based services to the farmers through libraries. This MoU stands forever unless concluded in writing by either institution at least three months in advance.
In witness of the parties hereto affix their Signature
For Vellalar College for Women
For MSSRF
Dr. V. Selvam
Executive Director
Dr. V. SELVAM
Executive Director
M.S. Swaminathan Research Foundation
3rd Cross Road,
Taramani Institutional Area,
Chennai - 600 113, INDIA.

Internship Training Programme @ MSSRF, CHENNAI

The PG Department of Library and Information Science (PGDLIS) has sent 12 students from I M.L.I.Sc for internship training at MSSRF for twenty days i.e., from May 14, 2018 to June 06, 2018. Based on the Memorandum of Understanding (MoU) signed with M.S. Swaminathan Research Foundation, Chennai, the students were trained in the ICT based innovative services that can be integrated for community development. They also learnt the research related services at Panchalingapuram Library of MSSRF as well as trained on community-related services through public libraries through partnership. The following are the list of students undergone the training:

S. No.	NAME OF THE STUDENT
1.	ANANTHI.N
2.	DHANYA.G
3.	DHIVYA.P
4.	KIRUTHIKA.N
5.	KRISHNA PRIYA.V
6.	MANGAIYERKARASI.I
7.	MIRUNALINI.K
8.	PAVITHRA.S
9.	RAGAVI.D
10.	SANJUPRIYA.S

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11.	SARATHA PREETHA.C
12.	VISUDHA.R

T. STEPHEN
HOD, PG DEPARTMENT OF LIBRARY AND INFORMATION SCIENCE, VELLALAR COLLEGE FOR WOMEN, ERODE

Dr. V. SELVAM
EXECUTIVE DIRECTOR
M.S. SWAMINATHAN RESEARCH FOUNDATION, CHENNAI

Village Knowledge Centre (Panchalingapuram, Erode District)

The PG Department of Library and Information Science (PGDLIS) has taken initiatives to establish Village Knowledge Centre in Panchalingapuram based on the Memorandum of Understanding(MoU) signed with M.S. Swaminathan Research Foundation, Chennai.

In this connection the Mr. T. Stephen, HOD, faculty members of the department Ms. D. Mercy Lydia and Ms. S. Esther Delsy visited Uzhavar Mandram, Panchalingapuram and had a fruitful discussion with the farmers towards setting up of Village Knowledge Centre(VKC) in that village on 12.08.2018. The objective of VKC is to facilitate the farmers with necessary information regarding the recent developments in farming technology, pest control, increasing the yielding, water management, dry farming etc. In addition, it aims to empower the farmers with various new techniques developed by the researchers and scientists of MSSRF by organizing programmes such as online chats, plant clinic, discussion forums etc.

The office bearers of Uzhavar Mandram and members of the same agreed to set us VKC in their village. The students of Master of Library and Information Science and faculty members had a fruitful discussion with the farmers and discussed the problems faced by them in their field.



WEBINAR ON DIGITAL PLANT CLINIC

The PG Department of Library and Information Science (PGDLIS) and **Unnath Bharath Abhiyan** in association with M.S. Swaminathan Research Foundation, Chennai has organized a webinar on **"Digital Plant**

Clinic". Based on the Memorandum of Understanding (MoU) signed with M.S. Swaminathan Research Foundation, Chennai a Community Development Programme was organized on 16.04.2020 through online-Google Meet platform.

Dr. R. Rajkumar, Scientist, MSSRF, Chennai was the resource person and has discussed many issues related to pests and diseases in plants during the pandemic period.

Resource person, Dr. G. Sudhakar, Plant Doctor, Thiruvaiyaaru has clarified the doubts of farmers and provided solutions to control the plant diseases and pests. Another resource person, Dr. K. Bharathidasan, Agriculture Entomology, Plant Doctor, MSSRF, Pudukkottai provided marketing strategies, storage and preservation methods during this pandemic period.

The coordinator of the program, Ms. D. Mercy Lydia, Assistant Professor, PG Department of Library and Information Science (PGDLIS) and, welcomed the gathering and introduced the resource person. Mr. T. Stephen, Head, PGDLIS introduced the theme and has felicitated the gathering. The programme ended with vote of thanks by Ms. S. Dhivya, Assistant Professor, PGDLIS. Nearly 47 farmers were benefitted through this programme.

Webinar on Safe Farming: During Corona Epidemic

The PG Department of Library and Information Science (PGDLIS) in association with M.S. Swaminathan Research Foundation, Chennai has organized a webinar on **"Safe Farming: During Corona Epidemic**". Based on the Memorandum of Understanding (MoU) signed with M.S. Swaminathan Research Foundation, Chennai a Student Development Programme was organized on 9.04.2020 through online-Google Meet platform.

The objective of the programme was to create awareness to farmers for a safe farming during this lock down period. Dr. R. Rajkumar, Scientist, MSSRF, Chennai was the resource person and has discussed many issues related to safe farming during the pandemic period.

Another resource person, Dr. T. Senthilkumar, Agriculture Officer and Advisor, MSSRF, Chennai has clarified the doubts of students from farming background at the end of the programme. Nearly 56 students were benefitted through this programme.

The expected outcome of the programme is uninterrupted Agriculture, Good Productivity and Marketing Strategies. The coordinator of the program, Ms. D. Mercy Lydia, Assistant Professor, PG Department of Library and Information Science (PGDLIS) and, welcomed the gathering and introduced the resource person.

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Dr. V. SELVAM
EXECUTIVE DIRECTOR
M.S. SWAMINATHAN RESEARCH FOUNDATION, CHENNAI

Mr. T. Stephen, Head, PGDLIS introduced the theme and has felicitated the gathering. The programme ended with vote of thanks by Ms. S. Dhivya, Assistant Professor, PGDLIS.

Conclusion

Libraries are not just repositories of books; they are potential synapses in the nervous system of rural knowledge economies. By strategically collaborating with agricultural database holders, we can transform

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passive data into active, field-level wisdom. This partnership promises a more resilient, informed, and prosperous farming community in Tamil Nadu, aligning perfectly with the goals of sustainable development and digital inclusion. Let us move from simply hosting information to cultivating it, together.





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Digital Transformation and Innovation

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[1&2]II M.com and [3]Assistant professor, Department of Commerce, Vellalar College for Women (Autonomous), Erode**.**

ABSTRACT

Digital transformation and innovation have become central to the development of modern information systems, particularly in libraries and knowledge institutions. The rapid growth of digital technologies has reshaped the way information is created, stored, accessed, and preserved. Libraries are no longer limited to physical collections; instead, they have evolved into digital knowledge hubs offering electronic resources, digital services, and long-term preservation solutions. This paper explores the concept of digital transformation and innovation with special reference to digital libraries, e-resources, and digital preservation. It highlights the role of emerging technologies, institutional strategies, and user-centered services in enhancing access to information. The study also examines the challenges faced during digital transformation and emphasizes the importance of innovation in sustaining library services in the digital era. The paper concludes that effective digital transformation is essential for improving information accessibility, ensuring preservation of digital content, and supporting lifelong learning in the knowledge society.

Keywords: Digital Transformation, Digital Libraries, E-Resources, Digital Preservation, Innovation

INTRODUCTION

The digital age has significantly transformed the way information is produced, disseminated, and utilized. Digital transformation refers to the integration of digital technologies into all areas of an organization, fundamentally changing how it operates and delivers value to users. In libraries and information centers, digital transformation has led to the development of digital libraries, electronic resources, and advanced preservation techniques.

Innovation plays a crucial role in this transformation by enabling libraries to adopt new technologies, improve service delivery, and meet the changing needs of users. Traditional library services have expanded to include online access, remote services, and digital content management. This shift has made information more accessible, efficient, and sustainable.

CONCEPT OF DIGITAL TRANSFORMATION

Digital transformation is a continuous process that involves the adoption of digital tools and innovative practices to improve organizational performance. In the library context, it includes automation, digitization of resources, implementation of digital platforms, and use of information and communication technologies (ICT).

Digital transformation is not limited to technology alone; it also involves changes in organizational culture, staff skills, and service models. Libraries must redesign workflows, develop digital competencies among professionals, and focus on user engagement to achieve successful transformation.

ROLE OF INNOVATION INDIGITAL TRANSFORMATION

Innovation is the driving force behind digital transformation. It enables libraries to experiment with new ideas, services, and technologies. Innovative approaches such as cloud computing, artificial intelligence, data analytics, and mobile applications have enhanced the efficiency of library operations.

Through innovation, libraries can introduce personalized services, virtual reference systems, and interactive learning platforms. Innovation also supports collaboration among institutions and promotes open access initiatives, thereby expanding the reach of knowledge resources.

DIGITAL LIBRARIES

MEANING OF DIGITAL LIBRARIES

A digital library is an organized collection of digital content that is accessible through electronic systems. It includes digitized documents, born-digital materials, multimedia resources, and online databases. Digital libraries provide users with anytime, anywhere access to information.

FEATURES OF DIGITAL LIBRARIES

Digital libraries offer features such as advanced search facilities, metadata management, interoperability, and remote access. They support multiple formats including text, images, audio, and video. These features enhance user experience and information retrieval.

IIMPORTANCE OF DIGITAL LIBRARIES

Digital libraries play a vital role in education, research, and knowledge dissemination. They reduce physical space requirements, improve access to rare materials, and support academic collaboration. Digital libraries also contribute to sustainability by reducing the use of paper.

E-RESOURCES

CONCEPT OF E-RESOURCES

E-resources refer to information materials that are available in electronic format. These include e-books, e-journals, online databases, institutional repositories, and open access resources. E-resources have become essential components of modern library collections.

TYPES OF E-RESOURCES

- **E-Books** – Digitized or born-digital books accessible online.
- **E-Journals** – Scholarly journals available in electronic format for research and reference.
- **Databases**– Structured collections of information, e.g., bibliographic, full-text, or multimedia databases.
- **Institutional Repositories** – Digital archives of an institution's research output, theses, and publications.
- **Open Access Resources** – Free-to-access scholarly content, including journals, books, and reports.
- **Multimedia Resources** – Audio, video, images, and interactive learning materials.

ADVANTAGES OF E-RESOURCES

E-resources provide instant access, multi-user availability, and updated content. They support remote learning and research, especially in situations where physical access to libraries is limited. E-resources also enable efficient information sharing and cost-effective collection development.

DIGITAL PRESERVATION

MEANING OF DIGITAL PRESERVATION

Digital preservation is the process of maintaining and ensuring long-term access to digital information. It involves strategies and techniques to protect digital content from technological obsolescence, data loss, and degradation.

METHODS OF DIGITAL PRESERVATION

- **Migration –** Periodically transferring digital content to newer formats or systems to prevent obsolescence.
- **Emulation –** Using software or hardware to replicate old systems, allowing access to obsolete digital files.
- **Replication –** Creating multiple copies of digital files stored in different locations to safeguard against loss.

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- **Backup and Archiving –** Regularly storing data in secure storage, including cloud servers and physical media.
- **Use of Standardized Formats** – Saving digital content in widely accepted formats (e.g., PDF/A, XML) to ensure long-term readability.
- **Metadata Documentation** – Recording descriptive, structural, and preservation metadata to maintain authenticity and usability of digital content.

IMPORTANCE OF DIGITAL PRESERVATION

Digital preservation ensures that valuable digital content remains accessible for future generations. It supports cultural heritage preservation, academic research, and institutional memory. Without proper preservation strategies, digital information is at risk of permanent loss.

TECHNOLOGIES SUPPORTING DIGITAL TRANSFORMATION

Emerging technologies such as cloud computing, artificial intelligence, blockchain, and big data analytics support digital transformation in libraries. These technologies enhance storage capacity, improve information retrieval, and ensure secure access to digital content.

Automation systems and integrated library management software streamline operations and reduce manual workloads. Innovative tools also support digital preservation and resource sharing among institutions.

CHALLENGES IN DIGITAL TRANSFORMATION

Despite its benefits, digital transformation faces several challenges. These include high implementation costs, lack of technical expertise, digital divide, and resistance to change. Data security and copyright issues also pose significant concerns.

Libraries must address these challenges through strategic planning, staff training, policy development, and collaboration with stakeholders. Sustainable funding and institutional support are essential for successful digital transformation.

FUTURE TRENDS IN DIGITAL TRANSFORMATION AND INNOVATION

The future of digital transformation lies in smart libraries, artificial intelligence-driven services, and immersive technologies such as virtual and augmented reality. User-centric design and open access initiatives will continue to shape library services.

Innovation will focus on enhancing user engagement, improving digital literacy, and expanding global access to information. Digital preservation strategies will evolve to address new formats and technologies.

CONCLUSION

Digital transformation and innovation have fundamentally reshaped the landscape of libraries and information services. The development of digital libraries, expansion of e-resources, and implementation of digital preservation strategies have improved access to information and ensured long-term sustainability of knowledge resources. Innovation plays a critical role in adapting to technological changes and meeting user expectations. Although challenges exist, effective planning and continuous innovation can help libraries overcome barriers and thrive in the digital era. Digital transformation is not an option but a necessity for libraries to remain relevant and impactful in the knowledge-driven society.

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Collaboration and Community Engagement – Corporate Social Responsibility

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Abstract

Corporate Social Responsibility (CSR) has evolved from a philanthropic activity to a strategic business approach that emphasizes sustainable development, ethical practices, and stakeholder involvement. In the contemporary business environment, collaboration and community engagement have emerged as critical components of effective CSR initiatives. Corporations increasingly recognize that partnerships with communities, non-governmental organizations (NGOs), government bodies, and other stakeholders enhance the social impact and long-term sustainability of CSR programs. This paper examines the role of collaboration and community engagement in CSR, highlighting their importance, models, benefits, challenges, and impact on corporate performance and societal development. Through a conceptual and analytical approach, the study emphasizes how collaborative CSR practices contribute to inclusive growth, trust-building, and shared value creation.

Keywords: Corporate Social Responsibility, Collaboration, Community Engagement, Stakeholders, Sustainable Development, Shared Value.

Introduction

In recent decades, the role of corporations in society has undergone a significant transformation. Businesses are no longer viewed solely as profit-generating entities but as social institutions responsible for contributing to economic, social, and environmental well-being. Corporate Social Responsibility (CSR) represents this broader obligation, encouraging firms to operate ethically and contribute to sustainable development while improving the quality of life of employees, local communities, and society at large.

Collaboration and community engagement have become central to modern CSR practices. Traditional top-down CSR initiatives often failed to address real community needs due to a lack of participation and understanding. As a result, companies now focus on collaborative approaches that involve community members and stakeholders in the planning, implementation, and evaluation of CSR programs. This participatory approach ensures relevance, effectiveness, and long-term impact.

This paper aims to explore the concept of collaboration and community engagement within CSR, analyze its importance, identify key stakeholders, discuss various models, and examine challenges and future prospects.

Meaning of Collaboration in CSR

Collaboration in CSR refers to the cooperative efforts between corporations and various stakeholders to achieve shared social and environmental objectives. It involves pooling resources, knowledge, expertise, and capabilities to maximize the impact of CSR initiatives.

Collaborative CSR initiatives often involve partnerships with:

- Local communities
- Non-governmental organizations (NGOs)
- Government agencies
- Educational institutions
- Social enterprises

Through collaboration, companies can leverage local knowledge, enhance credibility, reduce implementation risks, and ensure sustainability of projects. Collaborative CSR shifts the focus from isolated corporate actions to collective problem-solving.

Concept of Community Engagement in CSR

Community engagement is the process through which organizations actively involve community members in decision-making, planning, and execution of CSR initiatives. It emphasizes dialogue, participation, and mutual respect between corporations and communities.

Community engagement ensures that CSR activities are aligned with the actual needs and priorities of beneficiaries. Rather than imposing solutions, companies work alongside communities, empowering them to take ownership of development initiatives.

Effective community engagement includes:

- Needs assessment through consultation
- Participatory planning
- Capacity building
- Continuous communication
- Monitoring and feedback

This approach enhances transparency, trust, and social acceptance of corporate initiatives.

Importance of Collaboration and Community Engagement in CSR

- Collaboration and community engagement play a crucial role in enhancing the effectiveness of CSR programs. Their importance can be understood through the following aspects:
- Firstly, they ensure relevance and effectiveness. By engaging communities, companies gain insights into real social issues, leading to more impactful interventions.
- Secondly, collaboration promotes shared responsibility. When multiple stakeholders participate, the burden of implementation is shared, reducing costs and risks for corporations.
- Thirdly, community engagement builds trust and legitimacy. Active participation fosters goodwill, strengthens corporate reputation, and improves relationships with local communities.
- Fourthly, collaborative CSR supports sustainable development. Projects designed with community involvement are more likely to be maintained and sustained over time.

Objectives of Corporate Social Responsibility (CSR)

The principles of corporate social responsibility (CSR) comprise ethical and sustainable practices that serve the community. Below, we have given the list of objectives of corporate social responsibility,

- **Promote Ethical Business Practices:** Ensuring that business operations are conducted in a fair, transparent, and ethical manner that respects human rights, environmental sustainability, and community welfare.
- **Enhance Brand Image and Reputation:** Building a positive corporate image through active engagement in social causes can increase customer loyalty and investor confidence.
- **Contribute to Sustainable Development:** Supporting long-term economic, social, and environmental sustainability by addressing poverty reduction, climate change, and resource management.
- **Support Community Development:** Investing in local communities by providing support in education, healthcare, infrastructure, and employment opportunities.
- **Foster Employee Engagement and Satisfaction:** Encouraging employees to participate in CSR initiatives can enhance job satisfaction, morale, and organisational commitment.
- **Adhere to Legal and Regulatory Requirements:** Ensuring compliance with local and international laws and regulations related to environmental protection, labour standards, and social welfare.

This is the scope of corporate social responsibility companies should work upon to serve the community while making profits.

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Reasons for CSR Collaboration in India

- **Amplified Social Impact & Scale:** Collaborating allows organizations to pool financial resources and expertise to tackle massive, systemic issues like rural development, sanitation, and education that a single company cannot solve alone.
- **Expertise and Local Knowledge:** Partnering with Non-Governmental Organizations (NGOs) provides crucial grassroots understanding, ensuring that projects are relevant to the community's needs and properly implemented.
- **Enhanced Credibility and Trust:** Collaborative initiatives are viewed as more authentic, helping to build community trust and goodwill, which is essential for the longevity of projects.
- **Overcoming Resource Constraints:** Companies often lack the manpower or logistical capability to implement large-scale social projects. Collaboration with specialized partners bridges this gap.
- **Regulatory Compliance and Risk Management:** In India, CSR is mandatory. Collaboration with reputable partners helps firms meet compliance requirements effectively while managing reputational risks.
- **Sustainability and Innovation:** Working together encourages innovative approaches to environmental sustainability, such as waste management and climate action.

These partnerships foster a shift from mere corporate philanthropy to sustainable, long-term development that benefits both society and the business.

Procedural Steps for CSR Collaboration

CSR collaboration in India requires eligible companies (based on net worth, turnover, or profit) to form a CSR Committee, select implementing partners registered with the MCA via Form CSR-1, and align projects with Schedule VII of the Companies Act, 2013. Key steps involve legal compliance, due diligence, and filing Form CSR-1.

- **Eligibility Check:** Confirm the company meets the criteria under Section 135 (net worth >₹500 crore, turnover >₹1000 crore, or net profit > ₹5 crore).
- **Form CSR Committee:** Establish a committee of 3+ directors (including at least one independent director) to formulate policy and recommend projects.
- **Identify Partners/Implementers:** Select registered NGOs, Societies, Trusts, or Section 8 companies that have a valid registration number.
- **Register Implementing Agency (Form CSR-1):** Ensure the chosen NGO/agency files Form CSR-1 on the MCA portal to obtain a unique CSR Registration Number, certified by a professional (CA/CS/CMA).
- **Due Diligence & Agreement:** Verify the NGO's 12A/80G certificates, track record, and credentials. Sign a Memorandum of Understanding (MoU) detailing project scope, budget, and reporting timelines.
- **Project Implementation & Monitoring:** Execute the project in line with Schedule VII activities (e.g., education, health). The committee must monitor the project's progress.
- **Reporting & Disclosure:** File the annual report on CSR activities, including details of the projects and partners, in the prescribed format (Form CSR-2) as part of the Board's Report.

Key Challenges in CSR Collaboration and Implementation:

- **Compliance vs. Impact Focus:** The, 2%, mandatory spend rule often leads companies to focus on meeting financial targets rather than creating long-term, sustainable, social impact.
- **Lack of Transparency and Trust:** Inadequate reporting and, audit, mechanisms hinder trust between companies, NGOs, and, communities, sometimes leading to, misappropriation of funds.
- **Weak Community Engagement:** Projects are frequently designed from the top-down without, consulting local communities, resulting in, poor, alignment with actual needs and low, community participation.

- **Regional and Sectorial Disparity:** CSR funds are concentrated in more developed states (e.g., Maharashtra, Tamil Nadu) and, urban areas, leaving, rural, areas and, less developed, states, underfunded.
- **Skill Gaps in Implementation:** There is a, scarcity, of, trained CSR professionals who understand, impact assessment, and, stakeholder, management, leading to poor, execution.
- **Lack of Strategic Collaboration:** Limited, cooperation, between, corporations, and, NGOs, results in, fragmented efforts and duplication of projects.

Key Partnership Models:

- **Corporate-NGO Partnerships:** The most common form, where companies provide funds/tech, and NGOs handle on-ground implementation, local knowledge, and community engagement.
- **Public-Private Partnerships (PPP):** Collaborations between corporations and government bodies for large-scale infrastructure, health, or education projects (e.g., skill development, disaster relief).
- **Employee Volunteering & Engagement:** Firms partner with NGOs to facilitate skilled or unskilled volunteering opportunities for staff, boosting morale and community impact.
- **Industry-Academic Partnerships:** Collaborations with universities for research, innovation, and technical skill development.
- **Consortium Partnerships:** Multiple companies collaborating on a single large-scale social issue to maximize resources and impact.

Conclusion:

Collaboration has emerged as a central pillar of effective Corporate Social Responsibility. By fostering partnerships among diverse stakeholders, organizations can enhance the scale, impact, and sustainability of CSR initiatives. For M.Com students and future managers, understanding collaboration-driven CSR is essential for responsible leadership and ethical decision-making. A collaborative approach to CSR not only supports societal development but also strengthens corporate reputation and long-term business performance.

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Empowering Communities Power through Digital Public Libraries

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Abstract

For a long time, public libraries have been places where everyone can get information and knowledge. The change from physical public libraries to digital public libraries has greatly increased their ability to empower communities in the digital age. Digital public libraries use information and communication technologies (ICTs) to give everyone access to digital resources, online services, and programs that are good for the community. This paper talks about the idea of digital public libraries, looks at how they can help communities become more powerful, and talks about the pros and cons of digital transformation. The study shows how digital public libraries help with digital inclusion, lifelong learning, social equity, and civic engagement, which makes communities stronger in a society that is becoming more knowledge-based. Digital Public Libraries, Community Empowerment, Digital Inclusion, ICT, Public Library Services

Introduction

Libraries have traditionally been places where people can learn, enjoy culture, and grow socially. As digital technologies improve quickly, public libraries are changing from places that focus on print materials to places that mix print and digital materials or are completely digital. Digital public libraries offer services that go beyond the walls of the library by providing electronic resources, online platforms, and services that use technology.

This digital transformation has a huge effect on communities, especially when it comes to closing the digital divide, encouraging people to learn how to use technology, and letting people get involved. In this situation, digital public libraries are very important for giving communities power by making sure that everyone has equal access to information and helping people learn the digital skills they need for social and economic growth.

The idea of digital public libraries

A digital public library is a library system that lets people use online platforms to access digital resources like e-books, e-journals, databases, multimedia content, and digitised local collections. These libraries use ICT tools to offer services like virtual reference, online membership, digital lending, and access to information from anywhere.

Digital public libraries are more than just places to store electronic content. They are active service platforms that adapt to the changing information needs of a wide range of user groups, such as students, researchers, job seekers, seniors, and people from under-represented communities.

Digital public libraries give people in the community more power.

Digital public libraries help communities become more powerful in many ways:

Getting Everyone Online

Public libraries help close the digital divide by giving people free or low-cost access to computers, the internet, and other digital resources. This is especially important for rural and low-income communities that may not have access to digital infrastructure.

Learning and education for life

Digital libraries help people learn for the rest of their lives by providing open educational resources, online courses, and programs that teach digital literacy. People of all ages can access educational content whenever and wherever they want, which encourages self-directed and ongoing learning.

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Media and Information Literacy

Public libraries are important for improving information literacy because they teach people how to find, judge, and use digital information in a responsible way. This gives people the power to make smart choices and take part in society.

Social Inclusion and Fairness

Digital public libraries help people with disabilities, language minorities, and other groups that don't get enough services by making them available to everyone. Assistive technologies, multilingual resources, and digital platforms that are open to everyone make it easier for everyone to take part.

Getting involved in your community and making it better

Digital platforms help public libraries make it easier for people to find government information, e-governance services, and community information portals. This makes people more involved in their communities and encourages them to take part in democratic processes.

The part that technology plays in digital public libraries

More and more public libraries are using technologies like cloud computing, mobile apps, artificial intelligence, and data analytics. These technologies make it easier to find resources, tailor services to each user, and make operations run more smoothly. Libraries can reach more people and get communities involved even more through social media and library websites.

Problems with Setting Up Digital Public Libraries

Even though they have some good points, digital public libraries have a lot of problems:

1. Poor digital infrastructure and lack of funding
2. Not enough trained library staff
3. Users who don't know how to use technology
4. Problems with licensing and copyright
5. Concerns about data privacy and cybersecurity

To deal with these problems, government agencies, library professionals, and community members need to work together, make plans, and get support from policies

What Lies Ahead

Creating digital services that are user-centred, inclusive, and long-lasting is the key to the future of digital public libraries. By combining new technologies and improving digital literacy programs, public libraries will be able to better help communities and support national development goals.

Conclusion

Digital public libraries have become important tools for giving people power in the digital age. They strengthen the role of public libraries as engines of knowledge and community development by making sure that everyone has equal access to information, encouraging digital skills, and promoting social inclusion. To make communities more informed, inclusive, and powerful, it is important to make digital public libraries stronger.

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Reading Habit among the Uniformed Personnel (Police Officers) of the Coimbatore District, Tamilnadu: A Study

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Abstract

Purpose*: Policing is a challenging job involving dealing with criminals, politicians, and pressure from higher officials. They are responsible for maintaining law and order during Bureaucrats' and politicians' visits, festive times, and any untoward incidents happening in the City. They stood under the scorching sun during the COVID 19 lockdown. They are sacrificing their happiness for the Nation. Hence, a study was done to find out their reading habit, which eventually reduced their stress level.*

Design*: A questionnaire-based study was conducted to determine the reading habit among the uniformed personnel of the Coimbatore District, Tamilnadu. Here uniformed personnel refer to the police officers. I have selected 25 Police Stations at random from 36 Stations in Coimbatore District. Questions were asked to 300 respondents from the 25 Police Stations, of which I received proper answers from 201 respondents, which resulted in a 67% response rate.*

Findings*: The collected responses were processed using SPSS software, and the following tests were conducted: Percentage Analysis, Mean score, Standard Deviation & Chi-square. The results showed that most of the respondents, 142 (70.6%), are in the age group of 41-50, and Politics is an interesting subject for less than half of the respondents 98(48.8%). 96(47.8%) respondents prefer to read if they find the time. The respondents suggest that the results of this study may be given to the officials concerned for their betterment.*

Originality*: No previous studies have been conducted that assess the various reasons for not developing reading habits by the Uniformed Personnel as they are susceptible to stress from various sources.*

Keywords*:* Reading Habit; Uniformed Personnel (Police Officers); reasons for not reading; print resources

Introduction

Studies on reading habits have been done on scientists, social scientists, school children and other professionals. Reading habits improve morality, relieve stress, lead to openness in society, provide free entertainment, improve concentration, stimulate curiosity, and remove social corruption.

Policing is a genuinely challenging work atmosphere with the danger, uncertainty at work, encounters, political pressure, exposure to cruelty and sometimes death. This might lead to stress among the Police Officers at work as there is negative pressure related to their work. As reading habit reduces the stress level to a greater extent, a study is conducted to determine the reading habit among Police Officers of the Coimbatore District.

Objectives

The following are the objectives of the study:

- To find out the time spent per day on reading
- To find the purpose of reading
- To know the interesting subject
- To know the preferred language of the reading materials
- To know if they are a member of a Library; and
- To know the reasons for not reading regularly

Literature Review

While searching for the literature related to the present study, I found a study titled "The information needs of female Police Officers involved in undercover prostitution work" by Baker[1] and found that Women Officers needed a diversity of information and they require several informal communication and dress code.

Existing information-seeking models do not meet the needs of Police Officers. More research is to be done to develop a model for Police Officers.

Methodology

In Coimbatore District, there are four regions such as Coimbatore West, East, Central, and South, resulting in 23 Police Stations. In Coimbatore Rural, I have taken the Perur and Periyanaicken Palayam Subdivisions resulting in 13 Police Stations [2]. Our study was confined to 36 Police Stations. Out of 36 Police Stations, 25 police stations were randomly selected and questionnaires were distributed and data could be collected up to the level of the Sub Inspector who was available and willing to participate at the time of data collection. Proper permission was obtained from the concerned authorities for data collection.

A study was conducted from June to November 2019 to solicit information on Reading habits among the Police Officers of the Coimbatore District. A structured questionnaire was used to solicit data from the respondents. It consists of two parts such as Part I & Part II, wherein Part I deal with questions ranging from gender, age group and educational qualification of the respondents and questions in part II deal with time spent per day for reading, preferred reading materials and language of reading materials, the purpose of reading, interesting subject, reasons for not reading regularly and whether they are a member of a Library. Questions were asked to 300 Police officers of the randomly selected 25 Police Stations from 36 Police Stations in Coimbatore District, and proper answers were received from 201 respondents, and the response rate was 67%.

The study is limited to the Sub Inspector level as other officers were very busy in their routines. The collected data were consolidated and analysed using SPSS software. Following tests were carried out: frequency, mean score, standard deviation and chi-square. These tests were carried out at 0.01 significant level.

Results and Discussion

Part I Personal Information

Table I provides information about the gender-wise distribution of the respondents. It is shown from table 5.1.1 that 63.7**%** (128) are male.

Table: 5.1.1 Gender wise Distribution

S.No	Gender	Frequency	Percentage (%)
1	Male	128	63.7
2.	Female	73	36.3
Total		**201**	**100.00**

Table: 5.1.2 Age Group of the Respondents

S.No	Age Group	Frequency	Percentage (%)
1	< 30	46	22.9
2.	31 - 40	7	3.5
3	41 - 50	142	70.6
4	**> 51**	**6**	**3.0**
Total		**201**	**100**

It is clear from Table 5.1.2 that 142(70.6%) respondents are in the age group of 41-50, while 6(3.0 %) respondents are in the age group of above 51.

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Table : 5.1.3 Educational Qualification of the Respondents

S.No	Qualification	Frequency	Percentage (%)
1	H.Sc	59	29.4
2.	Diploma	20	10.0
3	Graduation	112	55.6
4	Post Graduation	10	5.0
Total		**201**	**100**

It is found from Table 5.1.3 that half of the respondents 55.7% (112) have completed Graduation while 5.0% (10) have completed post-graduation.

Part - II: Study Area

Table: 5.2.1 Time spent per day for Reading

S.No	Time Spent	Frequency	Percentage (%)
1	<1 hour	125	62.4
2.	1 - 2 hour	37	18.3
3	2 - 3 hour	39	19.3
4	> 3 hour	0	0
Total		**201**	**100**

It is understandable from table 5.2.1 that more than half of the respondents, 125(62.4%), spend less than one hour per day for reading, and none of the respondents can spend more than 3 hours per day.

Table: 5.2.2 Types of Reading Materials

S.No	Types	Frequency	Percentage (%)
1	News Paper	128	63.7
2.	Magazine	60	29.8
3	Novel	13	6.5
Total		**201**	**100**

Table 5.2.2 shows the types of reading materials respondents are reading. More than half of the respondents 128 (63.7%) read newspapers daily.

Table: 5.2.3 Purpose of Reading

S.No	Types	Frequency	Percentage (%)
1	Education	59	29.4
2.	Information	93	46.3
3	Recreation	49	24.3
Total		**201**	**100**

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Table 5.2.3 illustrates the purpose for which respondents are reading. 93 respondents (46.3%) are reading for keeping themselves informed and (24.3%) 49 respondents are reading for recreation.

Table: 5.2.4 Subject of Interest

S.No	Interested Subject	Frequency	Percentage (%)
1	Politics	98	48.8
2.	S&T	8	4.0
3	Sports	70	34.8
4	Religion	19	9.4
5	Others	6	3.0
Total		**201**	**100**

Table 5.2.4 explains the interested subject of the respondents. Less than half of the respondents, 98 (48.8%) are interested in reading information related to Politics, while 6 (3%) are interested in reading news related to other items.

Table: 5.2.5 Language Preferred

S.No	Language	Frequency	Percentage (%)
1	Tamil	169	84.06
2.	English	23	11.44
3	Others	9	4.50
Total		**201**	**100**

Table 5.2.5 shows the preferred language. The majority of the respondents 169 (84.07%) prefer to read the information in Tamil while 9 (4.5%) respondents prefer other languages.

Table: 5.2.6 Library Membership

S.No	Library Membership	Frequency	Percentage (%)
1	Yes	53	26.36
2.	No	148	73.64
Total		**201**	**100**

It is clear from Table 5.2.6 that most of the respondents 148(73.64%) are not a member of a Library while 53 (26.36%) respondents are a member of a Library.

Table: 5.2.7 Reasons for not Reading

S.No	Reason	Frequency	Percentage (%)
1	Not Interested	6	3.0
2.	Boring Activity	7	3.4
3	Non-availability of reading materials	98	48.8
4	Heavy Workload	90	44.8
Total		**201**	**100**

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Table 5.2.7 describes the reasons for not reading by the respondents. It is shown that less than half of the respondents, 98 (48.8%) are not reading due to non-availability of reading materials and 90 (44.8%) respondents are not able to read because of their heavy workload.

Table: 5.2.8 I would read more, if

S.No	Reason	Frequency	Percentage (%)
1	More time	96	47.8
2.	Cost of the Book	92	45.8
3	Interesting Subject	13	6.4
Total		**201**	**100**

Table 5.2.8 explains that 96 (47.8%) respondents would read more if they had more time and 13 (6.5%) respondents would read more if they find information on interesting subjects.

Table: 5.2.9 Mean & Standard Deviation

S.No		Mean Score	Std. Dev
1	Gender	1.36	0.482
2	Age Group	2.54	0.877
3	Educational Qualification	2.36	0.960
4	Time to read/day	1.57	0.798
5	Types of materials	1.78	0.839
6	Purpose of Reading	1.95	0.733
7	Interested subject	2.14	1.213
8	Language Preferred	1.45	0.582
9	Member of Library	1.54	0.500
10	Reason for not reading regularly	3.35	0.693
11	They would read more, if	1.59	0.611

Table 5.2.9 shows the mean score and standard deviation. It is observed that the reason for not reading regularly ranked high with a maximum mean score of 3.35 and interesting subjects ranked high with the highest standard deviation score of 1.213.

Table: 5.2.10 Chi-Square Value-Personal factors - Time to Read per day

Table 5.2.10 explains the personal factors of the respondents, chi-square values, p values and their significance on time to read per day.

Personal factors	Chi-Square Value	Probability	NS/S
Gender	9.003	0.01	S
Age Group	49.762	0.00	S
Educational Qualification	79.629	0.00	S

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It is evident from table 5.2.10 that personal factors of the respondents have a significant influence on time to read per day.

Table: 5.2.11 Chi-Square Value-Personal factors- Types of Reading Materials

Table 5.2.11 explains the personal factors of the respondents, chi-square values, p values and their significance on types of reading materials.

Personal factors	Chi-Square Value	Probability	NS/S
Gender	26.661	0.00	S
Age Group	56.139	0.00	S
Educational Qualification	63.004	0.00	S

It is evident from Table 5.2.11 that the personal factors of the respondents have a significant influence on types of reading materials.

Table: 5.2.12 Chi-Square Value-Personal factors - Purpose of Reading

Table 5.2.12 explains the personal factors of the respondents, chi-square values, p values and their significance on the purpose of reading.

Personal factors	Chi-Square Value	Probability	NS/S
Gender	10.563	0.01	S
Age Group	86.862	0.00	S
Educational Qualification	1.382	0.00	S

It is evident from Table 5.2.12 that personal factors of the respondents have a significant influence on the purpose of reading.

Table: 5.2.13 Chi-Square Value - Personal factors - Subject Interest

Table 5.2.13 explains the personal factors of the respondents, chi-square values, p values and their significance on the interested subject.

Personal factors	Chi-Square Value	Probability	NS/S
Gender	47.593	0.00	S
Age Group	52.881	0.00	S
Educational Qualification	1.458	0.00	S

It is evident from Table 5.2.13 that personal factors of the respondents have a significant influence on the interested subject.

Table: 5.2.14 Chi-Square Value-Personal factors- Language Preferred

Table 5.2.14 explains the personal factors of the respondents, chi-square values, p values and their significance on the preferred language.

Personal factors	Chi-Square Value	Probability	NS/S
Gender	25.45	0.00	S
Age Group	57.548	0.00	S
Educational Qualification	76.703	0.00	S

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It is evident from Table 5.2.14 that the personal factors of the respondents have a significant influence on the preferred language.

Table: 5.2.15 Chi-Square Value - Personal factors- Member of Library

Table 5.2.15 explains the personal factors of the respondents, chi-square values, p values and their significance on member of the Library.

Personal factors	Chi-Square Value	Probability	NS/S
Gender	66.756	0.00	S
Age Group	91.564	0.00	S
Educational Qualification	98.820	0.00	S

It is evident from Table 5.2.15 that the personal factors of the respondents have a significant influence on member of the library.

Table: 5.2.16 Chi-Square Value-Personal factors- Reasons for not reading regularly

Table 5.2.16 explains the personal factors of the respondents, chi-square values, p values and their significance on reasons for not reading regularly.

Personal factors	Chi-Square Value	Probability	NS/S
Gender	10.182	0.012	S
Age Group	2.114	0.00	S
Educational Qualification	48.550	0.00	S

It is evident from Table 5.2.16 that the personal factors of the respondents have a significant influence on reasons for not reading regularly.

Table: 5.2.17 Chi-Square Value - Personal factors - They would read more, if

Table 5.2.17 explains the personal factors of the respondents, chi-square values, p values and their significance on they would read more if they had.

Personal factors	Chi-Square Value	Probability	NS/S
Gender	0.0350	0.9830	NS
Age Group	13.426	0.0127	S
Educational Qualification	35.758	0.0000	S

It is evident from Table 5.2.17 that except gender of the respondents, the rest of the personal factors have a significant influence on whether they would read more.

Findings

- Personal factors of the respondents have significant influence on the all the factors such as time spent per day to read, types and preferred language of the reading materials, interested subject, member of a library, reasons for not reading regularly and the respondents would read more if they had more time.
- 53 respondents became a member of a District Library during their School days. At present, they do not find time to visit the Library.
- It is also observed that they face many pressures from their higher officials, politicians, and dealing with criminals leads them to mental turmoil; sometimes, they feel like committing suicide.

Conclusion

This paper studied the opinion of 201 uniformed personnel of the Coimbatore relating to the reading habit among them. It is evident that all the personal factors significantly influence the time spent per day reading, types and preferred language of the reading materials, interested subject, member of a library, reasons for not reading regularly and the respondents would read more if they had more time. It is suggested to set up a Library with print resources such as News Papers, Weekly Magazines and some general books in all the Police Stations of the Coimbatore District to combat the stress level of the Uniformed Personnel. This study can be conducted more rigorously and exhaustively. The respondents suggest that the results of this study may be given to the officials concerned for their betterment.

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Building Sustainable Communities through Collaborative Partnerships

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ABSTRACT

Collaboration and community engagement play a vital role in achieving sustainable development by fostering shared responsibility, knowledge exchange, and inclusive participation. In the modern knowledge-driven society, partnerships among institutions, communities, governments, and organizations enhance resource utilization and strengthen collective problem-solving. Citizen science empowers individuals to actively participate in research and decision-making processes, thereby bridging the gap between scientific knowledge and societal needs. Outreach initiatives further extend awareness, education, and access to sustainable practices, ensuring that development benefits reach diverse and marginalized communities. This paper explores the importance of collaboration and community engagement through partnerships, citizen science, and outreach as key approaches to advancing sustainable development. It also discusses the challenges, opportunities, and future directions for reinforcing community-led sustainability efforts.It highlights the need for strong communication, equitable power-sharing, and ethical engagement to address challenges such as resource constraints, data reliability, and participation gaps. Furthermore, the paper underscores the role of policy support, digital tools, and capacity-building initiatives in strengthening collaborative practices.

KEY WORDS: Collaboration, Community Engagement, Partnerships, Citizen Science, Outreach

INTRODUCTION

Sustainable development requires collective action that incorporates social, economic, and environmental dimensions. No single institution or sector can address complex sustainability challenges seperately. Collaboration and community engagement have emerged as analytical approaches to achieving sustainable development goals by encouraging cooperation among stakeholders and active public participation. Through partnerships, citizen science, and outreach programs, communities become collaborators of sustainable solutions rather than passive recipients.

CONCEPT OF COLLABORATION AND COMMUNITY ENGAGEMENT

Collaboration refers to the process of working jointly with multiple stakeholders to achieve shared objectives, while community engagement highlights meaningful participation of local communities in planning and implementation. Together, these approaches promote transparency, trust, and accessibility.

PARTNERSHIPS FOR SUSTAINABLE DEVELOPMENT

Meaning and Importance of Partnerships

Partnerships involve cooperative relationships between public institutions, private organizations, non-governmental organizations, and communities. These partnerships enable the sharing of experience, and infrastructure, making sustainability initiatives more effective and scalable.

Benefits of Partnerships

- **Complementary skills and expertise:** Partnerships combine diverse skills and knowledge from different stakeholders. This improves efficiency and strengthens project outcomes.Partnerships benefit from complementary skills and expertise by combining different strengths toward a common goal.
- **Enhanced innovation and problem-solving:** Collaboration encourages idea sharing and creativity. Multiple perspectives help solve complex problems effectively.Collaboration allows partners to tackle complex challenges more effectively. As a result, problems are solved faster and with greater impact.Different experiences and ways of thinking lead to more creative solutions.

- **Shared risk and responsibility:** Responsibilities and risks are distributed among partners. This reduces pressure on individual organizations.Joint accountability leads to more balanced decision-making. Together, partners can handle uncertainties more confidently and sustainably.
- **Resource sharing and cost efficiency:** Partners share funds, infrastructure, and expertise. This reduces costs and avoids duplication of efforts.Partnerships enable resource sharing and cost efficiency by pooling assets, skills, and infrastructure. This reduces individual expenses and avoids duplication of efforts. Shared resources maximize productivity and optimize operations.

Types of Partnerships

- **Public–Private Partnerships (PPPs):** These partnerships involve collaboration between government bodies and private organizations to implement sustainable infrastructure, education, and environmental projects.The government provides support or funding, while the private sector brings expertise, technology, and investment. PPPs are common in infrastructure like roads, hospitals, and utilities.
- **University –Community collaborations:** Universities and research institutions collaborate with local communities to address real-world sustainability challenges through research, training, and capacity building.This collaboration promotes mutual learning and problem-solving. It strengthens community development and enhances practical learning for students.
- **Government–Community Partnerships:** These partnerships focus on involving local communities in policy implementation, environmental conservation, and social development programs.The government provides resources, policy support, and funding, while the community offers local knowledge and participation. This partnership ensures that initiatives are relevant and effective.
- **Non-Governmental Organization (NGO) Partnerships:** NGOs partner with institutions and communities to promote social inclusion, environmental awareness, and sustainable livelihoods.NGOs contribute expertise, resources, and outreach, while partners provide support, funding, or additional skills. This partnership enhances project impact, efficiency, and sustainability.
- **Worldwide and Multilateral Partnerships:** Global organizations collaborate across borders to support sustainable development goals through funding, knowledge exchange, and policy guidance. They pool resources, knowledge, and expertise across borders. These partnerships are common in areas like health, climate change, trade, and education.

Challenges in Partnerships

- **Lack of coordination and communication among stakeholders:** Poor communication can lead to misunderstandings and delays, duplication of efforts. Without clear coordination, trust and efficiency in the partnership suffer. Regular updates and structured communication are essential to keep all stakeholders aligned.
- **Power imbalance between institutions and communities:** Dominant institutions may control decision-making, community voices may be overlooked, reducing engagement and ownership. This can lead to initiatives that don't meet local needs.
- **Clarity and communication:** Lack of clear communication about goals, roles and responsibilities creates confusion among partners. This often leads to misunderstanding and conflicts. Clear communication improves coordination and trust.
- **Cultural differences:** Differences in values, beliefs, and working styles can create misunderstandings among partners. These differences may affect collaboration and decision-making. Cultural sensitivity promotes mutual respect.

CITIZEN SCIENCE AS A TOOL FOR ENGAGEMENT

Concept of Citizen Science

Citizen science refers to the involvement of non-professional volunteers in scientific research and data collection. It allows communities to contribute local knowledge and observations, enriching scientific understanding and promoting inclusive research.

Methods of Citizen Science

- **Data Collection and Monitoring:** Citizens collect environmental data related to air quality, biodiversity, water resources, and climate change. Regular monitoring by the community also raise awareness about local environmental issues and trends.
- **Crowdsourcing and Online Platforms:** Digital tools and mobile applications enable large-scale participation and real-time data submission.They allow people from different regions to contribute simultaneously, increasing the scope and speed of research.
- **Participatory Mapping:** Community members contribute local knowledge by mapping natural resources, hazards, and environmental changes. This method ensures that local perspectives and experiences are captured accurately.
- **Community-Based Research:** Local communities collaborate with researchers to identify problems and co-create solutions. It also fosters trust, mutual learning, and capacity building among participants.
- **Volunteer Observation Programs:** Participants record observations of wildlife, weather patterns, or environmental conditions over time.

Challenges in Citizen Science

- **Data correctness and quality control:** Non-expert data may lack accuracy. Validation and supervision are required. Proper validation, training are essential to maintain reliability.
- **Digital divide and lack of technological access:** Limited access to technology restricts participation. This affects inclusiveness. Providing alternative data collection methods or community support can help bridge this divide.
- **Sustaining long-term public participation:** Maintaining volunteer motivation is difficult. Lack of feedback reduces engagement. Regular updates, engagement activities are key to sustaining involvement.
- **Ethical issues related to data use and privacy:** Data privacy and consent must be protected. Ethical practices ensure trust. Ensuring ethical practices builds trust and encourages continued participation.

OUTREACH PROGRAMS FOR COMMUNITY DEVELOPMENT

Meaning of Outreach

Outreach refers to activities designed to disseminate knowledge, services, and resources beyond institutional boundaries to reach wider communities. It plays a crucial role in awareness-building and education for sustainability.

Types of Outreach Programs

- **Educational Outreach:** Workshops, seminars, and training programs aimed at building awareness of sustainability issues. They also encourages critical thinking and problem-solving around environmental challenges.
- **Community Outreach:** Direct engagement through community meetings, local events, and grassroots initiatives helps foster local participation.
- **Digital Outreach:** Use of social media, websites, webinars, and mobile platforms to reach broader audiences efficiently. They also enable continous communication and feedback, making outreach more dynamic.
- **Institutional Outreach:** Collaboration with schools, libraries, and community centers to promote sustainability education and environmental awareness.
- **Advocacy and Awareness Campaigns:** Public campaigns focused on influencing behavior change and policy support for sustainability. They can include media campaigns, petitions, and community events to engage diverse audiences.

Challenges in Outreach Programs

- **Insufficient funding and resources:** Limited financial and material resources restrict the scope of outreach programs. This affects continuity, quality, and long-term sustainability.

- **Low community participation or interest:** Lack of awareness or relevance reduces community involvement. As a result, outreach outcomes become limited.
- **Cultural and language barriers:** Language and cultural differences hinder effective communication. They affect understanding and trust.
- **Lack of continuous engagement and subsequent action:** One-time programs fail to create lasting change. Continuous follow-up is essential for meaningful change.

APPLICATIONS OF COLLABORATION AND COMMUNITY ENGAGEMENT

- **Joint Initiatives for Shared Goals:** Organizations and communities work together to combine resources, expertise, and knowledge. This collaboration ensures projects are more effective and achieve collective objectives.
- **Educational and Training Programs:** Workshops, seminars, and skill-building sessions engage communities to enhance knowledge and capacity. These programs empower participants and support long-term development.
- **Environmental Monitoring and preservation:** Community participation in observing and reporting environmental data strengthens conservation efforts. It ensures sustainable management of natural resources and ecosystems.

FUTURE DIRECTIONS OF COLLABORATION AND COMMUNITY ENGAGEMENT

- **Strengthening collective networks:** Building stronger connections among institutions and communities will improve coordination and resource sharing. Enhanced networks will support more effective and inclusive initiatives.
- **Promoting inclusive participation:** Encouraging involvement from diverse groups ensures that multiple viewpoints are considered in planning and decision-making. Inclusive engagement leads to equitable and impactful outcomes.
- **Leveraging technology and digital tools:** Advanced digital platforms will enable efficient communication, data collection, and collaboration. Technology will make engagement more interactive, accessible, and scalable.

CONCLUSION

Collaboration and community engagement are core elements of sustainable development. Partnerships enable shared responsibility and resource optimization, citizen science promotes inclusive knowledge creation, and outreach ensures widespread awareness and participation. Together, these approaches to promote strength for communities and sustainable solutions. By strengthening collaborative frameworks and empowering communities, sustainable development goals can be achieved more effectively and equitably.

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A Conceptual Framework for Library-Led Training Programmes in Capacity Building and Professional Development

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Abstract

Libraries have evolved from static repositories into dynamic centres for knowledge and learning. Library-led training programmes play a crucial role in this transformation by supporting capacity building and professional development among library professionals, students, researchers, and user communities. This conceptual study examines the role, scope, and significance of training programmes conducted by libraries in developing skills, competencies, and lifelong learning attitudes. Drawing on existing literature and professional frameworks, the study highlights how such programmes contribute to individual and institutional development while also identifying challenges and future directions for strengthening training initiatives in the field of Library and Information Science.

Keywords: Capacity Building, Professional Development, Library-led Training Programmes, Skill Development; Library and Information Science

Introduction

Libraries have evolved into active learning centres in the modern information society, no longer limited to custodial functions. Rapid technological development, digital transformation, and shifting user expectations necessitate ongoing skill improvement for both library staff and patrons. Training programmes provided by libraries are now a crucial part of professional development and capacity building. The process of improving performance and flexibility via the development of competencies, skills, and abilities is known as capacity building. In contrast, professional development emphasizes lifelong learning to improve leadership, ethics, and professional expertise. Libraries are essential in meeting these requirements through organized training programmes, workshops, orientations, and efforts for continuous education. Libraries now perform a significantly expanded role due to the exponential increase in digital information and the rapid development of information and communication technology (ICT). Libraries now serve as active learning spaces that promote teaching, learning, research, and professional development rather than just providing circulation services and collection development. Organizing and executing training programmes targeted at improving users' abilities and competencies is one of the most significant new functions of libraries.Library-led training programmes improve research skills, professional competencies, digital literacy, and information literacy. These programmes actively assist capacity building by providing individuals with the knowledge and skills necessary to thrive in both academic and professional contexts. Additionally, these programmes promote continuous professional development, which aids individuals in adapting to changing information and technology settings.

Objectives of the Study

1. To examine the scope of library-led training programmes in the context of library services.
2. To identify the role of library-led training initiatives in enhancing capacity building among library professionals and user communities.
3. To analyze the contribution of training programmes to professional development in the field of LIS.
4. To identify the outcome and best practices of effective library-led training programmes.
5. To find out the challenges faced in implementing library-led training programmes and suggest suitable strategies.

Theoretical and Conceptual Framework

The following theoretical stances serve as the foundation for this conceptual investigation:

- Human Capital Theory
- Lifelong Learning Theory
- Organizational Learning Theory
- Knowledge Management Theory

Human Capital Theory: The Theory of Human Capital, developed by economists Theodore W. Schultz and Gary S. Becker, posits that knowledge, skills, education, training, and health are valuable capital forms that can enhance individual productivity and drive economic growth when invested in. Becker expanded on Schultz's idea by showing that education and skill development yield measurable economic returns, such as higher wages and improved labour market efficiency. This theory clarifies why societies prioritize human development as a long-term investment rather than a mere expense.

Lifelong Learning Theory: The text discusses lifelong learning, defined as the ongoing acquisition of knowledge and skills throughout an individual's life, emphasizing that education continues beyond formal graduation as a flexible, continuous process. Libraries play a crucial role in this by providing access to diverse digital and physical resources, promoting transparency and inclusion, and thus supporting various demographics, including the underprivileged, elderly, and financially struggling individuals. They act as information hubs that facilitate self-paced learning aligned with personal interests by offering free resources like books, digital databases, multimedia, and seminars. Libraries have educational objectives that promote such learning environments, adapting since the establishment of the first public library in the nineteenth century, particularly in light of the digital age. Today, they conduct a range of innovative programmes, including professional development seminars, language courses, and digital literacy workshops, acknowledging that modern learning requires competencies beyond traditional reading to encompass effective use of technology and critical evaluation of online content.

Organisational Learning Theory: Organisational learning is essential for navigating modern corporate environments, according to the Organisational Learning Theory developed by Yoesoep Edhie Rachmad in 2022. This framework outlines how businesses can acquire, manage, and utilize knowledge to enhance performance and competitiveness amidst evolving information and technology. Rachmad emphasizes that learning is a dynamic, ongoing process occurring at individual, group, and organisational levels, opposing traditional views focused solely on individual learners. Fundamental to effective organisational learning are transparency, collaboration, and an experimental mindset, enabling continuous reflection and applied insight. This holistic approach fosters the competencies necessary for sustainable innovation and adaptation in organisations.

Knowledge Management Theory: According to knowledge management theory, organisations can enhance learning, creativity, and performance by systematically managing information. It emphasizes the management of both implicit and explicit knowledge, viewing knowledge as a strategic asset. Individual knowledge is transformed into collective knowledge, aiding decision-making and competitive advantage. A key contribution is the SECI model, which describes the continuous interplay of tacit and explicit knowledge within organisations. Overall, this theory provides a framework for understanding how knowledge fosters sustainable growth and organisational effectiveness.

Concept of Library-Led Training Programmes

The term "library-led training programmes" refers to planned, methodical learning activities that libraries plan and conduct to satisfy their patrons' educational, informational, and professional requirements. Librarians and information specialists work with academic and research groups to undertake these programmes.

The following are key components of library-led training:

- Information literacy
- Digital literacy and ICT skills
- Utilising databases and electronic resources

- Scholarly communication and research methods
- Citation guidelines and reference management tools
- Academic integrity and knowledge of plagiarism
- Open access resources and data management

These initiatives strengthen libraries' position as active collaborators in education and career advancement.

Information Literacy: The concept of "information literacy," introduced by Zurkowski in 1974, refers to the ability to identify when information is needed and to efficiently find, evaluate, and use it in a moral context. This skill fosters critical thinking, informed decision-making, and lifelong learning. In today's digital landscape, information literacy enables users to assess the authenticity, relevance, and reliability of information from various sources. UNESCO (2006) emphasizes its role in empowering individuals for personal development, while the American Library Association (1989) underscores the skills it provides for recognizing information needs and utilizing information effectively.

Utilising Databases and Electronic Resources: An organized and verified access to scholarly literature through databases has become essential in the digital age, enhancing academic collaboration and information retrieval. Researchers, students, and professionals can leverage various types of databases—bibliographic, full-text, citation, and factual—to efficiently find relevant, high-quality information, thereby improving productivity and research results. Advanced search functionalities, including keyword searches, Boolean operators, truncation, filtering, and controlled vocabularies, contribute to better search precision and results refinement, significantly impacting research behavior and information-seeking habits in academia, as noted by Tenopir (2003).

Research Methods and Scholarly Communication: Scholarly communication encompasses the production, assessment, sharing, and preservation of academic information through various outlets such as journals, books, and digital platforms. The rise of digital technologies has accelerated the dissemination of research, allowing for global access to scientific information. According to Borgman (2007), this process is shaped by a complex interplay of social, technological, economic, and policy factors. The integrity and impact of scholarly outputs depend on the rigor of research methodologies, which include mixed-method, qualitative, and quantitative approaches used to collect and interpret data. Common research techniques in library and information science include surveys, interviews, bibliometric analysis, content analysis, and case studies, focusing on information behavior and academic publishing practices (Creswell and Creswell, 2018).

Reference Management Tools and Citation Guidelines: Citation guidelines establish consistent standards for source citation in academic writing, which is essential for ensuring research traceability, transparency, and integrity. These guidelines help prevent plagiarism, facilitate access to original works, and acknowledge authors. Common citation styles such as APA, MLA, Chicago, IEEE, and Vancouver cater to various academic disciplines, as emphasized by the American Psychological Association (2020), which notes that accurate and regular citation enhances the credibility of academic writing. Additionally, reference management tools assist researchers in organizing, storing, citing, and sharing bibliographic information efficiently. These tools enable collaboration on projects, facilitate importing references from databases, and automate the creation of reference lists and in-text citations. Prominent reference management software, including EndNote, Zotero, Mendeley, and RefWorks, are widely used in academic and research environments. Research by Gilmour and Cobus-Kuo (2011) indicates that such software significantly improves research efficiency and citation accuracy.

Academic Integrity and Plagiarism Awareness: Academic integrity includes professional standards and ethical principles that are necessary for academic work, such as accountability, honesty, fairness, respect, and trust. It is essential for the validity of intellectual communication and the value of academic credentials. It guarantees that academic activity is carried out responsibly and transparently, serving as the basis for teaching, learning, and research. Presenting someone else's work without giving due credit is known as plagiarism, and it seriously compromises academic integrity. It can take many different forms, such as direct copying and

improper citations. One of the main causes of plagiarism in academic contexts is a lack of knowledge about citation conventions.

Information and Communication Technologies (ICT) Skills: The term information and communication technologies (ICT) encompasses the generation, processing, storage, retrieval, and transport of data, aimed at enhancing information availability and facilitating efficient communication. ICT significantly benefits learning by utilizing modern computer, telecommunications, and audiovisual technologies. Economically, ICT stimulates regional growth and is considered a catalyst for social and economic transformation, fostering resilience, equity, sustainability, and inclusivity. Moreover, a robust ICT infrastructure is crucial for regional economic integration, as it helps reduce information asymmetries, lowers transaction costs, and improves resource allocation across regions.

Open Access Resources and Data Management: Open access (OA) materials refer to publications and research findings that are freely accessible online without restrictions, including peer-reviewed articles, books, and educational resources. The open access movement aims to promote equitable information dissemination, enhancing research visibility and accessibility. According to Suber (2012), open access enables unrestricted use of academic content for study and teaching. In parallel, research data management (RDM) involves the systematic handling of data throughout its lifecycle, ensuring long-term usability, repeatability, and integrity. As emphasized by Borgman (2015), effective data management is vital for contemporary academic communication, supported by increasing demands from funders and publishers for open data sharing with proper metadata and management strategies.

Role of Library-Led Training in Capacity Building

Libraries' training programmes are vital for enhancing skills in information organization, digital resource management, and emerging technologies. They improve operational efficiency and boost digital literacy among professionals and users, fostering societal knowledge. These programmes enhance research capabilities, customer satisfaction, and institutional reputation, while supporting a positive work culture through well-trained employees. Ultimately, they promote academic excellence, innovation, and sustainable growth in educational and research institutions.

Role in Professional Development

Library-led training programmes are crucial for the professional development of library and information science (LIS) professionals, promoting lifelong learning, ethical conduct, and leadership skills essential for career progression. These initiatives provide ongoing training, workshops, and practical sessions that keep professionals updated on emerging technologies, digital resources, and user-centered services. They adhere to standards set by organizations like the ALA and the IFLA, fostering best practices and professional integrity.

Central to these training programmes is the emphasis on management and leadership skills, equipping professionals for supervisory roles through training in communication, strategic planning, decision-making, and team management. Participation enhances professionals' identity, employability, confidence, and recognition in the LIS community. By focusing on continuous education and adapting to changing responsibilities, library-led training ensures the development of crucial skills such as information organization, ethical practices, research support, and user services. Furthermore, they promote networking, peer learning, and information exchange, strengthening the LIS professional community and facilitating long-term career advancement.

Conceptual Framework

The conceptual framework for library-led training programmes presents a model where libraries serve as critical facilitators for learning and service enhancement through three interconnected components: Features, Protocols, and Products. The Features component emphasizes necessary inputs such as human resources (librarians, information specialists, and trainers) and technology (digital tools and learning management systems), supported by institutional backing including leadership and policy alignment with organizational goals. The Protocols component outlines the systematic approach for implementing training programmes, covering aspects such as user needs assessments, curriculum development, teaching strategies, and program

execution, culminating in evaluations based on participant feedback and performance metrics. Finally, the Products component encapsulates the outcomes from effective training initiatives, which boost participants' information literacy, digital skills, and research abilities, ultimately leading to enhanced library services, heightened user satisfaction, and improved institutional performance.

Scope of the Study

This study is limited to a conceptual examination of library-led training programmes in academic and research libraries. It focuses on capacity building and professional development activities undertaken by libraries for library professionals and user communities. The study does not include empirical data collection but relies on existing literature, theoretical models, and professional practices in the field of Library and Information Science.

Methodology

The study adopts a conceptual and descriptive research approach. Relevant literature was reviewed from books, scholarly journals, professional reports, and policy documents related to library-led training, capacity building, and professional development. Theoretical frameworks such as Human Capital Theory, Lifelong Learning Theory, Organisational Learning Theory, and Knowledge Management Theory were used to develop a conceptual framework explaining the role of libraries in training and development.

Challenges in Implementation

Despite its significance, the execution of library-led training programmes is fraught with difficulties. Limited infrastructure and resources, such as limited budget, subpar technological facilities, and a lack of designated training locations, are major obstacles. Another obstacle is the restricted availability of experts with current technological know-how. Furthermore, the adoption of new technology and procedures may be hampered by professionals' aversion to change, especially among those who are used to more conventional approaches. The development of training initiatives is further complicated by the need for regular changes to training materials due to the quick speed of technology improvement. It is challenging to quantify learning results and defend training program investments in the absence of reliable assessment techniques. When taken as a whole, these difficulties demonstrate the necessity of institutional support, strategic planning, and ongoing assessment to guarantee the effective implementation of library-led training programmes.

Future Directions

In order to meet changing professional demands, future library-led training programmes will emphasize innovation, collaboration, and sustainability. A combination of online and in-person training techniques will improve student engagement and accessibility. By collaborating with academic institutions and professional associations, libraries may enhance their services and guarantee adherence to national and international standards. Learner evaluation and program efficacy will be made easier by cutting-edge technology like artificial intelligence, learning analytics, and adaptive learning systems. In order to meet corporate objectives and skill shortages, training modules will also be need-based and outcome-oriented. Maintaining these programmes and encouraging the recognition of training in professional progression require institutional support and governmental recognition.

Conclusion

In today's knowledge-driven world, library-led training programmes are essential for professional growth and capacity building. Libraries make a substantial contribution to academic quality, research productivity, and lifelong learning by providing professionals and users with the necessary skills and abilities. Libraries will become even more relevant and influential in the future if training programmes are strengthened via strategic planning, teamwork, and technology integration. Training programmes provided by libraries are essential for LIS professionals' professional growth and capacity building. Libraries provide a substantial contribution to both human development and institutional success by promoting technical proficiency, digital competency,

leadership abilities, and lifelong learning. Libraries will continue to be important and influential in the changing knowledge society if these programmes are strengthened via strategic planning, teamwork, and innovation.

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Digital Leadership and Technology Driven in Agri-Business

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Abstract

Agribusiness related to the entire agricultural value chain-from input supply and farming to processing, distribution, and marketing-applying commercial principles to optimize food and fiber production. Digital technologies transforms agriculture activities into smart agriculture to increase productivity, optimize the resources management, and foster marketing. Digitalization focus on transmission of agri activities with the help technology like IoT(Internet of Things), BC(blockchain), climate smart practices. Increased productivity farming techniques have improved up to 20% yield increase in cereal crops. Supply chain management directly connect farmers with buyers, reducing intermediaries and improving price discovery. Digital transformation is no longer a luxury but a necessity for building a more resilient, efficient, and sustainable agricultural sector capable of meeting the demands of a growing global population. Future trends point towards fully automated, AI-driven farms and the integration of 5G for real-time monitoring. The key to successful, widespread adoption lies in providing training to farmers, expanding rural internet infrastructure, and fostering public-private partnerships to make technologies affordable and accessible to small-scale farmers.

Keywords*:* Internet of Things, real time monitoring, AI driven farms, marketing, farming to processing.

Introduction

Agribusiness plays a vital role in economic development, food security, and rural employment, especially in developing countries like India, China, Brazil, and so on. Due to modern years, the agribusiness sector has been undergoing a major transformation due to the rapid adoption of digital technologies. Leaders who embrace digital tools such as data analytics, artificial intelligence, Internet of Things (IoT), blockchain. A technology-driven agribusiness organisation leverages digital platforms to optimize supply chains, improve farm management, reduce risks, and connect farmers directly with markets. Digital leadership ensures effective decision-making, promotes innovation, and enables organisations to respond quickly to changing market conditions and climate challenges. Thus, digital leadership and technology-driven organisations are essential for transforming agribusiness into a more efficient, competitive, and sustainable sector in the modern economy.

Objectives of digital and technology in agribusiness

- To provide a digital system that supports the progress of farmers nationwide.
- To increase the transparency and efficiency of government-led initiatives.
- To help the government make informed policy decisions.
- To integrate the growth of aggrotech's through private and public partnerships.
- Utilizing real-time data from soil sensors, satellites, and drones to optimize crop management, planting patterns, and input application.
- Developing practices that increase resilience to climate change, such as drought-tolerant crops and precise water management.

Benefits of digitalization

- Improved supply and demand matching.
- The goal of using resources more sustainably and efficiently through Procedures.
- Proactively implementing and improving decision-making processes.
- A decrease in the volatility of the market and output.
- A proactive approach to anticipating society demands and commercial difficulties.
- Consumer interaction and easy information availability.

Challenges in adopting digitalization and technology in agribusiness

1. **High Costs and Investment:** Highly initial investment in digital infrastructure and tools limits especially for small size farmers.
2. **Technical skills and knowledge:** The lack of digital literacy among farmers which brings huge effectiveness use of technology.

3. **Data Security and Privacy:** Growing concerns regarding the security of farm-related data, potential for data breaches, lack of trust in sharing data.
4. **Digital Divide and Infrastructure:** Poor internet connectivity and lack of access to electricity in rural areas limit the use and access of digital methods.
5. **Automation and unemployment:** As the agriculture industry becomes increasingly automated, there is a growing concern that unskilled farmers may lose their jobs to machines and robots that can perform repetitive tasks more efficiently.

Importance of Digitalization in Agriculture Is Critical for India

Satellite Imaging

Early crop stress detection, yield prediction, better resource allocation, sustainability tracking. Learn about satellite-enabled carbon footprinting for agriculture which increases adoption rate in 2025 ah 61%.



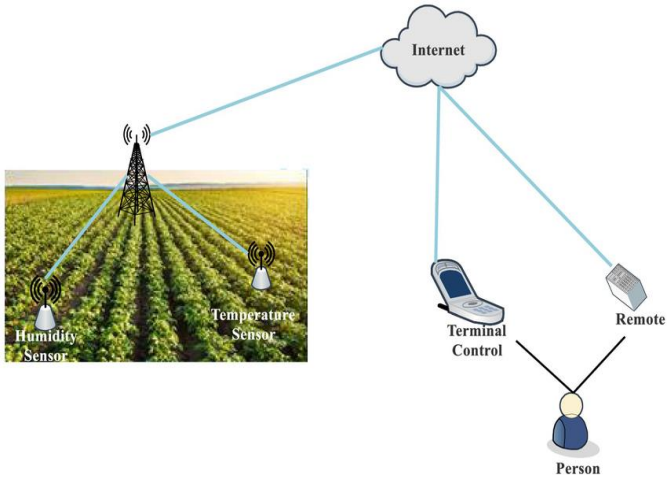
Digital Finance & Insurance

Faster credit, tailored insurance, reduced fraud, increased financial inclusion Crop loan and insurance solutions via digital verification it includes adoption rate as 41%.



IoT Sensors

Water/chemical savings, increased yield, informed input use, Conserving natural resources Manage farms via advanced agro-admin software it has an estimated adoption rate in 2025 is 53%.



Why Agricultural Technology Matters

One of the most significant advantage of modern agricultural technology is the ability to utilize resource use. Farmers no need to apply water, fertilizers, and pesticides uniformly across whole field. They can target specific areas or even treat individual plants according to their unique needs. This precision leads to numerous benefits, including:

- **Improves Crop Productivity:** Advanced tools help maximize yield of plant receiving exactly what it needs.
- **Decrease Resource Usage:** By utilizing resources more efficiently, farmers can decrease their water, fertilizer, and pesticide use, which helps to keep food prices down.
- **Environmental Advantage:** Less use of chemicals reduces the impact on natural ecosystems, protecting rivers, groundwater, and wildlife habitats.
- **Enhanced Worker Protection:** With less exposure to chemicals and better working conditions, agricultural workers are safer.

Tools and Techniques

a. **Business Planning**: Business planning tools will assist agricultural entrepreneurs in developing business plans, financial projections, and marketing strategies. These tools help entrepreneurs define their goals, analyze market opportunities, assess financial viability.

b. **Market Research Tools**: Market research tools integrate entrepreneurs togather and analyze information about target markets, customer preferences, and competitive landscapes. These tools provide market trends, consumer behavior, and demand patterns, helping entrepreneurs make informed decisions about product development, pricing, and market entry strategies.

c. **Financial Management Tools**: Financial management tools adopt entrepreneurs in budgeting, expense tracking, cash flow management, and financial analysis. These tools help entrepreneurs screen their financial performance, identify areas of improvement, and make informed financial decisions.

d. **Crop Management Software**: Crop management software helps entrepreneurs in planning and screening crop production activities. These tools creates features such as crop planning, inventory management, pest and disease monitoring, irrigation scheduling, and yield forecasting. By utilizing crop management practices, entrepreneurs can embellish productivity, minimize losses, and improve overall farm efficiency.

e. **Farm Record-Keeping Tools**: Farm record-keeping tools help entrepreneurs assert organized records of farm activities, including inputs, expenses, yields, and sales. These tools permit entrepreneurs to track their performance, analyze costs and returns, and comply with regulatory requirements.

f. **Supply Chain Management Tools**: Supply chain management tools promote entrepreneurs in managing the flow of agricultural products from production to consumption. These tools including features such as inventory management, order tracking, logistics planning, and quality control. By optimizing supply chain processes, entrepreneurs can ensure timely delivery, minimize wastage, and maintain product quality.

g. **E-commerce Platforms**: E-commerce platforms provide entrepreneurs the opportunity to sell their agricultural products directly to consumers or connect with potential buyers. These platforms creates a digital marketplace where entrepreneurs can showcase their products, manage online orders, and facilitate secure payment transactions. E-commerce platforms permit entrepreneurs to expand their market reach and increase sales.

h. **Climate-Smart Technologies**: Increasing challenges posed by climate change, the AIP promotes the adoption of climate-smart technologies. This includes drought-tolerant crop varieties, increase water management techniques, conservation agriculture practices, and agroforestry systems. These technologies help to strengthen farmers build resilience, enhance productivity, and contribute to sustainable farming systems.

i. **Data Analytics and Artificial Intelligence**: Data analytics and artificial intelligence (AI) play a role in transforming agribusiness. By examining large datasets, AI-powered tools can provide insights on market trends, yield predictions, disease diagnostics, and supply chain optimization. These technologies permit agribusinesses to make data-driven decisions and enhance overall efficiency.

Recent scheme related to digital agribusiness

This scheme is designed as an umbrella scheme to support various initiatives. The scheme is developed on two foundational pillars:

Agri Stack

Agri Stack is designed as a farmer-centric Digital Public Infrastructure (DPI) to streamline services and scheme delivery to farmers. It includes three key components:

1. Farmers' Registry
2. Geo-referenced village maps
3. Crop Sown Registry

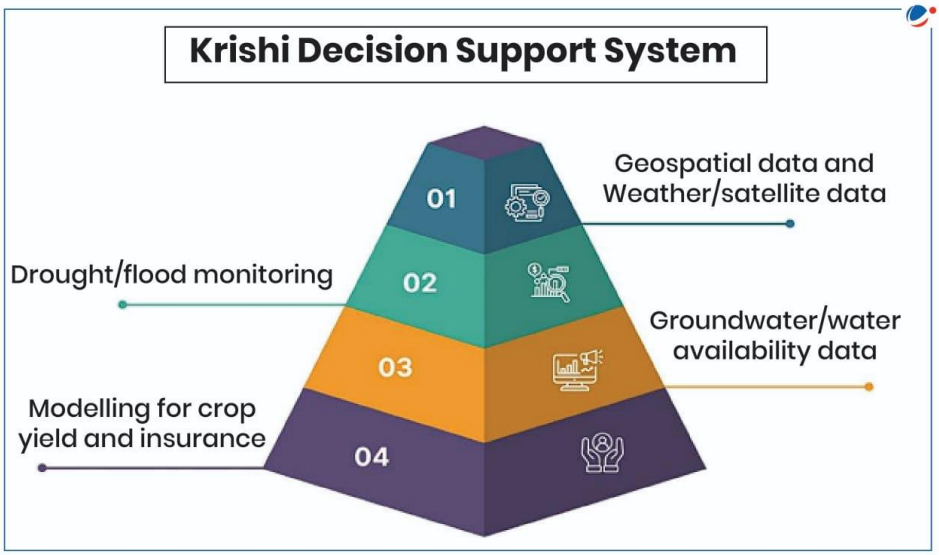
A important feature of Agri Stack is the introduction of a 'Farmer ID', similar to Aadhaar card, serving as a trusted digital identity for farmers. These IDs, developed and controlled by the State Governments/ Union Territories, will be linked to various farmer-related data, including land records, livestock ownership, crops sown. The execution of Agri Stack is progressing between the Central and State Governments, with 19 states having signed MoUs with the Ministry of Agriculture. Pilot projects have been conducted in six states to test the creation of Farmer IDs and the Digital Crop Survey. The six states include Uttar Pradesh (Farrukhabad), Gujarat (Gandhinagar), Maharashtra (Beed), Haryana (Yamuna Nagar), Punjab (Fatehgarh Sahib), and Tamil Nadu (Virudhnagar).

Key targets include

- Creating digital identities in agri stack for 11 crore farmers over three years (6 crore in FY 2024-25, 3 crore in FY 2025-26, and 2 crore in FY 2026-27.
- Introducing the Digital Crop Survey nationwide within two years, covering 400 districts in FY 2024-25 and all districts in FY 2025-26

Krishi Decision Support System

The Krishi Decision Support System (DSS) will incorporate remote sensing data on crops, soil, weather, and water resources into a geospatial system.



Conclusion

Digital transformation enhances sustainability by optimizing resources (water, fertilizers) and improves resilience against climate volatility through precision agriculture and real-time data insights. Technology (AI, IoT, drones, blockchain) enables a shift from reactive to proactive. By 2025, digital-first agribusinesses are achieving higher efficiency and better market prices through smart farming techniques and data-driven insights.

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From Custodian to Catalyst: Re-Architecting the National Research Library as a Knowledge Infrastructure

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Abstract

The existential challenge facing national research libraries is not one of obsolescence, but of purpose. In a landscape defined by distributed digital access, algorithmic discovery, and open science mandates, the traditional model of the library as a centralized custodian of purchased and curated collections is insufficient. This paper argues for a strategic re-architecting of the national research library into a proactive knowledge infrastructure—a foundational, enabling platform that actively facilitates the entire research lifecycle, from ideation to preservation and public engagement. Drawing on the theoretical framework of "boundary infrastructure" (Star & Griesemer, 1989) and international case studies from the British Library's "Living Knowledge" vision and the Netherlands' national digital scholarship strategy, we analyze this necessary evolution. We propose a tripartite model centered on Active Curation, Interoperable Platforms, and Embedded Partnership. The paper concludes that by shifting from a focus on holding knowledge to enabling its creation and use, national research libraries can secure an essential, value-generating role in the 21st-century national innovation ecosystem, directly contributing to research excellence, public understanding, and economic vitality.

Keywords: National Research Libraries, Knowledge Infrastructure, Digital Scholarship, Research Lifecycle, Open Science, Strategic Transformation.

Introduction: The Inflection Point

National research libraries stand at a critical inflection point. For centuries, their authority derived from the scale, uniqueness, and permanence of their physical collections. However, the digital transition has democratized access to information while simultaneously fragmenting the scholarly record across proprietary platforms, institutional repositories, and ephemeral websites. This environment poses a fundamental question: What is the unique value proposition of a national library when information is ubiquitous but context is scarce?

We contend that the answer lies not in competing with commercial aggregators, but in leveraging the library's enduring institutional virtues—its mandate for long-term stewardship, its commitment to equitable access, and its role as a trusted, non-commercial public good—to build a new form of public infrastructure. This paper moves beyond descriptive accounts of library services to propose a coherent, actionable model for this transformation.

Theoretical Framework: The Library as Boundary Infrastructure

To conceptualize this shift, we employ Susan Leigh Star and James R. Griesemer's theory of "boundary objects" and "boundary infrastructure." Boundary objects (like standardized forms or classifications) are plastic enough to adapt to local needs yet robust enough to maintain a common identity across different social worlds (e.g., researchers, policymakers, the public). Boundary infrastructure is the scaffolding that supports the creation and use of these objects.

We argue the modern national library must become a boundary infrastructure for national scholarship. It must:

- **Standardize and Connect:** Create and maintain the technical and metadata standards that allow disparate research outputs (data, pre-prints, code, multimedia) to be linked and understood.
- **Translate and Mediate:** Act as an interpreter between the specialized world of academic research and the needs of industry, government, and civil society.
- **Provide a Common Ground:** Offer shared platforms and services that are usable by, and beneficial to, multiple constituencies without imposing a single worldview.

This framework moves the library from being a repository at the boundary to being the infrastructure of the boundary itself.

The Tripartite Model for a Catalytic Library

Our proposed model consists of three interdependent, strategic pillars.

Pillar One: From Passive Collection to Active Curation

This shifts the focus from acquiring finished publications to actively managing the nation's intellectual output.

- **Lifecycle Stewardship:** Implementing national Research Data Management (RDM) services, including data repositories, preservation guidance, and data citation support.
- **National Digital Collection Strategy:** Moving beyond legal deposit to proactive harvesting and curation of nationally significant born-digital materials (websites, social media, and software).
- **Context as a Service:** Curating not just objects, but their relationships. This involves building knowledge graphs that link publications, datasets, grants, researchers, and institutions to reveal research networks and impact.

Pillar Two: From Siloed Systems to Interoperable Platforms

The library's digital presence must be an open, integratable platform, not a destination website.

- **API-First Design:** Exposing catalogues, digital collections, and authority files via robust APIs, allowing other national systems (funding portals, university CRIS) to build upon them.
- **National Scholar Registry:** Developing and maintaining a canonical, disambiguated registry of national researchers (an ORCID hub) to accurately attribute work and map expertise.
- **Federated Authentication & Access:** Leading national solutions for seamless, secure access to licensed and open resources across institutions.

Pillar Three: From Service Desk to Embedded Partnership

Expertise must be deployed in the research workflow, not waiting at a reference desk.

- **Digital Scholarship Labs:** Establishing physical and virtual centers providing advanced training and support in text analysis, data visualization, geospatial mapping, and computational research methods.
- **Grant-Economy Partnership:** Embedding information specialists in major national research grant consortia from the proposal stage, advising on data management, intellectual property, and dissemination planning.
- **Public Engagement Engine:** Systematically packaging research narratives from the national collection for public consumption through data journalism partnerships, interactive exhibits, and educational resources.

Evidence and Precedents: International Case Analysis

- **The British Library's "Living Knowledge" Vision:** Explicitly reframes the BL as a platform for research, business, and culture, exemplified by its Business & IP Centre network, which supports entrepreneurship using library resources, directly linking collections to economic activity.
- **The Netherlands' National Programme Open Science:** Libraries, coordinated by the National Library, play a lead infrastructural role in the national open science roadmap, focusing on building shared services for open access, FAIR data, and recognition & rewards.
- **The Library of Congress's Labs Initiative:** Demonstrates a platform approach by providing experimental digital access to collections, encouraging researchers and artists to build new interfaces and interpretations of the data.

Challenges and Strategic Imperatives

- **Governance & Funding:** Transition requires a shift from collection-line budgets to infrastructure and skills funding. New cross-sectoral governance models are needed.
- **Skills Transformation:** Staff development must aggressively prioritize data science, software carpentry, product management, and community engagement.

- **Metrics for Success:** New KPIs must be developed, measuring infrastructure use (API calls, platform logins), research enablement (grants supported, datasets curated), and amplification (public engagement reach, policy citations).

Conclusion: Securing the National Intellectual Commons

The role of the national research library is not diminishing; it is becoming more complex and more critical. By consciously re-architecting itself as a public knowledge infrastructure—a boundary infrastructure for national scholarship—the library transforms from a custodian of the past into a catalyst for future discovery and innovation. This model positions the library not as a cost center, but as a vital piece of national research capital, essential for ensuring the integrity, accessibility, and productive use of the nation's intellectual output. The challenge is not technological, but strategic and imaginative. The time for this deliberate evolution is now.

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Growth Strategies through Mergers and Acquisitions in Pharmaceutical Industry

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ABSTRACT

Growth through mergers and acquisitions has become a key part of how the global pharmaceutical industry expands. Pharmaceutical companies are using mergers and acquisitions more often as a way to stay competitive. They face higher costs for research and development, patents wearing out, strict rules from regulators, and tough competition. To keep their position in the market and remain successful over time, they are turning to M&A as a key strategy. This study looks at how mergers and acquisitions help companies grow by allowing them to add more products, get new technologies, enter new markets, and save costs through larger operations. The paper also looks at why companies in the pharmaceutical industry do M&A, such as improving their product development plans, spreading out their focus into different areas of medicine, reducing risks, and boosting their ability to come up with new ideas. It also shows the financial and operational benefits that come from combining companies, like saving money, better ways to get products to customers, and more influence in negotiations. At the same time, the study talks about the difficulties that come with mergers and acquisitions. These include problems with combining different company cultures, facing strict government rules, paying a lot of money for the deal, and possible interruptions to current research projects. By looking at recent trends and how industries usually handle these situations, the study says that even though M&A can be risky, they are still a strong way to grow when they are well thought out and smoothly combined

***Key Words**:* Mergers and Acquisitions (M&A), Pharmaceutical Industry, Corporate Growth Strategies, Inorganic Growth, Strategic Expansion.

INTRODUCTION

The modification in industrial policy in 1991concreted the mode for first wave of M&A in India. Policy transformations assisting M&A initiates with the elimination of restrictive provisions of Monopolies and Restrictive Trade Practices (MRTP) Act trailed by reforms in Foreign Exchange Regulation Act (FERA) in 1993 and Foreign Exchange Management Act (FEMA) in 2000. But at the same time in order to eradicate forces which lessen competition, the Competition Policy Act 2002 decided to determine a Competition Commission of India (CCI). This commission meant at examining the anti-competitive activities such as formation of cartels, collusive bidding, and consolidation via M&A which could cause market dominance abuses.

The most discussed topic nowadays in Corporate Field is Mergers & Acquisitions (M&A). In developed economies like United States, Europe and Japan, M&A is a regular feature. In India too, Mergers and Acquisition have become a part of corporate strategy. The terms ‘mergers’, ‘acquisitions’ and ‘takeovers’ are often used interchangeably in colloquial language. Merger means fusion of two entities into one, while an acquisition involves one entity buying out another and absorbing it. In legal sense merger is known as ‘Amalgamation’, in India An entity may grow its business either by internal expansion or by external expansion. In the case of internal expansion, a firm grows gradually over time in the normal course of the business, through different ways viz. acquisition of new assets, replacement of the technologically obsolete equipments, the establishment of new lines of products etc. However, if a firm wants to jump few steps in the growth ladder, they can opt for external expansion. Under this expansion technique, a firm may acquire a running business and grows overnight through combinations between two companies. These combinations may be in the form of mergers, acquisitions, amalgamations, takeovers etc. and have now become important facet of corporate strategy. In nutshell, Merger is when the shareholders of more than one company, usually two, decide to pool the resources of the companies under a common entity. As a result of a merger, if a new company comes into existence, it is a process of ‘Amalgamation’.

In the Pharmaceutical sector, Mergers and acquisitions also play an important role for 'market-entry' strategy as well as for the 'expansion strategy'. In the last few decades there has been severe competition all over the world in the Pharmaceutical Sector.

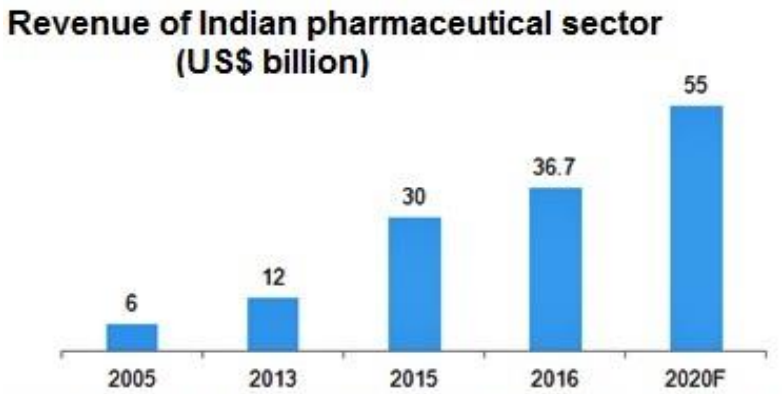
MERGERS AND ACQUISITIONS IN THE INDIAN PHARMACEUTICAL INDUSTRY

The Indian Pharmaceuticals marketplace is the third lead in terms of volume and thirteenth largest in terms of worth, as per a report by Equity Master. India is the greatest contributor of generic drugs worldwide with the Indian generics accounting for 20 percent of international exports in terms of volume. Of late, consolidation has become an essential feature of the Indian pharmaceutical market as the industry is greatly disintegrated.

India possesses avital position in the global pharmaceuticals sector. The nation also has a huge pool of scientists and engineers who have the prospective to handle the industry ahead to an even greater level. Currently over 80 percent of the antiretroviral drugs expended universally to conflict AIDS (Acquired Immuno Deficiency Syndrome) are provided by Indian pharmaceutical firms. The UN-backed Medicines Patent Pool has contracted six sub-licences with Aurobindo, Cipla, Desano, Emcure, Hetero Labs and Laurus Labs, permitting them to create generic anti-AIDS medicine TenofovirAlafenamide (TAF) for 112 developing countries.

GROWTH OF THE INDIAN PHARMACEUTICAL INDUSTRY

The Indian Pharma Industry, which is anticipated to develop over 15 percent per annum between 2015 and 2020, will outpace the global Pharma Industry, which is set to produce at an annual rate of 5 percent among the same period. The market is anticipated to raise to US$ 55 billion by 2020, thereby developing as the sixth biggest pharmaceutical market internationally by absolute size, as specified by an Indian Ambassador to the US. Branded generics control the pharmaceuticals market, comprising nearly 80 percent of the market share (in terms revenues).



MERGERS AND ACQUISITIONS GROWTH STRATEGIES

Precision-Focused "Bolt-on" Acquisitions

- Companies are focusing on "tuck-in" and "bolt-on" deals- buying smaller mid-cap biotech companies often with already proven innovations, like those in clinical trials, to reduce risk. These offer quicker integration and more reliable results compared to big mergers and acquisitions.

Vertical integration for supply security

- Vertical integration for supply security involves a strategic move to take control of the whole value chain. In areas such as radiopharmaceuticals and GLP-1 treatments for obesity, more than 80% of the

deals planned for 2025 involved either making the products or getting access to isotopes, which helps prevent issues with production delays.

AI-Enabled Strategic Dealmaking

AI is now a basic requirement for due diligence, and it's used to forecast how likely a target asset is to succeed technically and in terms of regulations. Acquirers are also purchasing AI startups to reduce the time it takes to develop new technologies from over 10 years down to about 3 to 6 years.

Therapeutic Area	2026 Strategic Drivers
Metabolic Health	There is a lot of competition for new treatments for obesity and NASH that use next-generation GLP-1 drugs.
Oncology	The focus is on precise treatments like Antibody-Drug Conjugates (ADCs) and radioligands.
Neurology (CNS)	There is strong interest in rare diseases and biological treatments that can reach the brain for Alzheimer's and Parkinson's.
Immunology	The strategy includes focusing on RNA therapies and portfolios related to immune system and neuromuscular conditions.

EXPLORING MERGER AND ACQUISITIONS -"A Review from 2014 to 2023":-

Stephen Mboroto (2012) this study was carried out to determine whether improvements occur after the merger and acquisition are undertaken. The analysis and results show that petroleum firms performed better in the post- merger/acquisition era as compared to the pre-merger/acquisition era. This is supported by the fact that merging/acquisition had a significant impact on the ROA, which is the overall standard measure of financial performance due to the statistical significance it has on ROA as well as total asset ratio. On the other hand, merger/acquisition was seen to have an insignificant positive effect on the liquidity and solvency of the petroleum firms. This suggests that there was a significant improvement on the financial performance as reflected by the significant increase in ROA. However, the overall financial performance significantly improved in the post-merger period.

Verma & Sharma (2014) conducted a review on the impact of mergers on the financial performance of Indian telecom sectors involved in M&A during the period 2001 2008. A sample size of 59 companies that had undergone merger and acquisition deals from 2001-02 to 2007-08 was selected. Secondary data were extracted for six years from the CMIE database PROWESS. The study utilized a regression model and various financial ratios to analyze the data, revealing that acquirer firms exhibited leverage synergies but ultimately experienced a decrease in the Return on Shareholders' funds after mergers and acquisitions. However, the overall financial performance significantly improved in the post-merger period.

Agarwal and Singh (2015) conducted a case study on the impact of a merger on the financial performance of Kingfisher Airlines (KFA). The objective of the study was to analyze the pre- and post-merger financial performance of KFA, utilizing accounting ratios such as profitability, liquidity, earnings per share, and leverage to evaluate the data. The statistical technique employed was the paired t-test, which led to the conclusion that there was no improvement or benefit in the acquiring firm (KFA) after the merger. Additionally, no significant results were observed in terms of return on equity and earnings per share.

Nasieku and Susan (2016) investigated the effect of financial restructuring on the financial performance of firms in Kenya. Drawing on three theories—Resource-Based View theory, Life Cycle theory, and Static Trade-Off theory—and an extensive analysis of past literature, the researchers concluded that an optimal and appropriate financing mix, or a proper balance of equity and debt funds, ensures a favorable return to shareholders.

Kinateder, Fabich, and Wagner (2017) performed a regression analysis of the cost-effectiveness of mergers and acquisitions. They conducted a study of 50 of the largest transactions realized between 2014 and

2016, concluding that operating cash flows improved after the completion of M&A transactions. It is important to note that these authors pointed to the direct impact of improved asset productivity in the cash flow performance of companies.

M. Campello and colleagues, et.al (2018) examined a certain specific effects of short selling constraints on corporate policies, and empirically showed how the equity lending market affects corporate behaviour. They considered 56 mergers conducted amongst Spanish investment funds between 2016 and 2018. Thus, concluded that mergers and acquisitions, in general, have a negligible effect on the performance of investment funds. It should be further noted that despite the fact that prior to acquisition target companies tended to have lower economic performance than their acquirers, the data on the final companies (created as a result of the M&A) does not allow one to draw definitive conclusions about the difference in cost-effectiveness of acquiring companies before and after the completion of such transactions.

Paulina, Junni, et.al (2019) investigated how mergers and acquisitions affect the performance and earnings quality of companies listed on the Stock Exchange from 2011 to 2014. The study found that, overall, profitability decreased significantly after mergers and acquisitions, except for GPR, which had a less significant decrease, and NPR, which showed insignificant increases. The research suggests that companies struggle to maximize resources, 8 increase sales, and minimize operational and non-operational costs after mergers and acquisitions. While earnings quality saw a slight increase, indicating changes in company profits, the overall impact on profitability was negative.

Borodin, Galina, et.al (2020) examined how mergers and acquisitions (M&A) affect the performance and earnings quality of companies listed on the Stock Exchange from 2011 to 2014. By analyzing 138 cases, also found that profitable companies maintained positive financial performance in post-M&A's but experienced a decline in return on sales (ROS). The result also highlighted a small impact on ROS that if the "cash" method is used for payment, M&A's tended to result in higher ROS than "mixed" or "stock" financing.

Simon Ragaqat, et.al (2021) the purpose of the paper is to identify the effect of merger and acquisition on the profitability of the five experimented medium sized technology companies listed on New York Stock Exchange. Three variables, including return on Assets, Return on Equity, and Earnings per share, have been selected and independent sample t-test has been applied on the gathered data. The study results show that the overall profitability declined after merger and acquisition because eight profitability ratios decreased and seven profitability ratios increased, which means that the number of decreased profitability ratios is more than the increased number of ratios increased profitability ratios. However, the earning per share ratio enhanced because the number of increased earnings per share ratio have exceeded the number of decreased earnings per share ratio. In comparison, return on assets and return on equity ratios deteriorated because the enhanced number of ratios found to be less than the decreased number of ratios of both return on assets and return on equity ratios. In conclusion, the return on equity significantly decreased and earnings per share ratio significantly increased. However, there is not significant impact on return on assets of the selected companies.

Liu, et.al (2021) applied feasible generalized least squares regression on eighty six cross-border merger & acquisitions and eight-one domestic merger & acquisitions, and concluded that the financial performance, on the whole, did not face an improvement. Also, the profitability of the sampled Chinese companies, including state-owned firms, in cross border mergers deteriorated whereas the domestic merger and acquisition companies found to have enhanced profitability in terms of return on assets and return on equity after the merger.

Gupta, Isha, et.al (2022) this study is to explore the expansion of merger and acquisition (M&A) literature in the context of Indian studies and examine the impact of mergers and acquisitions on various financial performance parameters of India's Agri-Food companies. The period of study is from 2011 to 2019, and Wilcoxon Sign Rank methodology has been used. The study hypothesized that there is significant growth in Indian literature of M&A and there is a significant difference in the operating performance, financial performance and shareholders' return of acquiring firms during the period of pre-M&A and post-M&A. The study findings state that the literature of M&A in India increases significantly, and the operating ratio, financial

ratio, and shareholder return also exhibit a significant improvement whereas the expense ratio related to the operating ratio shows no improvement in performance. The study concludes that the India Agri-Food company's financial performance has improved overall for the acquiring firms during the post-M&A period.

Hampson, et.al (2023) this study aims to evaluate the impacts of M&A on the financial performance of selected banks in the pre-post-M&A period. The findings of this research study concluded that the overall financial performance of BOKL has mixed results in the pre-post-merger period. The results indicated that profitability ratios and liquidity ratios such as ROA, NIM, and ITA improved significantly, whereas the leverage ratio did not improve significantly. The merger did not create wealth for shareholders as its key indicators DPS and MPS ratios deteriorated in the post-merger period. On the other hand, the M&A has an insignificant impact on all the profitability, liquidity, leverage, and wealth of shareholders ratios of PRVU bank except for a significant improvement in the DPS ratio in the pre-post-M&A.

CONCLUSION

In the pharmaceutical industry, mergers and acquisitions have become a key way for companies to grow. This strategy helps them deal with strong competition, high costs for research and development, and fast changes in technology. By merging with or buying other companies, drug makers can add more products to their offerings, start working in new areas of medicine, build better research projects, and get access to new technologies like biologics, gene therapy, and drug discovery that uses artificial intelligence. These strategic combinations also help companies save money by producing more efficiently, expand their presence in international markets, and speed up the time it takes to bring new treatments to patients. In addition to financial benefits, mergers and acquisitions encourage innovation by letting big companies combine their resources with the flexibility and expert knowledge of smaller biotech firms. It also helps in spreading out risks, as companies put their money into different drug options and various markets.

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Policy Frameworks, Governance Mechanisms, and Advocacy Efforts

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ABSTRACT

Nutrition challenges are increasingly addressed through global partnerships and multisectoral initiatives, making effective governance essential for achieving large-scale and sustainable impact. The Collective Impact (CI) approach provides a useful framework for guiding and evaluating the governance of such initiatives. However, two key gaps remain in the existing CI literature: limited understanding of how expansion affects initiatives operating under CI conditions, and insufficient attention to advocacy for policy change within CI initiatives. This paper presents a case study applying the CI framework to the advocacy efforts of Alive & Thrive (A&T), UNICEF, and their partners. The initiative expanded from national programs into a regional movement and successfully influenced infant and young child feeding policies across seven Southeast Asian countries. The analysis addresses the identified gaps by examining the governance structures and processes that supported the initiative's expansion from a national to a regional, multilayered model, highlighting key adaptations and challenges. In addition, the study compares advocacy practices within the A&T–UNICEF initiative to those commonly observed in CI initiatives, offering insights into how advocacy for policy change can be more effectively integrated and strengthened within the CI approach.

Keywords: advocacy, Collective Impact, expansion, governance, nutrition, policy change.

INTRODUCTION

In recent years, complex nutrition challenges have increasingly been addressed through global partnerships, platforms, and multisectoral initiatives (Alderman et al., 2013; Levinson, Balarajan, & Marini, 2013). Prominent examples include the Scaling Up Nutrition Movement, the Renewed Efforts Against Child Hunger and Undernutrition initiative, the Zero Hunger Challenge, the United Nations Decade of Action on Nutrition, and the Global Breastfeeding Collective. These initiatives promote the large-scale implementation of cost-effective nutrition-sensitive interventions (Ruel & Alderman, 2013) and nutrition-specific interventions (Bhutta et al., 2013). Although they operate through diverse structures and strategies, all aim to build global partnerships and coalitions that align the efforts of multiple stakeholders to improve nutrition outcomes.

The impact and sustainability of such initiatives depend largely on the development of effective governance arrangements (Shiffman et al., 2016). A key challenge lies in the fact that many initiatives operate across multiple levels—global, regional, and national—where governance structures that are effective at one level may not translate well to others. While the literature offers a growing number of governance frameworks to guide such efforts (Dodgson, Lee, & Drager, 2002; Gostin & Mok, 2009), and provides extensive discussion on various governance modes and forms (Lowndes & Skelcher, 1998; Provan & Kenis, 2008), much of this work remains largely theoretical, offering limited practical guidance for implementation.

The Collective Impact (CI) approach represents a practical framework designed to guide the governance of multiorganizational initiatives. First articulated by Kania and Kramer (2011) in the *Stanford Social Innovation Review*, the CI approach has since become a widely adopted model for cross-sector collaboration aimed at achieving large-scale social change (Hanleybrown, Kania, & Kramer, 2012). CI has been applied across diverse contexts and problem areas, including poverty reduction, public health, and obesity prevention (Amed et al., 2015; Dipankui, 2017; Flood et al., 2015; Garber & Adams, 2017; Grumbach et al., 2017; Hoey et al., 2017; Smart, 2017; Thompson & Jocius, 2017). The framework is applicable at local, national, and regional or global levels (Hanleybrown et al., 2012; Patscheke et al., 2014). Initiatives involving multiple organizations that adopt this framework are referred to as CI initiatives, while those spanning multiple geographic levels are described as multilayered CI initiatives. Despite the growing application of CI, few multilayered CI initiatives have been thoroughly documented in the literature. One notable exception is the Vibrant Communities initiative, launched in 2002, which has demonstrated sustained success in reducing poverty across multiple Canadian communities (Gamble, 2010, 2012).

METHODOLOGY

Evaluation and Inquiry Approach

The reflections presented in this paper are grounded in a real-time evaluation conducted across seven countries in Southeast Asia (SEA) between May 2015 and March 2017. A research team employed a

developmental evaluation (DE) approach to actively engage with policy advocates throughout the evaluation process. Developmental evaluation is particularly suited to supporting innovation in complex and evolving contexts, as it involves the continuous collection and analysis of diverse data to generate timely feedback that informs adaptive decision-making (Patton, 2010; Patton, McKegg, & Wehipeihana, 2015). Through this approach, the evaluation systematically documented and monitored activities implemented in each country over the course of the initiative, enabling an understanding of how actions evolved in response to contextual dynamics.

Case Study

This study adopts a rich single-case study design focusing on the A&T–UNICEF initiative, with seven embedded units of analysis representing collective impact (CI) initiatives in each participating country (Yin, 2009). Building on prior analyses that examined country-level progress, experiences, and the drivers and triggers influencing change (Michaud-Létourneau, Gayard, & Pelletier, 2019b), as well as the contribution of the A&T–UNICEF approach to observed outcomes (Michaud-Létourneau, Gayard, & Pelletier, 2019a), this paper further investigates the activities undertaken by key actors. These activities are analyzed through multiple conceptual lenses to generate deeper insights. In particular, the collective impact framework is applied to examine the governance of the initiative. This framework identifies five core conditions necessary for achieving effective results: a backbone support organization, a common agenda, shared measurement systems, mutually reinforcing activities, and continuous communication.

RESULTS AND INTERPRETATION

Expansion of the Initiative into a Regional Movement and Transformation of Its Governance

This section outlines the key elements and challenges associated with expanding a collective impact (CI) initiative into a multilayered structure. As shown in Table 1 (column 3), the A&T initiative fulfilled four of the five core conditions of an effective CI initiative, despite not being intentionally designed according to the CI framework.

In a typical CI model, strategic direction is provided by an oversight group composed of representatives from multiple organizations, while operational coordination is managed by a backbone organization that supports the initiative. The backbone usually consists of independently funded staff dedicated to the initiative and represents the first essential condition for an effective CI. Its presence enables the establishment of the remaining four conditions: a common agenda, mutually reinforcing activities, continuous communication, and shared measurement systems. In practice, the backbone monitors progress and coordinates the work of various working groups.

In the initial phase of the initiative in Vietnam, several organizations led different aspects of work related to infant and young child feeding (IYCF) policies within their respective mandates. Nevertheless, UNICEF and A&T assumed leadership of advocacy efforts and thus functioned as the oversight group by providing strategic guidance. A&T simultaneously acted as the backbone organization by supporting coordination among national-level actors.

Toward the end of the first phase, A&T and UNICEF began sharing their experiences and extending support to other countries in the region. This marked the transition from a country-level initiative to a broader

CONCLUSION

This paper offers insights into two critical dimensions of collective impact (CI) initiatives that have received limited attention in prior literature: the expansion of CI initiatives into multilayered structures and the role of policy advocacy within CI approaches.

With respect to expansion, the findings suggest that scaling a CI initiative to the regional or higher level necessitates a transformation of governance structures. Such transformation is essential to enable the regional backbone organization to effectively fulfill its coordinating, monitoring, and support functions across multiple levels, including sustained engagement with in-country actors. Equally important is fostering a shift in mindset among country-level stakeholders so that the purpose and value of a shared workplan are clearly understood and collectively embraced. Moreover, communication—both between and among actors—emerges as a central yet challenging component of multilayered CI initiatives. Geographic dispersion and organizational diversity intensify these challenges, underscoring the need for robust and intentional communication mechanisms.

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Library Policy Management

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Abstract

Library policy management is a fundamental component of effective library administration, ensuring consistency, accountability, and quality in service delivery. Policies provide a structured framework that guides decision-making in areas such as collection development, access control, staff responsibilities, and user conduct. In the contemporary information environment, libraries must manage a hybrid ecosystem of print and digital resources while complying with legal, ethical, and institutional standards. This paper examines the concept and scope of library policy management, outlines its objectives, and analyzes major policy domains and implementation processes. It further explores challenges faced during policy development and enforcement and proposes best practices for strengthening policy governance. The study emphasizes that clearly articulated, flexible, and regularly reviewed policies are essential for sustaining library services and meeting evolving user expectations.

Keywords: Library policy management, policy framework, library governance, information services, administration

Introduction

Libraries play a vital role in supporting education, research, and lifelong learning by providing organized access to information resources. As service-oriented institutions, libraries must operate within clearly defined administrative and functional boundaries to ensure efficiency and fairness. Library policies serve as formal instruments that regulate operations, guide staff actions, and inform users about acceptable practices.

Library policy management refers to the systematic approach used to design, implement, monitor, and revise these policies. It ensures that library operations are aligned with institutional objectives, legal requirements, and professional standards. In the absence of clearly defined policies, libraries may experience inconsistent service delivery, resource misuse, and operational inefficiencies.

The rapid expansion of digital technologies, increased dependence on electronic resources, and changing user expectations have further complicated library management. Issues such as copyright compliance, licensing agreements, data privacy, and open access require libraries to adopt well-structured and adaptive policy frameworks. This paper explores how effective library policy management contributes to organizational stability, service quality, and user satisfaction.

Objectives of the Study

The objectives of this study are:

- To explain the concept and significance of library policy management
- To identify and analyze major categories of library policies
- To examine the stages involved in policy formulation and implementation
- To discuss challenges associated with managing library policies
- To suggest best practices for improving policy effectiveness and sustainability

Scope of Library Policy Management

The scope of library policy management extends beyond routine rule enforcement. It encompasses strategic planning, service evaluation, and governance mechanisms that influence all aspects of library functioning.

Policy management affects

- Resource acquisition and organization
- User access and service delivery
- Staff roles and professional conduct
- Legal and ethical compliance
- Financial accountability and sustainability

In modern libraries, policy management also addresses emerging areas such as digital preservation, institutional repositories, open-access publishing, and information security. As libraries evolve into hybrid information centers, the scope of policy management continues to expand.

Concept of Library Policy Management

Library policy management is a continuous administrative process that ensures policies remain relevant, practical, and aligned with institutional goals. Policies act as guiding principles rather than rigid directives, allowing flexibility while maintaining consistency in decision-making.

An effective policy management system includes:

- Clearly documented policy statements
- Defined authority and responsibility structures
- Regular staff training and orientation
- Mechanisms for feedback and evaluation

Policies must be realistic, legally compliant, and adaptable to technological change. Well-managed policies promote transparency, reduce ambiguity, and support informed decision-making across library operations.

Major Areas of Library Policies

Collection Development Policy

The collection development policy provides guidelines for selecting, acquiring, evaluating, and withdrawing library materials. It ensures balanced collection growth and supports institutional academic and research goals. This policy also addresses issues related to format diversity, subject coverage, language preferences, and budget allocation.

Circulation Policy

Circulation policies regulate membership categories, borrowing privileges, loan periods, renewals, reservations, and fines. These policies help maintain equitable access to library materials while protecting resources from loss or misuse.

Access and Usage Policy

Access and usage policies define library hours, use of reading areas, computer facilities, and access to special collections such as rare books and archives. They also address accessibility considerations for users with special needs.

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Digital and Electronic Resource Policy

Digital resource policies govern access to electronic journals, e-books, databases, and institutional repositories. They ensure compliance with licensing agreements, copyright laws, and ethical standards while promoting responsible use of digital content.

User Conduct Policy

User conduct policies establish acceptable behavior within library premises. These policies promote a respectful and productive environment by addressing issues such as noise control, use of personal devices, and care of library property.

Staff and Administrative Policy

Staff policies define roles, responsibilities, service expectations, and ethical standards. They support professional development, accountability, and efficient internal management.

Policy Formulation and Implementation Process

Library policy management follows a structured process to ensure effectiveness and acceptance:

Needs Assessment: Identifying operational challenges and service requirements

a. **Policy Drafting:** Developing clear and concise policy documents
b. **Consultation:** Seeking input from stakeholders
c. **Approval:** Obtaining authorization from governing bodies
d. **Implementation:** Communicating policies to staff and users
e. **Monitoring:** Evaluating compliance and effectiveness
f. **Revision:** Updating policies based on feedback and change

This cyclical process ensures policies remain dynamic and relevant.

Role of Library Professionals in Policy Management

Library professionals play a key role in the successful management of policies. Their responsibilities include policy development, interpretation, implementation, and user education. Librarians must also stay informed about legal developments, technological trends, and professional standards to ensure policy relevance.

Continuous professional development and leadership skills are essential for effective policy governance.

Challenges in Library Policy Management

Libraries face several challenges in managing policies, including:

- Resistance to organizational change
- Limited staff training and awareness
- Rapid technological developments
- Legal and copyright complexities
- Budgetary and staffing constraints

Addressing these challenges requires institutional support, clear communication, and strategic planning.

Best Practices for Effective Library Policy Management

Best practices include:

- Stakeholder participation in policy formulation
- Transparency and clarity in documentation

- Regular review and updating of policies
- Staff training and user orientation programs
- Alignment with institutional mission and user needs

These practices enhance policy acceptance and effectiveness.

Conclusion

Library policy management is a critical element of modern library administration. Well-designed policies provide direction, protect resources, and ensure equitable service delivery. In an evolving information landscape, libraries must adopt flexible and forward-looking policy frameworks that respond to technological change and user expectations. Continuous evaluation and improvement of policies are essential for maintaining relevance, efficiency, and service excellence.

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Zotero: A Reference Management Tool for Research Scholars

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Abstract

In academic research, managing references accurately is essential for maintaining scholarly integrity and avoiding plagiarism. With the rapid growth of digital resources, researchers face difficulties in organizing citations manually. Zotero is a free and open-source reference management tool designed to help researchers collect, organize, cite, and share research sources efficiently. This paper explores the features, advantages, and academic significance of Zotero for research scholars. It also examines how Zotero simplifies the research process and supports academic writing across disciplines.

***Keywords*:** Zotero, Reference Management, Research Scholars, Citation Tools, Academic Writing

Introduction

Research is a systematic process of discovering new knowledge through careful investigation and analysis. One of the most important aspects of research writing is proper referencing. An accurate citation not only gives credit to the original authors but also strengthens the credibility of research work. However, manual referencing is time-consuming and prone to errors. With the advancement of digital technology, several reference management tools have been developed to assist researchers. Among these tools, Zotero has gained popularity due to its user-friendly interface, free availability, and strong integration with academic databases. This paper discusses Zotero as an effective reference tool for research scholars.

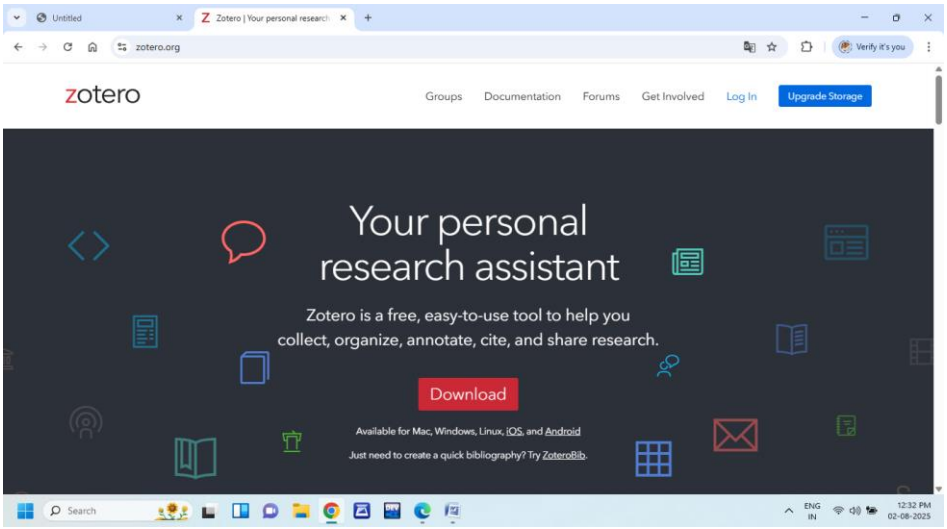
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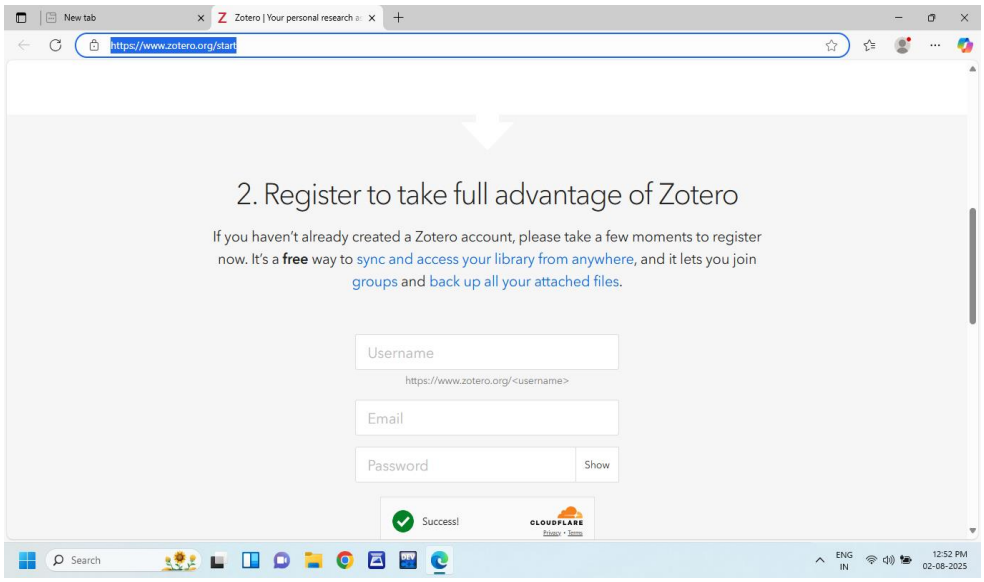
Reference management tools are software applications that help researchers store, organize, and format bibliographic references. Common reference tools include EndNote, Mendeley, RefWorks, and Zotero.

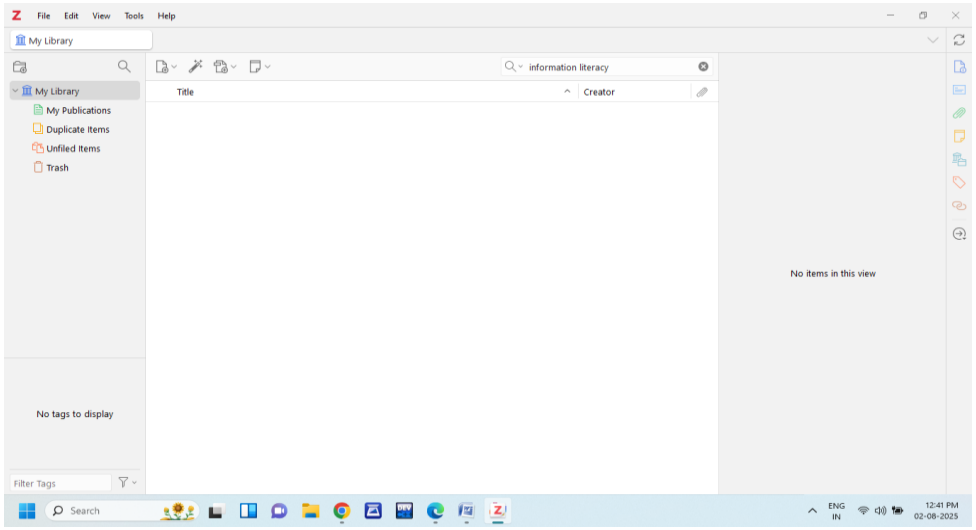
These tools allow users to:

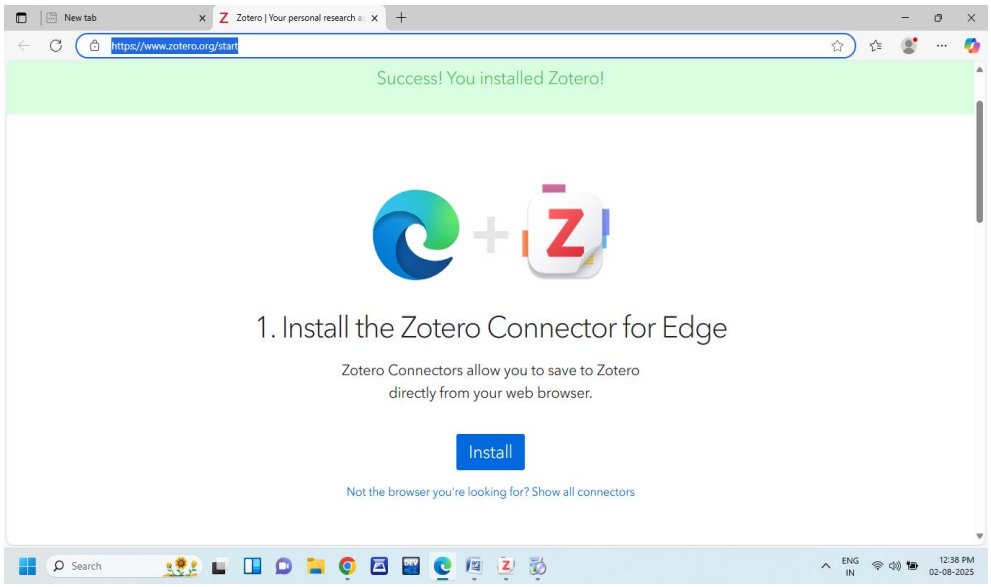
- ❖ Collect references from online sources
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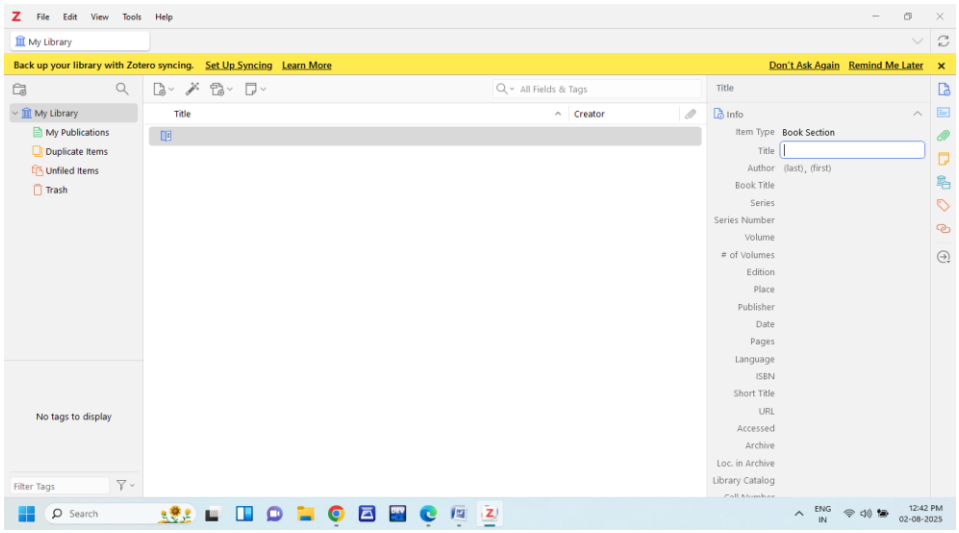
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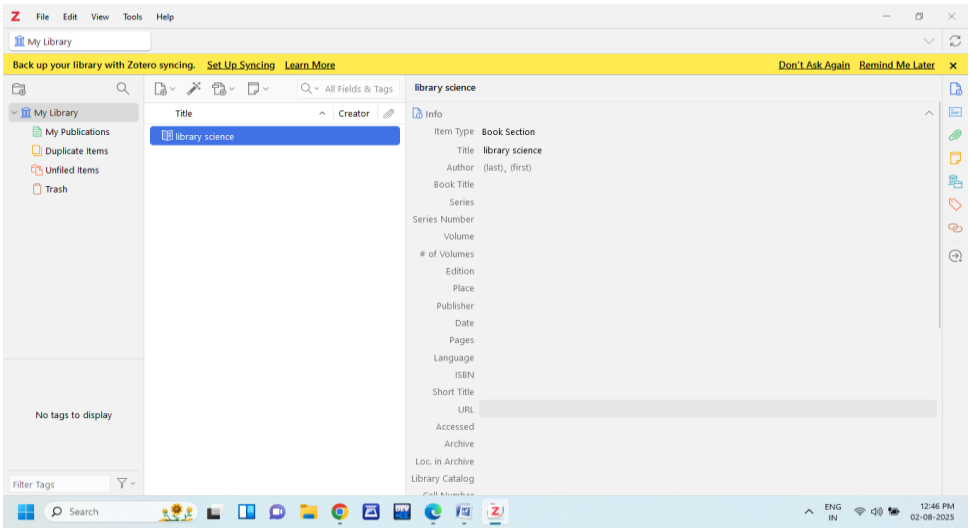


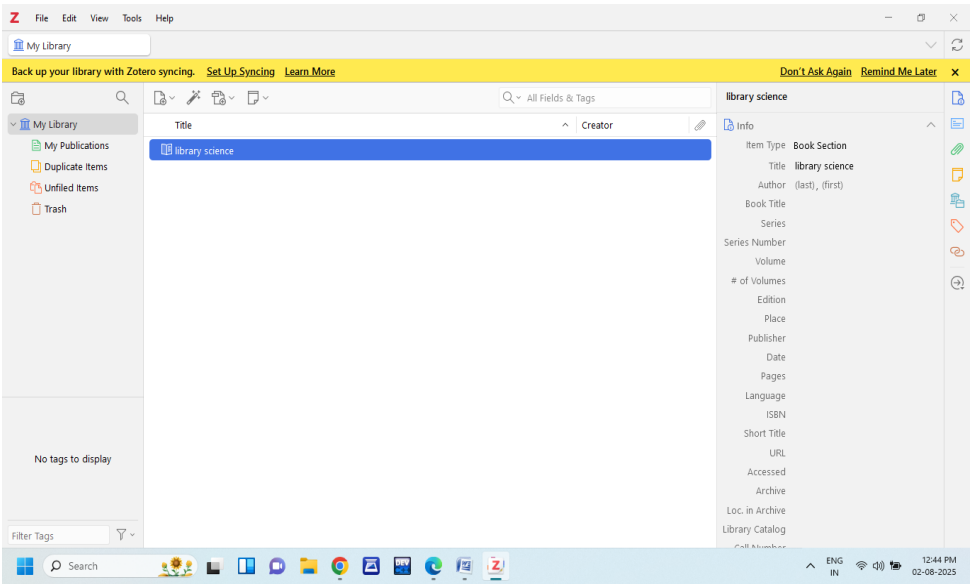

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2. Register to take full advantage of Zotero
If you haven't already created a Zotero account, please take a few moments to register now. It's a free way to sync and access your library from anywhere, and it lets you join groups and back up all your attached files.
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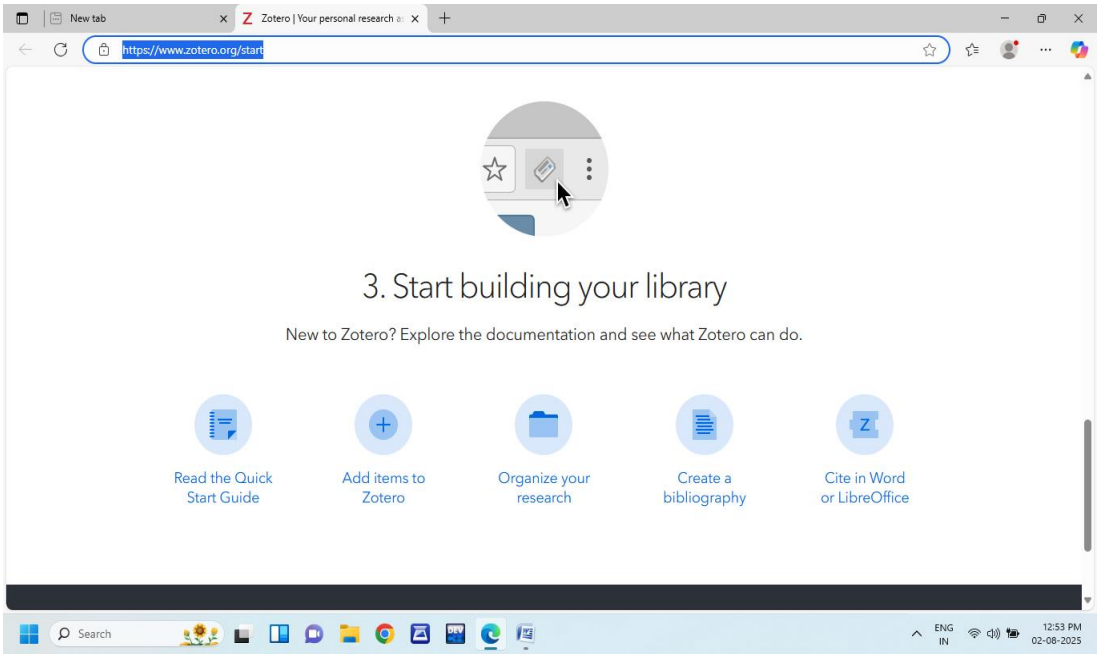

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Overview of Zotero

Zotero was developed by the Roy Rosenzweig Center for History and New Media at George Mason University. It is designed to assist scholars in managing research materials such as books, journal articles, websites, reports, and theses.

Zotero works as:

- ❖ A standalone desktop application
- ❖ A browser connector (Chrome, Firefox, Edge)
- ❖ This combination allows users to save references directly from the web with a single click.

Features of Zotero

➢ **Collection and Organization**

Zotero allows users to collect references automatically from academic databases such as Google Scholar, JSTOR, and PubMed. References can be organized into folders and subfolders for easy access.

➢ **Citation and Bibliography Creation**

Zotero supports various citation styles, including MLA, APA, Chicago, and Harvard. It integrates smoothly with word processors like Microsoft Word and LibreOffice, enabling automatic citation insertion.

➢ **Storage and File Management**

Users can attach PDFs, images, and notes to references. Zotero also offers cloud storage, making it easy to access research materials from multiple devices.

➢ **Collaboration and Sharing**

Zotero supports group libraries where researchers can collaborate, share references, and work collectively on projects.

Importance of Zotero for Research Scholars

Zotero is highly beneficial for research scholars for the following reasons:

- ❖ Saves time in citation management
- ❖ Reduces referencing errors
- ❖ Supports plagiarism-free academic writing
- ❖ Enhances organization of research materials
- ❖ Useful for theses, dissertations, and research papers

For postgraduate and doctoral scholars, Zotero simplifies the complex task of managing large numbers of references.

Advantages of Zotero

- ❖ Free and open-source
- ❖ Easy to use
- ❖ Supports multiple citation styles
- ❖ Compatible with major browsers and word processors
- ❖ Encourages collaborative research

Limitations of Zotero

Despite its advantages, Zotero has some limitations:

- ❖ Limited free cloud storage
- ❖ Requires internet access for syncing
- ❖ Advanced features may require training

However, these limitations do not significantly reduce its usefulness for academic research.

Role of Libraries and Librarians

Academic libraries play a crucial role in promoting the use of reference management tools like Zotero. Librarians can conduct training programs and workshops to help students and scholars use Zotero effectively. This enhances research quality and promotes ethical academic practices.

Conclusion

Zotero is an efficient and reliable reference management tool that supports research scholars in organizing and citing academic sources accurately. Its open-source nature, ease of use, and powerful features make it an ideal tool for modern research practices. By adopting Zotero, research scholars can improve the quality, accuracy, and efficiency of their academic writing.

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User Awareness of Onos Resources among Students, Researchers & Faculty in Erode District

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ABSTRACT

For the purpose of giving research and higher educational establishments equal and national-level access to research journals and higher educational resources, the One Nation One Subscription (ONOS) scheme has been initiated by the government of India. Despite the revolutionary character of the ONOS scheme, the usage of the resources provided by it differs. The present study examines the awareness, usage, and problems associated with the usage of the ONOS resources in the Erode District in the state of Tamil Nadu. A structured and semi-structured study has been done with 10 librarians through the former, and a structured survey has been done with 200 people, consisting of 120 students and 40 each of researchers and faculty members. The study reveals that the awareness and usage are maximum with the faculty members, followed by the research researchers, and that the students have very low awareness and occasional usage. The main problems associated with the usage are low digital literacy awareness and a lack of awareness due to insufficient advertising and technology issues.

KEYWORDS: ONOS, One Nation One Subscription, User Awareness, E-Resources, Students, Research Scholars, Faculty, Erode District, Digital Literacy, Academic Libraries

INTRODUCTION

Availability of scholarly information is essential in teaching, learning, and research in higher educational institutions. In the past, higher educational institutions in India have experienced difficulties in subscribing to international journals because of costs and a lack of awareness about e-resources. In a move to address these challenges, the Government of India launched the One Nation One Subscription (ONOS), which is a national-level subscription service for access to thousands of scholarly journals and databases in all eligible higher educational institutions **(Press Information Bureau, 2025).**

Erode District has numerous colleges and universities operating in different areas of arts, science, engineering, and management. Though ONOS is spread all over the country, its utilization is in a different manner or to a different extent in different institutions. This paper will examine how much it is used, what problems are faced by students, research scholars, and faculty, and how its utilization can be improved.

REVIEW OF RELATED LITERATURE

Quite a number of studies conducted in recent years have drawn their focus towards awareness and the use of digital library resources, thereby bringing the growing need for information literacy and institutional support in the academic environment. With this emerging national initiative in India to provide access to quality e-resources—ONOS, or One Nation One Subscription—renewed interest in user awareness and resource utilization is targeted across higher education institutions.

Many have attempted to portray awareness and usage patterns of digital databases and e-resources. **Kumar and Kumar (2018)** discussed the use of e-resources by faculty and students in affiliated engineering colleges. The study identified that the level of awareness was directly related to exposure to training programs and promotional activities at the library. It emphasized the role of librarians in bridging the gap between availability and user knowledge. Similar studies are reported by **Patil (2019),** who mentions that students underutilize these resources owing to a lack of formal orientation regarding accessing and searching databases.

In a similar vein, considering the digital projects such as ONOS, a study was conducted by **Reddy & Narayana, 2020,** on perceptions of national subscription programs, and they found that while the faculty had

better awareness of the available resources, students have shown considerable app learning behavior. In an effort to trace the root difference between the two categories of people, the two authors cited the differing needs and exposure to research activity. Likewise, **Sharma & Singh, 2021,** found that considerable interest in the use of e-resources was shown by researchers and postgraduate students compared to UG students, thus re-emphasizing once again that research needs dictate the behavior of awareness/usage.

Organizing training sessions and advocacy for libraries was also stressed in several research works. **Lakshmi and Rao (2022)** have proved in their research study that workshops have greatly helped students in searching and fetching the necessary information from digital sources. It was revealed in their study that promoting sources through consistent methods increases students' satisfaction and awareness level of electronic sources. **Mehta (2023)** conducted a study on the digital literacy skills of faculty members, and it was revealed that their digital literacy skills had a positive impact on using paid sources efficiently.

Regional research also proves to be helpful in gaining specific insight into the topic. In a study on awareness of e-resources in colleges of Tamil Nadu, **Sundaram (2021)** found moderate levels of awareness, with differences based on departments and academic programs. The importance of policies and support of the library in determining users' behavior was emphasized.

OBJECTIVES OF THE STUDY

The following objectives have been drawn up to measure User Awareness of ONOS Resources among Students, Researchers, and Faculty in Erode District:

- ✓ To identify User Awareness of ONOS Resources among Students.
- ✓ To determine the level of awareness regarding ONOS (One Nation One Subscription) resources among students, research scholars, and faculty members.
- ✓ To analyze the use of ONOS resource capabilities by various user communities in terms of their frequency and pattern.
- ✓ To evaluate reasons why the resources of ONOS are used by students, researchers, and professors alike.
- ✓ Identify barriers & problems/constraints faced by the user community to access/utilize ONOS resources.
- ✓ For comparing the levels of awareness as well as usage of ONOS resources by students, research scholars, and faculty members.

METHODOLOGY

The current study uses a descriptive survey approach to determine the level of knowledge of the use of the ONOS (One Nation One Subscription) resources among the students, research scholars, and faculty members in the institutions of higher education in the Erode District. The research technique used here is very effective in identifying the facts related to the knowledge level of the use of the resources by the members.

The population of this study includes undergraduate, postgraduate students, research scholars, and faculty members of selected colleges and universities in the Erode District. For this purpose, a random sampling method has been used to select the targeted population.

Data was gathered using a structured questionnaire comprising closed-type questions about awareness of ONOS resources, source of information, usage level, and difficulties encountered in accessing resources. The questionnaire was used both offline and online to gather maximum data.

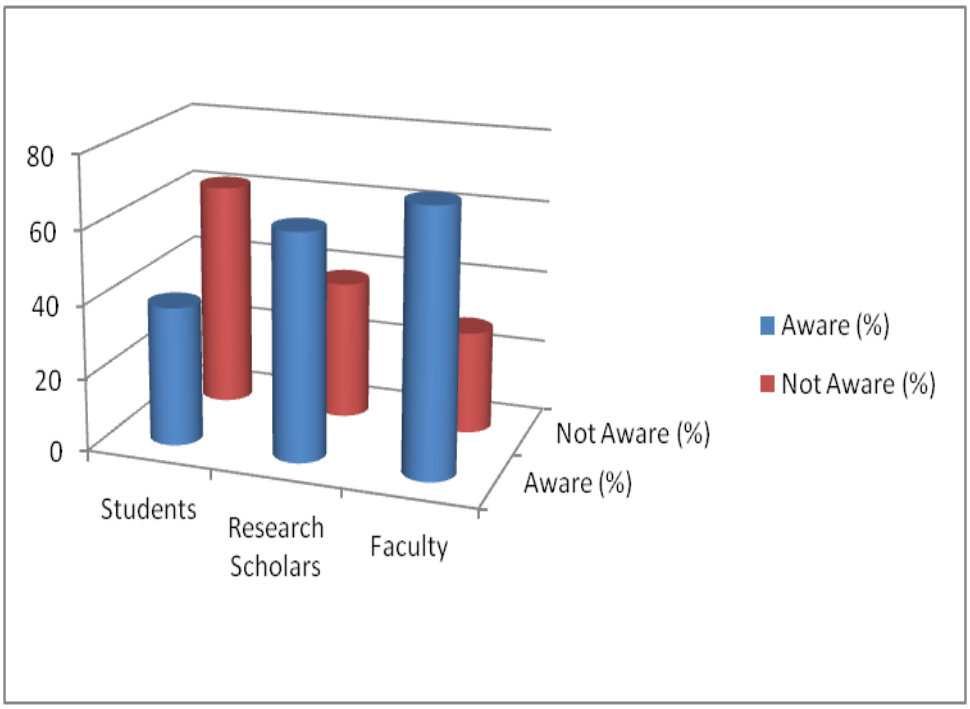
The collected data was processed by the use of simple statistical techniques like percentage and frequency analysis. The results of the study were displayed in the form of tables and graphs for a clear understanding of the subject. The study was only conducted in the selected institutions in the Erode District,

considering data based on the perception of the respondents. The ethical considerations of volunteer participation and anonymity were ensured in the study.

DATA ANALYSIS AND INTERPRETATION

Awareness Levels

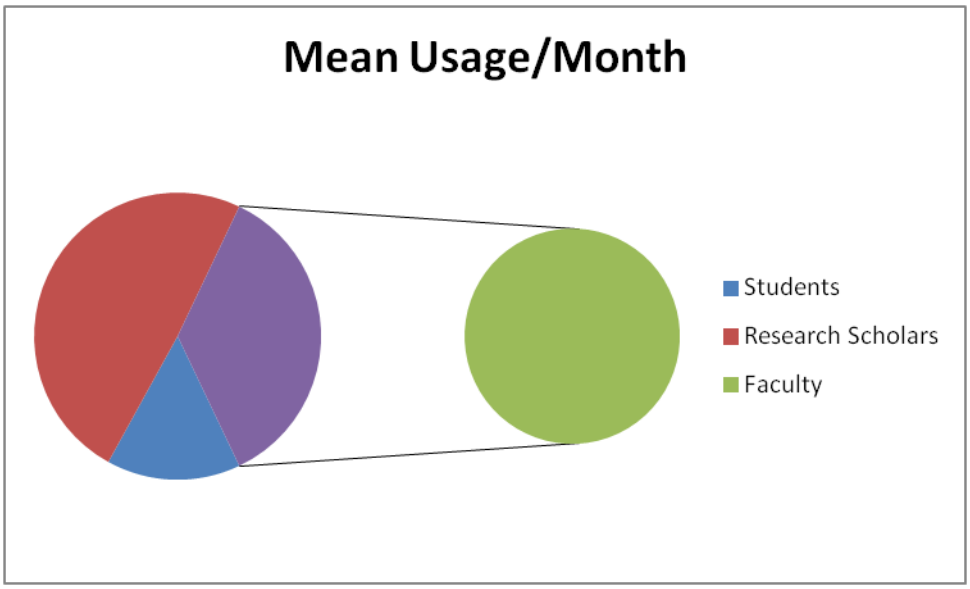
User Group	Aware (%)	Not Aware (%)
Students	38	62
Research Scholars	62	38
Faculty	72	28



From the table, it is revealed that faculty members possess the highest awareness level of the ONOS resources, which is 72%, suggesting that they are most exposed to the e-resource and the related activities of an academic nature. The awareness level of the research scholars is also considerably high, which is 62%, suggesting that the database is used extensively for the purpose of performing the research work. The awareness level of the students is relatively lower, which is 38%, with 62% of the total being unaware of the ONOS resources. This generates a notable awareness gap.

Frequency of Usage (Mean / Month)

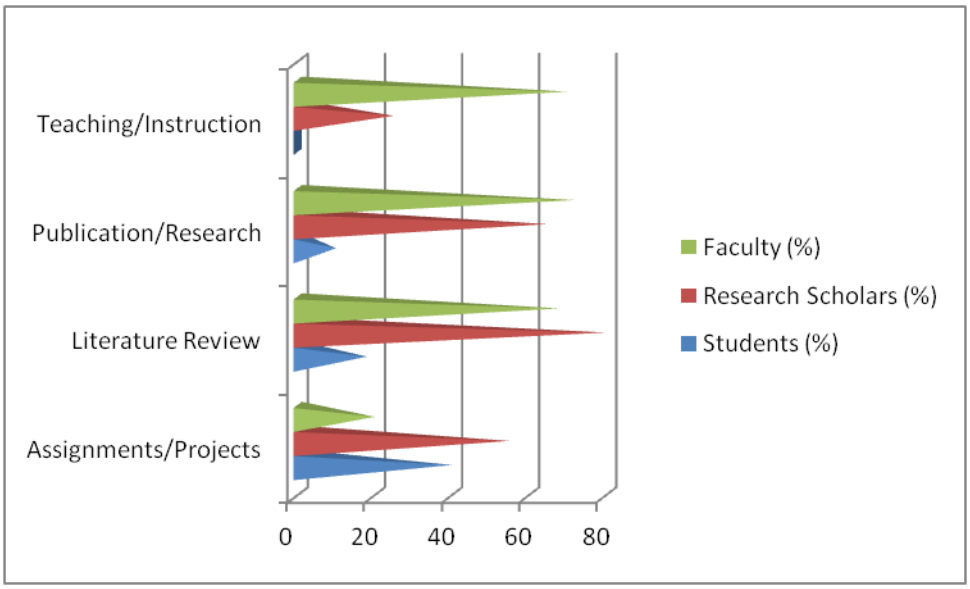
User Group	Mean Usage/Month
Students	1.6
Research Scholars	5.2
Faculty	3.8



On analyzing the average usage statistics, it is found that the highest number of times the ONOS resources are utilized is by the research scholars, amounting to 5.2 times per month. This is owing to the continuous need for scholarly literature and research. The second highest number of times the ONOS resources are utilized is by the faculty members, amounting to 3.8 times per month. This is because of the ONOS resources are helpful to the faculty members in their teaching and research. However, the lowest number of times the ONOS resources are utilized is by the students, amounting to 1.6 times per month.

Purpose of Access

Purpose	**Students (%)**	**Research Scholars (%)**	**Faculty (%)**
Assignments/Projects	40	55	20
Literature Review	18	80	68
Publication/Research	10	65	72
Teaching/Instruction	0	25	70



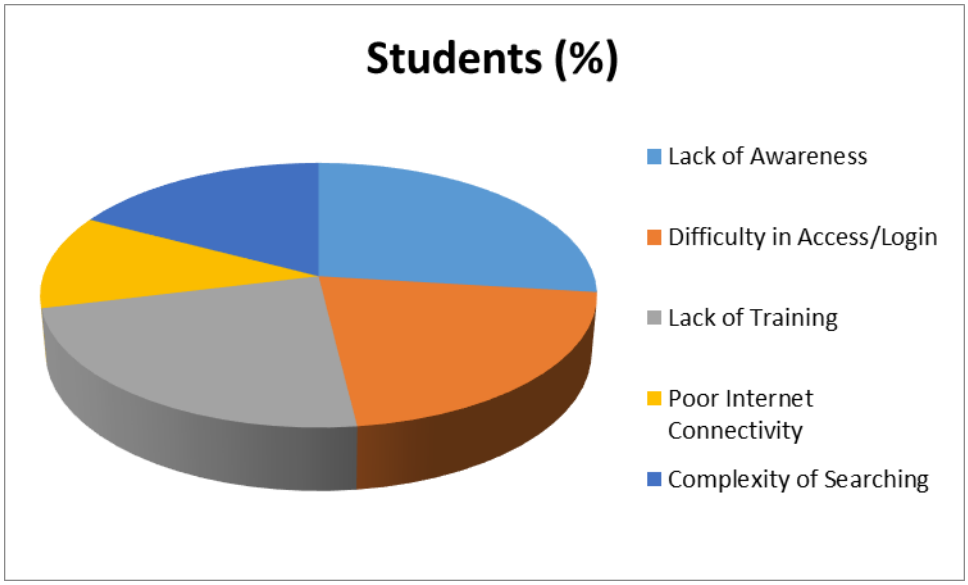
ISBN: 978-93-47799-57-0

The above table shows marked variations in the purpose of using the ONOS resources by the three categories of users. Students' use the ONOS resources largely for their project works (40%), while their use for the literature review (18%) and research/publication (10%) purposes is still less. Research scholars use the ONOS resources extensively for both the purposes of literature review (80%) and research/publication (65%), which is evident due to the research-oriented nature of their studies. Faculty members use the ONOS resources largely for research/publication (72%) and teaching/instruction (70%), which makes their use multifaceted, being both teaching and research-oriented.

It is quite evident from the findings mentioned above that the use of the ONOS resources by the three categories of users differs in their purposes, which makes it necessary to design of separate training programmes for students, research scholars, and faculty members.

Barriers to Usage

Barrier	**Students (%)**	**Research Scholars (%)**	**Faculty (%)**
Lack of Awareness	70	40	25
Difficulty in Access/Login	55	38	30
Lack of Training	60	48	35
Poor Internet Connectivity	30	28	18
Complexity of Searching	45	35	22



The data regarding the critical factors highlight that there is less awareness among students (70%), followed by less training (60%), and difficulties in accessing/logging in (55%), which clearly signifies that the students have severe difficulties in accessing the resources of ONOS. The lack of training among research scholars has been labeled as one of the critical factors by 48 percent, followed by less awareness by 40 percent. It signifies that there is an absolute need for advanced research-related user education. Compared to students, the critical factors have been fewer among faculty members. However, less training has been labeled as one of the critical factors by 35 percent, followed by difficulties in access/login by 30 percent. The lack of reliable net connectivity has been labeled as one of the least critical factors by all three groups, followed by the complexity of searching by 45 percent among students.

CONCLUSION

The study concludes that the awareness of ONOS resources is moderately established among students, researchers, and faculty of Erode District. It is also revealed that the awareness level of faculty and researchers is greater than that of students. ONOS provides vast access to quality educational resources; however, the use of ONOS resources is limited due to a lack of proper understanding and training. The library orientation programs and educational programs play a major role in the proper use of ONOS resources. Improvements are needed regarding promotional and digital literacy programs. Greater collaboration between the library and the academic staff will be helpful to utilize the educational resources of ONOS to a greater extent.

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13th & 14th February, 2026

Utilization of E-Resources by the Academic Community: A Case Study of Central University of Kerala

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Abstract

The e-resources were more popular during the pandemic period; everyone is familiar with them. So, it is very important to study the proper and maximum use of the online resources. The purpose of this study is to determine the electronic resources available in the Central University of Kerala, Kasaragod Library. This paper makes use of electronic resources for study and other activities since they can access these materials quickly and from any location in the world. Nowadays, learning and research are not limited by physical presence. In the modern era, most of the users utilize the remote access facility for their education requirements. During the time of pandemic period, educational systems were completely transformed to the digital platform. At the same time, the libraries are also being the part of the transformation. The library patrons have changed their way of using the library resources to the online mode to fulfill their academic needs. It is compelled to introduce a facility to use library resources remotely. A remote access facility in a university library enables students, faculty, and researchers to access digital resources and library services from off-campus locations. These resources include e-journals, e-books, and electronic theses and dissertations (ETDs). The University Library, Central University of Kerala, started the remote access facility through INFED and MyLoft Software. It also extends the reach of the library's resources beyond campus boundaries.

Keywords: e- resources, use and awareness, remote access and library consortium

Introduction

The Central University of Kerala (CUK)[4] is a prestigious institution committed to promoting academic excellence and innovation. CUK, headquartered in Kasaragod, provides a wide array of undergraduate, postgraduate, and doctoral programs in multiple fields. The university has built a strong reputation as a centre for learning and intellectual exploration through its dedication to research, community involvement, and comprehensive education. The University Library of the Central University of Kerala serves as a pivotal resource hub, housing an extensive and diverse collection of learning materials in fields such as Arts, Humanities, Science, and Social Sciences. The Library supports research and educational endeavours of Students, Research Scholars, and the Faculties of the university by collecting, organizing, preserving and disseminating information and provides instructional programs in all formats through need-based services and enables access to online information resources using modern Information & Communication Technologies. Within a short period of time, the library attained a considerable level of development. The very ambience of the Library is appealing and user-friendly, and is automated with Wi-Fi network.

The library is automated with KOHA[5] Open Source Integrated Library Management System (ILMS). The library is using the Dewey Decimal Classification (DDC) system to organize the knowledge Collection. Library is having good collection of documents on all subjects, and the total collection of books is around 64708 and 632 Braille collections. All the students, faculty members and staff are members of the University Library. University Library has membership in the eShodhSindhu consortium and accesses 13000+ e-journals through ONOS. The University Library is individually subscribing to both Indian and foreign journals. The library is regularly updating the new arrivals of books and journal issues to the students and faculty members. Regular Orientation Programmes are given to the library members**.**

Library Collections

Library collection is an important indicator of any good library. The library users' satisfaction largely depends on the kind of library collections that the libraries possess. We have taken utmost care to develop robust collections of books on various subjects of knowledge.

Collections

- Books :64708
- E-Books :1353
- Print Journals :86
- E-Journals :17679 +
- Bound Volumes :1004
- Magazines :38
- Braille Collection :632

Objectives of the study

- To study the status of the e-resources in the CUK Library.
- To examine the effective utilization of the e-resources.
- To examine the facilities given for the search of e-resources.
- To find out the most preferred mode of access used by the users.

Methodology

The methodology will provide a comprehensive understanding of e-resource access for both IP-based and remote access, informing strategies for improvement and optimization. Usage Statistics: Analysis of existing usage logs for IP-based access and remote access. The current versions of MS Excel and SPSS were used for statistical analysis and data Description.

Review of Literature

Sharma, Neetika (2018)[1], examines the utilization of e-resources by the faculty members and students of Swami Shraddhanand College, University of Delhi. The main aim of the study was to find out how academicians compare e-resources with print resources, how they perceive the advantages of e-resources, and how they face the problems while accessing them. Out of 200 questionnaires distributed among students and faculty in the Social Sciences departments (Political Science, History, Geography, and Economics), 180 were completed and returned. The study found that the majority of users are aware of the availability of e-resources. The majority of the faculty respondents use e-resources for their teaching and research work activities. The results of the study it may be said that the fast growth of information and communication technologies and electronic resources have changed the total scenario of research, storage, retrieval and communication of scholarly information. The study showed that the use of electronic resources has created a great impact on users of Swami Shraddhanand College, University of Delhi and has helped faculty members and students in their respective research works. **Pitla, Raja Suresh Kumar, Kona, Ramakrishna, and Gowridevi, Rudraksha (2020)**[2] examined the use of Electronic Resources in Engineering College Libraries in Krishna District, Andhra Pradesh, India. A survey method was used for collecting primary data, using a structured questionnaire designed to gather information from faculty members who use these libraries. Out of 890 distributed questionnaires, 705 valid responses were received, yielding a response rate of 79%. The analysis revealed that a majority of respondents were male (63.54%) and Assistant Professors (53.75%). About 36.73% reported visiting the library daily, and 89.5% found the library's operating hours to be convenient. Most users accessed the library to borrow books, refer to textbooks, and consult electronic journals. The study found that the majority of users use IEEE, SCOPUS, Springer, and NPTEL services. The study found that highly satisfied with IEEE facility, DELNET facility, NPTEL Videos, and 419 (59.43%) are not availing the facility of CMIE Prowess. The study concluded that many users were unaware of certain electronic resources and recommended that engineering college libraries should organize information literacy programs to improve awareness and effective usage of these resources. **Daramola, Florence (2023)**[3] examined how undergraduate students utilize electronic resources (e-resources) for learning. A descriptive survey design was used for the study. The population for this study consists of all National Open University of Nigeria (NOUN) undergraduates. Using proportional sampling techniques based on the Israel Model, the number of respondents from each NOUN center was determined relative to its estimated population. Data were collected through a questionnaire. Both descriptive and inferential

statistical methods were applied to address the research questions and test the hypotheses, utilizing SPSS version 20.0 at a 0.05 significance level. The findings indicated that undergraduate students had positive utilization of E-resources for learning. The study concluded that learning can be enhanced among undergraduate students if appropriate resources are deployed for learning.

Mode of Access of E-resources:

Digital technology has transformed libraries by transitioning from traditional print materials to electronic resources for accessing information. The Central University of Kerala Library has embraced this trend by providing an extensive array of e-resources, featuring 9 databases, 1318 eBooks, and over 1000 e-journals to support its academic community. The One Nation One Subscription (ONOS) initiative is poised to greatly transform the accessibility of e-resources. Here we have three platforms to access the e-resources.

- **IP-based access**: This system allows users to access e-resources within the campus network only. To access these resources, users must be connected to the campus network. The users can access all the e-resources of the University Library.
- **Remote Access**: INFED[7] and MyLoft are the two platforms available for accessing e-resources remotely. MyLoft[8] is a platform that grants access to all the e-resources available in the University Library. INFED is a remote access platform freely provided by INFLIBNET.

These two platforms provide different modes of access to e-resources, catering to the needs of the academic community of CUK.

E-Resources available in the University Library:

The Central University of Kerala Library has subscribed to the 9 databases providing access to the vast collection of e-resources to its academic community. They are:

- **SCOPUS:** Scopus is a comprehensive abstract and citation database that provides access to a vast collection of scholarly literature, data, and analytical tools, developed and maintained by Elsevier. It provides access to bibliographic information, including abstracts and citations, for millions of records. Scopus helps users identify trends, discover relevant sources, evaluate research output, and measure research performance.
- **DELNET:** DELNET (Developing Library Network) is a significant library network in South Asia that fosters resource sharing among libraries and grants access to an extensive array of materials. Its goal is to update and connect libraries, promoting resource sharing and collaboration between member organizations.
- **MathSciNet**: MathSciNet, created by the American Mathematical Society (AMS), is an extensive online database for mathematical literature. It grants access to the complete archives of Mathematical Reviews (MR) and Current Mathematical Publications (CMP) from 1940 to today.
- **NotNul**: The NotNul Hindi Database comprises a variety of Hindi books, magazines, and research papers available on the NotNul e-learning platform. This platform, NotNul, enables users to explore over 5,000 Hindi books and supports the publishing and trading of diverse content formats like eBooks, audiobooks, and videos.
- **Indiastat:** Indiastat is a **comprehensive e-resource of socio-economic statistical information of India**. It is an endeavor of Datanet India and provides a comprehensive storehouse of socioeconomic statistical data about India and its sectors, regions and states. This database provides Secondary level of Statistical Information on the socio-economic sectors of India and its states.
- **EPWRF India Time Series**: The "EPW database" most likely refers to the EPWRF India Time Series (EPWRFITS), a comprehensive online database of economic data provided by the Economic and Political Weekly Research Foundation (EPWRF). This database offers a variety of time series data on the Indian economy, including national accounts, state-wise GDP, price indices, and more. It aims to facilitate research and analysis by providing a user-friendly interactive platform.

- **CMIE-ProwessIQ:** ProwessIQ is an interactive querying system created by CMIE (Centre for Monitoring Indian Economy) that allows users to search their extensive database of Indian company financial performance data. It's a powerful tool for finding companies that meet specific criteria, unlike a general search engine
- **CMIE-States of India:** States of India is a statistical compendium of the 37 states and union territories and 724 districts of India. Statistics on states are released by various state & central agencies. CMIE excels in compiling all this information into one cohesive and seamless offering.
- **Supreme Court Cases:** SCC Online is a comprehensive legal database that provides access to a wide range of Indian and international legal materials, including case law, statutes, and other legal documents. It is a subscription-based service developed by Eastern Book Company (EBC), a leading Indian law publisher.

Software

1. **Grammarly:** It is an algorithms flag potential issues in the text and makes context-specific suggestions to help with grammar, spelling, usage, wordiness, style, punctuation, and even plagiarism.
2. **Turnitin:** Turnitin automatically evaluates and grades papers, eliminating the need for instructors to grade them. Turnitin matches text similarity and does not grade papers for the instructors. It is up to the instructor and/or student to determine whether the assignment exhibits plagiarism
3. **DrillBit: It** is a plagiarism detection software primarily used in academic and professional settings to check for instances of plagiarism in written content. It helps users identify if any part of their document has been copied from other sources or contains unoriginal material.
4. **Check for Plag: It** is a plagiarism detection software designed to help users identify instances of plagiarism in written content. It is commonly used in academic, professional, and content creation fields to ensure the originality of work and avoid the consequences of copied or improperly attributed material.
5. **BioRender: BioRender** is a web-based software tool designed for creating professional and visually appealing scientific illustrations. It is primarily used by researchers, scientists, and educators to create diagrams, figures, and illustrations for research papers, presentations, posters, and educational materials.
6. **SigmaPlot:** SigmaPlot is a scientific graphing and data analysis software package. It is used by researchers, scientists, and engineers to visualize and analyze data, create high-quality graphs, and perform statistical analysis.

The University Library, Central University of Kerala, is accessing the following e-resources through INFLIBNET[6], which provides a vast collection of digital resources to support research and learning.

- **ACM Digital Library** (http://dl.acm.org/**)**: ACM Digital Library provides access to 53 peer-reviewed scholarly journals; 8 technical magazines, including Communications of the ACM (ACM's flagship magazine), ACM's complete collection of conference proceedings containing over 2,500 volumes of scholarly materials; and 37 technical newsletters sponsored by ACM's technical Special Interest Groups (SIGs).
- **American Institute of Physics** (https://pubs.aip.org/pages/journals): The American Institute of Physics (AIP) is a non-profit corporation chartered in 1931 to advance and diffuse the knowledge of physics and its application to human welfare. AIP's online platform (Scitation) hosts more than 1,000,000 articles from more than 170 scholarly publications for 25 learned society publishers.
- **American Physical Society** (https://journals.aps.org/browse.html): The American Physical Society was founded on May 20, 1899, when 36 physicists gathered at Columbia University for that purpose. Through the consortium access of APS-ALL collection is available to subscribing members. Also, the PROLA (Physical Review Online Archive) search engine (which indexes all APS journal material published from 1893 to present) is now freely available to all users.

- **Annual Reviews** (http://arjournals.annualreviews.org): Annual Reviews journals are among the most highly cited in the scientific literature, and are available in print and online to individuals, institutions, and consortia throughout the world. Annual Reviews volumes are published each year for 46 focused disciplines within the Biomedical, Life, Physical, and Social Sciences including Economics.
- ASCE Journals Online (http://ascelibrary.org/): The ASCE Library provides online access to a high-quality collection of civil engineering content. It contains articles from ASCE journals, papers from conference proceedings, and e-books and standards.
- **ASME Journals Online (**http://asmedigitalcollection.asme.org/): Founded in 1880 as the American Society of Mechanical Engineers, ASME is the premier professional membership organization for more than 127,000 mechanical engineers and associated members worldwide. The Consortium subscribes to the Complete Package for ASME Journals + AMR, which gives access to 29 journals.
- **JSTOR** (http://www.jstor.org/): JSTOR was founded in 1995 to build trusted digital archives for scholarship. In 2009, JSTOR merged with and became a service of ITHAKA, a not-for-profit organization helping the academic community use digital technologies to preserve the scholarly record and to advance scholarship and teaching in sustainable ways.
- **Oxford University Press** (https://academic.oup.com/journals): Oxford Journals is a division of Oxford University Press, which is a department of Oxford University. It publishes well over 230 academic and research journals.
- **Project Muse** (http://muse.jhu.edu/): Project MUSE is a unique collaboration between libraries and publishers, providing 100% full-text, affordable and user-friendly online access to a comprehensive selection of prestigious humanities and social sciences journals.
- **Springer Link** (http://link.springer.com/): Springer is the leading global scientific publisher, delivering quality content through innovative information products and services. It publishers high quality content in various formats like books, journals, newsletters, CD-ROMs, online platforms, protocols, databases and conferences.
- **Taylor and Francis** (https://think.taylorandfrancis.com/journals-access-under-eshodhsindhu-consortium/): Taylor and Francis, founded in 1798, is the oldest commercial journals publisher in the world. Taylor & Francis Group publishes more than 1600 journals and around 1,800 new books each year

One Nation One Subscription (ONOS)

The National Education Policy, 2020 (NEP 2020) has also identified research as a co-requisite for outstanding education and development in our country. In response to the vision of making India Atmanirbhar and Viksitbharat@2047, the Government of India approved the One Nation One Subscription scheme to provide country-wide access to international high-impact scholarly research articles and journal publications to students, faculty and researchers of all Higher Education Institutions managed by the central government and state governments and Research & Development Institutions of the central government. Consortia journals are provided to the users in the library through Wi Fi network and to computer labs, faculty rooms, class rooms and the students' common reading room.

Analysis

Table-1: Remote Access Usage (MyLoft and INFED)

Sl.no	Resources	2021	2022	2023	2024	2025	Total
1.	Jstor.org	1005	8438	4845	1233	844	**16365**
2.	SCC Online.com	1136	4381	7537	2876	1260	**17190**
3.	EPW.in	371	492	222	166	122	**1373**

4.	Springer.com	484	548	845	415	154	**2446**
5.	Scopus.com	6294	10661	12301	14215	3229	**46700**
6.	Wiley.com	227	722	272	343	211	**1775**
7.	Tandfonline.com	311	226	682	826	113	**2158**
8.	Sciencedirectassets.com	364	368	338	349	190	**1609**
9.	Sciencedirece.com	387	479	791	197	147	**2001**
10.	Springernature.com	436	363	630	633	210	**2272**
11.	Ieee.org	640	141	0	0	0	**781**
12.	Nature.com	252	123	332	233	66	**1006**
13.	Jhu.edu	121	527	318	420	96	**1482**
14.	Cambridge.org	0	3650	1543	0	0	**5193**
15.	Els-cdn.com	210	346	338	1462	138	**2494**
16.	Taylorfrancis.com	942	276	256	367	98	**1939**
17.	Itaka.org	355	402	406	624	186	**1973**
18.	Jgateplus.com	161	705	810	28	0	**1704**
19.	Cmie.com	313	130	507	528	0	**1478**
20.	Ebsco-content.com	190	102	181	121	64	**658**
21.	Manupatra.com	62	48	34	47	23	**214**
22.	Videeya.in	168	154	130	109	62	**623**
23.	Prowessiq.cmie.com	6815	4862	1824	7808	826	**22135**
24.	Ebscohost.com	254	371	589	410	183	**1807**
25.	oxfordmedicine.com	27	61	47	79	21	**235**
26.	isid.org.in	3	1	2	1	1	**8**
27.	epnet.com	2	1	1	2	1	**7**
28.	Indiastat.com	746	635	1398	384	620	**3783**
29.	Iop.org	575	209	1410	609	0	**2803**

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Figure-1

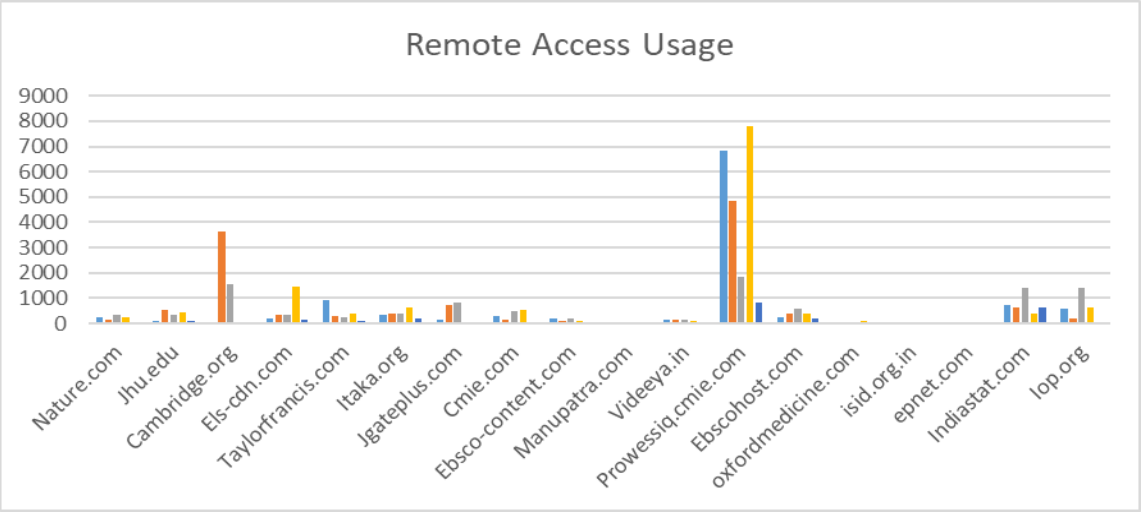
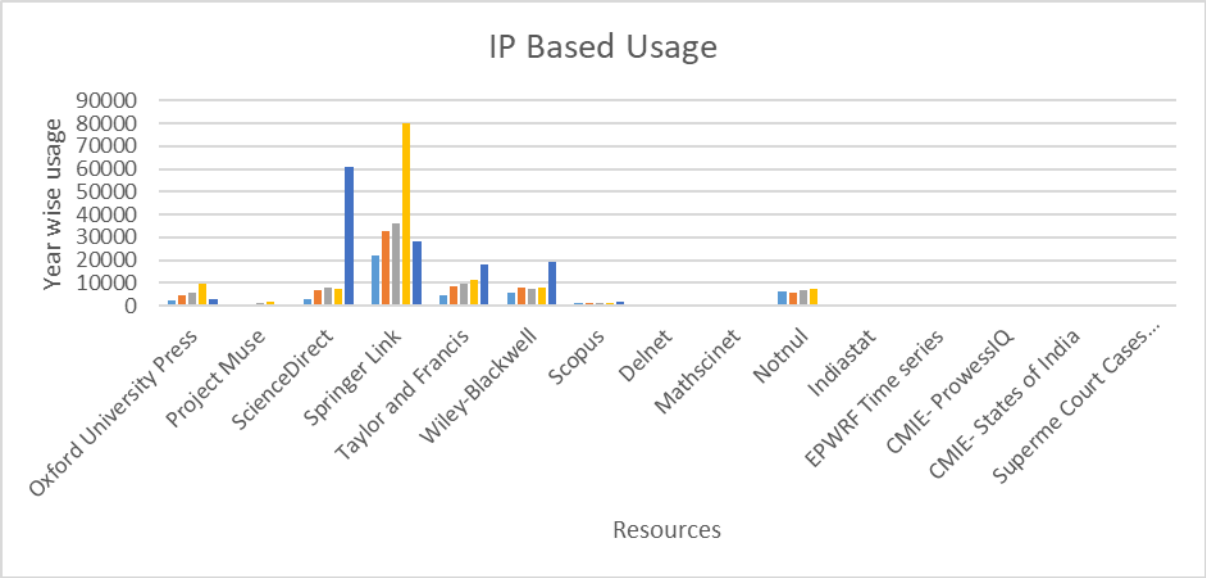


Table-2: IP Based Usage

Sl No.	Resource	2021	2022	2023	2024	2025	Total
1.	American Institute of Physics	1031	1214	772	718	0	**3735**
2.	Annual Reviews	486	776	749	902	542	**3455**
3.	APS	1015	1630	1192	5756	207	**9800**
4.	JSTOR	21532	29325	33453	31521	6953	**122784**
5.	Nature	2737	3638	4839	4120	0	**15334**
6.	Oxford University Press	2501	4623	5685	9906	2816	**25531**
7.	Project Muse	489	884	976	2042	152	**4543**
8.	ScienceDirect	3005	6620	8220	7318	60880	**86043**
9.	Springer Link	21915	32498	35916	80194	28362	**198885**
10.	Taylor and Francis	4778	8761	9726	11479	17988	**52732**
11.	Wiley-Blackwell	5458	7919	7630	8213	19022	**48242**
12.	SCOPUS	1251	1081	1489	1339	1547	**6707**
13.	DELNET	98	125	62	64	25	**374**
14.	MathSciNet	242	147	560	187	45	**1181**
15.	NotNul	6328	5649	6593	7149	0	**25719**
16.	Indiastat	126	217	138	120	25	**626**
17.	EPWRF Time Series	274	188	120	85	12	**679**
18.	CMIE- ProwessIQ	656	928	228	340	66	**2218**
19.	CMIE- States of India	145	76	120	66	0	**407**
20.	Superme Court Cases (SCC)	252	183	765	212	26	**1438**

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Figure-2



The outbreak of the COVID-19 pandemic has necessitated sudden and radical changes in the delivery of library services, as strict social distancing and lockdown measures were imposed in the early phases of the pandemic. The physical access of the library was very difficult for the library users. The Internet and web technologies have created a new and unparalleled environment, enabling libraries to enhance and strengthen research, teaching and learning even in this difficult and uncertain time. The concept and practice of providing remote access to e-resources by libraries is not new, but the user-friendly way adopted by the University Library and the number of resources made available during the pandemic are exemplary.

MyLOFT is your personal library, where a person can include the content he needs and categorize them the way he likes. It is a single app that allows accessing, organizing, sharing and reading offline all of your e-contents, anytime, anywhere. It is one place to Access- Organize-Share e-Content and library-subscribed scholarly resources of your professional & personal interests. MyLOFT provides access to all the subscribed e-Content, that is Access to the Library subscribed E-Resources. It provides direct access to scholarly Databases, E-Books and the latest articles from your favourite journals subscribed to by the Central University of Kerala Library. The fact that library users are making effective use of the remote access option that the library provides for their convenience is noteworthy. Because they could access the resources of the library at anytime, anywhere, 24 X 7, they can use the resources.

Conclusion

The study on the e-resource usage at Central University of Kerala reveals valuable insights into the utilization habits of its patrons. The findings of this study show that there is a significant correlation between e-resource usage and academic performance. This study will help the information professional in developing e-resources for their users. In conclusion, the study on the utilization of e-resources by the library patrons of the Central University of Kerala, Kasaragod, reveals a growing dependence on digital materials for academic purposes. The findings highlight both the positive impact of e-resources on research and learning and the challenges faced by users. The majority of patrons recognize the convenience and advantages of e-resources; the study also points to the need for enhanced training and infrastructure to maximize their effectiveness.

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Electronic Information Resources Usage among Humanities research Scholars at Periyar University, Salem

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Abstract

University libraries play a vital role in supporting teaching, learning, and research by providing access to a wide range of electronic information resources. However, the effective utilization of these resources depends largely on users' awareness and information-seeking behavior. The present study examines the usage pattern, awareness, and perceived importance of electronic information resources among Humanities research scholars at Periyar University, Salem, Tamil Nadu. With the rapid growth of information and communication technologies (ICT), social media platforms, and digital networks, traditional information access methods have significantly shifted toward electronic modes. In this context, the study aims to analyze how research scholars access and utilize e-resources provided by the university library. The findings reveal that a majority of respondents actively used the university's digital library resources for academic and research purposes. A significant proportion of respondents (64.38%) reported visiting the library on a daily basis, indicating a high level of engagement with available information services. Furthermore, 81.88% of the respondents considered electronic information resources to be very important for their research and academic activities. Overall, the study indicates a high level of satisfaction among users regarding the availability and performance of e-resources at the university library. The results highlight the need for continuous enhancement of digital library services and user awareness programs to maximize effective utilization of electronic resources.

Keywords: Electronic Information Resources, Digital Library, Information-Seeking Behaviour, Humanities Research Scholars, University Library, OPAC

Introduction

In the contemporary academic environment, electronic information resources (EIRs) have become indispensable for scholarly communication, research productivity, and knowledge dissemination. The rapid growth of digital technologies has transformed traditional library services, enabling researchers to access scholarly information anytime and anywhere. Particularly in the humanities discipline, electronic resources such as e-journals, e-books, online databases, digital theses, and institutional repositories play a crucial role in supporting advanced research activities.

In this digital context, humanities research scholars increasingly depend on electronic information resources for literature review, data collection, citation, and academic writing. Therefore, the present study focuses on examining the usage pattern, accessibility, and level of awareness of electronic information resources among humanities research scholars at Periyar University, Salem. The study aims to assess how effectively electronic resources support their research work and to identify challenges faced in accessing and utilizing these resources.

Review of Literature

Several researchers have studied the usage patterns and impact of electronic resources among university communities in Periyar University, Salem:

Velmurugan (2020) investigated how **electronic journals** are used by postgraduate and doctoral scholars in the School of Social Sciences at Periyar University. The study found that a large proportion of respondents preferred using PDF formats and frequently accessed e-journals via the Internet as part of their research activities.

Ramesh Krishnan (2019) also examined the **use and impact of electronic journals** among the users of Periyar University Library. Results showed that electronic journals were preferred over print formats, and a significant number of respondents accessed e-resources regularly for research and academic work.

In a related study, **Pramanathan & Baskaran (2023)** carried out a comparative analysis of **electronic resource access** between research scholars of Periyar University and Bharathidasan University, showing patterns in usage and researcher preferences for e-resources among postgraduate and PhD scholars.

Objectives

The present study seeks to examine the level of awareness and utilization of electronic information resources among humanities research scholars at Periyar University, Salem. In line with this purpose, the study is guided by the following specific objectives:

1. To assess the level of awareness of electronic information resources among humanities research scholars.
2. To examine the extent of use of electronic information resources for academic and research purposes.
3. To identify the methods and tools employed by research scholars to access and retrieve electronic information.
4. To analyze the frequency and pattern of library usage by research scholars.
5. To evaluate the effectiveness of existing electronic library services provided by the University Library.
6. To study the preferences of research scholars towards different types of electronic information resources.
7. To identify the problems faced by research scholars in accessing and using electronic information resources.
8. To collect suggestions from research scholars for improving electronic information services.
9. To recommend suitable measures for enhancing electronic library services based on the findings of the study.

Methodology

The present study adopted a descriptive survey method to examine the usage of electronic information resources among humanities research scholars at Periyar University, Salem. Primary data were collected using a structured questionnaire designed to capture relevant information pertaining to the objectives of the study.

The population of the study comprised humanities research scholars enrolled at Periyar University. A total of 175 questionnaires were distributed among research scholars from selected humanities departments using a random sampling technique. Out of these, 160 duly filled questionnaires were received and considered valid for analysis, yielding a response rate of 80.00 per cent, which is adequate for drawing meaningful inferences.

For data analysis, the collected responses were tabulated and analyzed using the simple percentage method. This method was employed to examine and interpret the distribution of data across various parameters. The study analyzed factors such as age-wise distribution of respondents, time spent on library visits, frequency of use of electronic information resources, frequency of browser access, types of electronic resources utilized, preferred search tools, perceived importance of electronic resources, and sources used for accessing electronic resources. The methodological framework adopted in this study enabled a systematic assessment of the usage pattern and perception of electronic information resources among humanities research scholars, thereby providing reliable insights aligned with the objectives of the research.

Data Analysis and Interpretation

Data analysis is an essential component of research, as it helps interpret data accurately and draw meaningful conclusions.

Table 1: Distribution of Questionnaires

S. No	Distribution Questionnaires	No. of Respondents	Percentage
1	Respondents	160	91.43
2	Not Respondents	15	8.57
Total		175	100

Table 1: A total of 175 questionnaires were distributed for data collection, and 160 were completed and returned, achieving a response rate of 91.43%. The analysis was based on data gathered from the user community of Periyar University (Table 1).

Table 2: Department wise distribution of E-Resources

S. No	Department	No. of Respondents	Percentage
1	Chemistry	23	14.38
2	Zoology	22	13.75
3	Sociology	19	11.88
4	Management studies	18	11.25
5	Mathematics	17	10.63
6	Botany	15	9.38
7	Physics	15	9.38
8	Nutrition and Dietetics ,	13	8.13
9	Geology	12	7.50
10	Library and Information Science	06	3.75
Total		160	100

Table 2 shows that the highest number of respondents, 23 (14.38%), were from the Chemistry department, followed by Zoology (22, 13.75%), Sociology (19, 11.88%), Management Studies (18, 11.25%), Mathematics (17, 10.63%), Botany (15, 9.38%), Physics (15, 9.38%), Nutrition and Dietetics (13, 8.13%), Geology (12, 7.50%), and Library and Information Science (6, 3.75%). The results indicate that respondents from various departments participated actively in the study, suggesting a strong interest among the university community to engage with this research.

Table 3: Age group wise Respondents

S. No	Age group	No. of Respondents	Percentage
1	21-25 Year	114	71.25
2	26-30 Year	26	16.25
3	31-35 Year	16	10.00

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4	36-40 Year	4	2.50
5	40 above	-	-
Total		**160**	**100**

Table 3 illustrates the age-wise distribution of respondents. It was observed that the majority of respondents, 114 (71.25%), were in the 21–25 years age group, followed by 26 respondents (16.25%) in the 26–30 years category. The 31–35 years group included 16 respondents (10.00%), while only 4 respondents (2.50%) were in the 36–40 years category. No respondents were above 40 years. These results indicate that the largest proportion of users belonged to the youngest age group, 21–25 years.

Table:4: Classification of Respondents by Gender

S. No	Gender	No. of Respondents	Percentage
1	Male	55	34.38
2	Female	105	65.63
Total		**160**	**100**

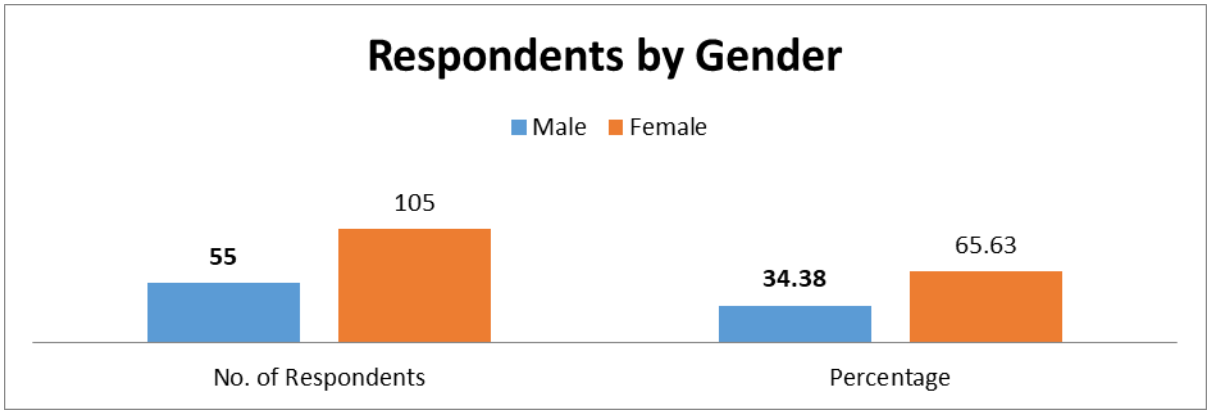


Table 4 shows that 105 respondents (65.63%) belonged to the female category across various departments such as Chemistry, Zoology, Sociology, Management Studies, Mathematics, Library and Information Science, and others. The remaining 55 respondents (34.38%) were male. The analysis reveals that female respondents constituted the majority of participants, indicating a higher level of interest and active involvement among female research scholars in completing the questionnaire.

Table 5: Library Visit Frequency of Respondents

S. No	Frequency	No of Respondents	Percentage
1	Every day	103	64.38
2	Once in a week	28	17.50
3	Once in a month	17	10.63
4	Occasionally	12	7.50
Total		**160**	**100**

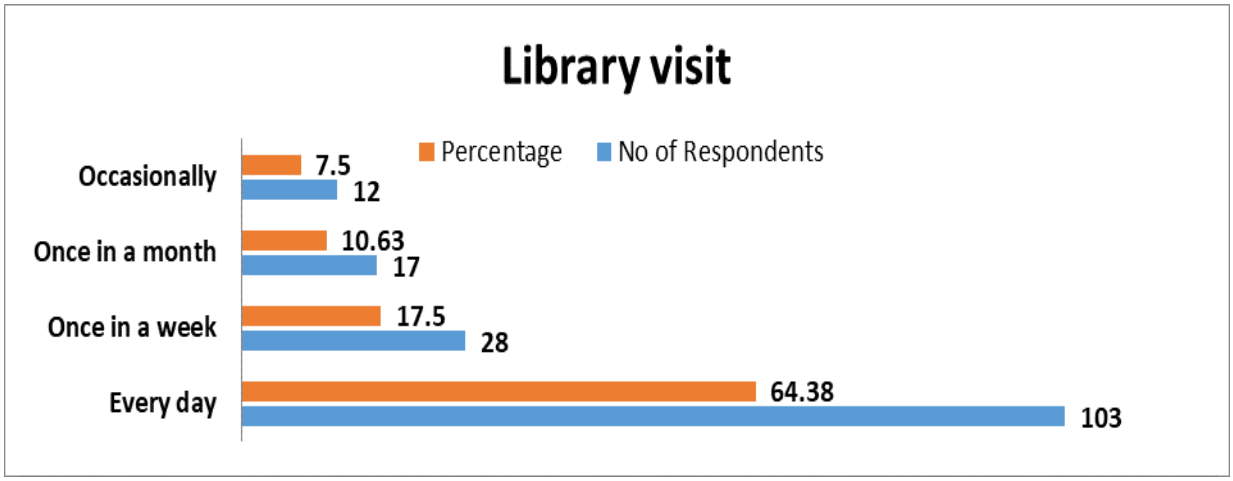


Table 5 presents the respondents' frequency of visits to the Central Library. Out of the 160 respondents, 103 (64.38%) reported visiting the library every day, followed by 28 respondents (17.50%) who visited once a week. A further 17 respondents (10.63%) visited the library once a month, while the least number, 12 respondents (7.50%), reported visiting the library only occasionally.

Table 6. Frequency of Using E-Resources

S. No	Frequency	No. of Respondents	Percentage
1	Daily	110	68.75
2	Weekly to days	21	13.13
3	Once in a week	15	9.38
4	Never	14	8.75
	Total	160	100

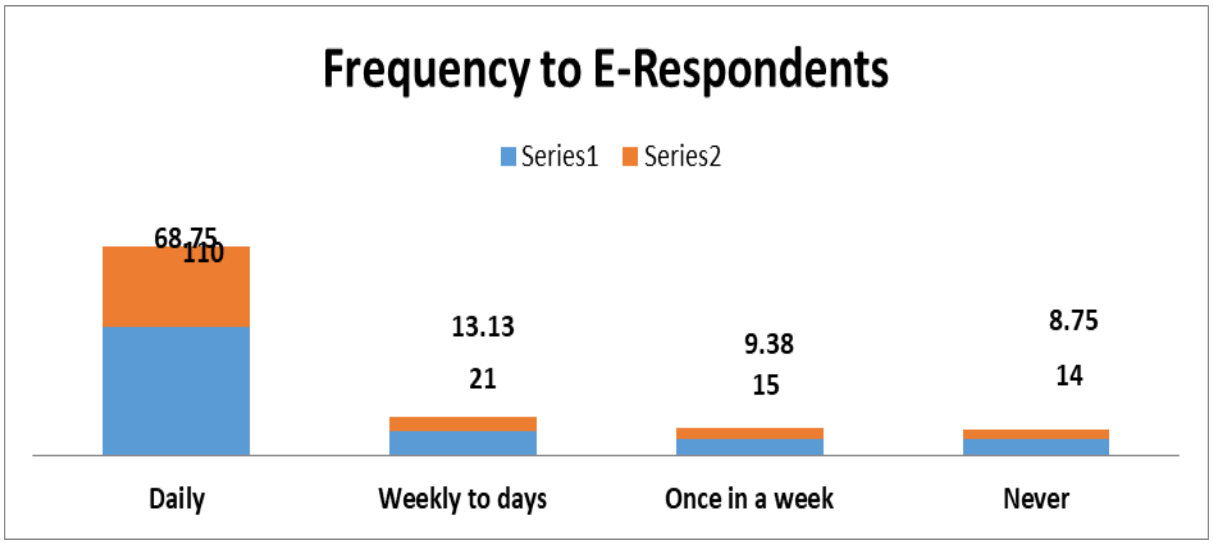


Table 6 presents electronic environment, electronic and internet-based information resources play a vital role in academic activities. Table 6 indicates that a majority of respondents, 110 users (68.75%), accessed electronic resources on a daily basis, while a small number of respondents (14; 8.75%) reported that they did not use the electronic resources available in the library.

Table 7: Knowledge and Awareness of Electronic Resources

S. No	Perception	No. of Respondents	Percentage
1	Yes	148	92.50
2	No	12	7.50
Total		**160**	**100**

Table 7 illustrates the respondents' awareness of online information resources. It was observed that a majority of respondents, 148 (92.50%), were aware of these resources, while a small proportion, 12 (7.50%), reported not being aware of them.

Table 8: Types of Using E-Resources

S. No	E-Resources	No. of Respondents	Percentage
1	E-Book	20	12.50
2	E-Journal	81	50.63
3	Online database	16	10.00
4	E-Theses and Dissertations	23	14.38
5.	CD-Rom	20	12.50
Total		**160**	**100**

Table 8 presents the various types of online resources used by the user community to obtain relevant information for research purposes. The identified online sources include e-books, e-journals, online databases, e-theses, and platforms such as Sage Publications and Web of Science, as well as CD-ROMs. The findings indicate that 50.63% of respondents preferred using online journals over printed journals. E-theses were the next most frequently used resource, accessed by 14.38% of respondents, while CD-ROMs were the least utilized, with only 12.50% of users reporting their use during the research period.

Table 9. Preferred keyword to searching document

S. No	Search Items	No. of Respondents	Percentage
1	Author	24	15.00
2	Title	30	18.75
3	Subject	45	28.13
4	Publisher	20	12.50
5	Key words	36	22.50
6	Other	05	3.13
Total		**160**	**100**

Table 9 presents the preferred keywords used by respondents while searching documents for research purposes. Search terms such as author names, titles, subjects, publishers, and other specific keywords were identified and analyzed. The table indicates that a majority of users (28.13%) preferred using the search term *Subject*. This was followed by *Keywords*, used by 22.50% of respondents, and *Title*, used by 18.75%. In contrast, only 3.13% of users relied on other search terms.

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Table 10. Purpose of using E-Resources

S. No	Purpose	No. of Respondents	Percentage
1	Research	120	75.00
2	Learning	28	17.50
3	Current Information	10	6.25
4	Teaching	02	1.25
Total		**160**	**100**

Table 10 shows Purpose of Using E-Resources, Various purposes for using online resources were identified. The table below presents four main purposes: research, learning, current information, and teaching. The findings reveal that a majority of respondents (75.00%) used e-resources primarily for research activities, followed by 17.50% who utilized them for learning purposes. In contrast, only a small proportion of respondents (1.25%) reported using e-resources for teaching.

Table 11. Importance of use of E- resources

S. No	Importance of E- resources	No of Respondents	Percentage
1	Very important	131	81.88
2	Somewhat important	24	15.00
3	Not important	3	1.88
4	Not very important	2	1.25
Total		**160**	**100**

Table 11 shows importance of online information resources was examined, as electronic resources play a vital role in academic activities such as reading and research. The results show that a substantial majority of respondents (81.88%) considered e-resources to be *very important*. In contrast, only a small proportion of respondents (1.25%) indicated that electronic information resources were *not important* during the research period.

Table 12. Location of Access to Internet

S. No	Sources of information	No. of Respondents	Percentage
1	Central Library	48	30.00
2	Department	62	38.75
3	Hostel laptop	28	17.50
4	Home	20	12.50
5	Internet care	2	1.25
Total		**160**	**100**

Table 12 illustrates the various locations from which researchers accessed the internet, including the Central Library, departments, internet cafés, hostels, and home. The findings reveal that the largest proportion of respondents (38.75%) accessed the internet from their respective departments, followed by 30.00% of research

scholars who used the digital library section of the University Central Library. In contrast, only a very small proportion of users (1.25%) accessed the internet from internet cafés, indicating minimal reliance on this source.

Table 13 Method prefer to improve skill in E-Resources

S.No	Preferred methods	Strongly Agree	Agree	Neural	Disagree	Strongly Disagree	Total	Percentage
1	Research scholar Development Programmes	7	21	4	2	1	35	21.88
2	Attending workshops/seminars/ Orientation programmes	11	25	14	8	2	60	37.50
3	INFLIBNET/E-Shodhsindhu Training Programmes	5	12	4	1	2	24	15.00
4	Peer Learning from Faculty Senior Scholars	7	3	2			12	7.50
5	Discussing with Experts	5	3	2	1		11	6.88
6	Discussing with colleagues	3	12	1	1	1	18	11.25
Total		**38**	**75**	**27**	**13**	**6**	**160**	**100**

Table 13 represents the preferred methods adopted by research scholars to improve their skills in using e-resources. The findings reveal that attending workshops, seminars, and orientation programmes is the most preferred method, accounting for 37.50% of the total responses. A majority of respondents either *strongly agreed* or *agreed* with this method, indicating that structured and formal training programmes play a significant role in enhancing e-resource skills.

The Research Scholar Development Programmes rank second, with 21.88% of respondents favoring this method. This shows that institutional initiatives aimed at research capacity building are considered effective in improving competency in e-resource usage.

INFLIBNET / e-ShodhSindhu training programmes are preferred by 15.00% of the respondents, highlighting moderate awareness and utilization of national-level digital library training initiatives among research scholars.

Informal learning methods such as discussing with colleagues account for 11.25%, suggesting that peer interaction also contributes to skill development, though to a lesser extent compared to formal programmes. Similarly, peer learning from faculty and senior scholars (7.50%) and discussing with experts (6.88%) are the least preferred methods, indicating limited reliance on individual mentoring or expert consultation for improving e-resource skills.

Conclusion

The study concludes that electronic information resources play a significant role in supporting humanities research at Periyar University, Salem. The findings reveal that research scholars exhibit a high level of

dependence on electronic resources for their academic and research activities, particularly for accessing scholarly literature, data, and reference materials. The widespread use of electronic information resources reflects their importance in enhancing research efficiency and academic productivity.

However, despite the positive usage patterns, the study identifies certain challenges that hinder optimal utilization. These include limited awareness of specialized electronic databases and inadequate training in advanced search techniques. Such constraints indicate the need for systematic user education and capacity-building initiatives.

In view of the findings, the study recommends the organization of regular orientation and training programs, enhancement of digital infrastructure, and strengthening of library support services. These measures would improve awareness, accessibility, and effective use of electronic information resources, thereby contributing to the overall quality of humanities research at Periyar University.

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Electronic Resource Management in Libraries

Kanmani, R
Students Bon Secours College for Women (Autonomous) Vilar Thanjavur

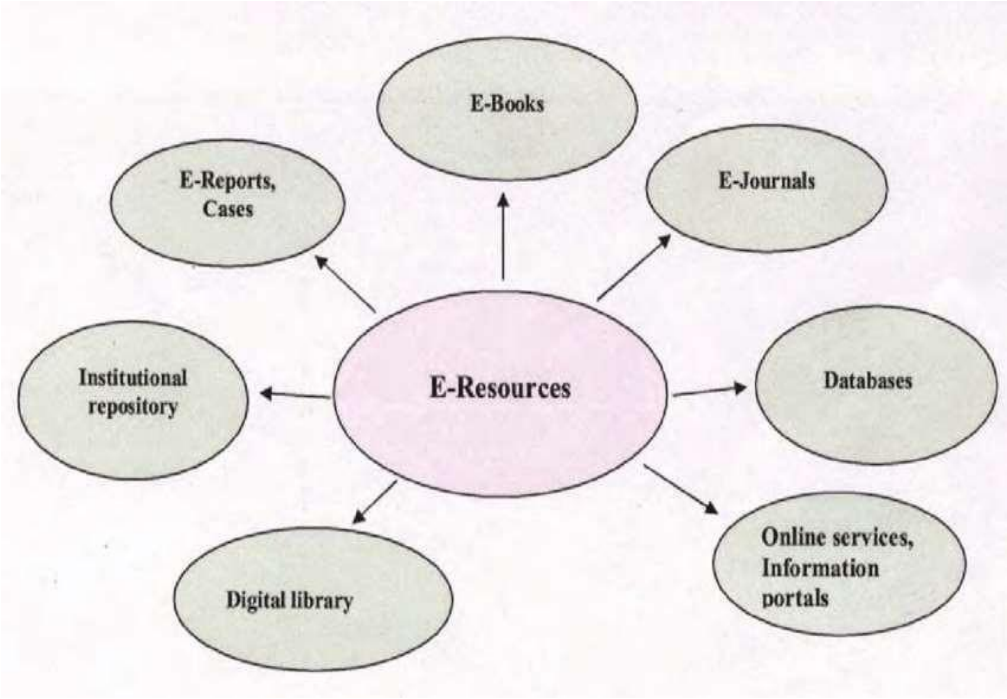
Abstract

E-resources represent an increasingly important component of the collection-building activities of libraries. "Electronic resources" refer to those materials that require computer access, whether through a personal computer, mainframe, or handheld mobile device. They may either be accessed remotely via the Internet or locally. As libraries dramatically increased their numbers of licensed electronic resources in the 1990s, such as online journals and databases, they realized the need for a recordkeeping system that would help manage the details of acquiring and maintaining them. As the idea of locally designed and built electronic resource management systems became more accepted, academic institutions began to seek assistance outside their universities to build their own systems. The author advocates provide one-stop shopping for the full range of journal literature available and of interest to library patrons.

Keywords: E-resources, E-resources management, Libraries

Introduction

Electronic resource management (ERM) is the practices and software systems used by libraries to keep track of important information about electronic information resources, especially internet-based resources such as electronic journals, databases, and electronic books. The development of ERM became necessary in the early 2000s as it became clear that traditional library catalogs and integrated library systems were not designed to handle metadata for resources as mutable as many online products are. Electronic Resource Management in Libraries: Research and Practice provides comprehensive coverage of the issues, methods, theories, and challenges connected with the provision of electronic resources in libraries, with emphasis on strategic planning, operational guidelines, and practices. This paper primarily focuses on management practices of the life- cycle of commercially acquired electronic resources from selection and ordering to cataloging, Web presentation, user support, usage evaluation, and more.



History

The idea of developing electronic resource management systems emerged in 2001-2002, growing out of research by Tim Jewell at the Washington. The Digital Library Federation and NISO began work on May 2002 to develop standards for ERM data these standards were published in the 2004 as an Electronic Resource Management: Report of the DLF ERM Initiative Since the publication of the report, several vendors of integrated library systems has released ERM products

Features of ERM

- Supporting the acquisition and management of licensed e- resources
- May be integrated into other library system modules or may be a objective system
- May have a public interface, either separate or integrated into the OPAC
- Providing descriptions of resources at the package (database) level and relate package contents (e.g. e-journals) to the package record
- Encoding and perhaps publicly displaying licensed, rights such as e-reserves, course packs, and interlibrary loan
- Tracking electronic resources from point of order through licensing and final access
- Providing information about the data providers, consortia arrangements, access platform
- Providing contact information for all content providers
- Logging problems with resources and providers
- Providing customizable e-mail alerting systems (e.g. Notices to managers when actions are expected or required)
- Linking license documents to resource records
- Supports retrieval of SUSHI usage statistics.

Technical Requirements

E-resources also present a number of technical issues that need to be considered to ensure resources are compatible with existing library hardware and software and that the library has the capability to provide and effectively maintain access to resources on an ongoing and cost effective basis. Evaluation should be in consultation with the appropriate technical staff and should include consideration of the following:

Method of Access – What methods of access are available (e.g., stand-alone, remotely via the Web, local Web mount or hosting)? Access to remote hosts via the Web is often preferable because it provides additional benefits such as faster updating, optimum access, reduced burden in terms of storage, preservation and maintenance.

Authentication – What methods of authentication are available (e.g., IP filtering, login and password)? Access via IP filtering is often preferable because it typically provides simultaneous access for multiple users. IP-address recognition can also provide access to users via a proxy server, allowing authorized library users to access content from outside the physical confines of the library is an important feature. In such circumstances, a commercial database "sees" and recognizes the library IP address, not the user's home or any other IP addresses, and grants this user access. It should, however, be noted that access via proxy server sometimes is negotiated in the license agreement.

Compatibility – The resource should be compatible across a range of platforms and, where local installation and maintenance are required, should be compatible with existing hardware and software supported by the library. The selector should also determine if the e-resource requires any special hardware, software,

multimedia, and/or audio capabilities. Where this is the case, consideration needs to be given to the additional cost of acquiring, installing and supporting the appropriate software or multimedia components. Consultation with staff responsible for reference services may be needed to determine if software or add- on components are required for all or only some of the public PCs before making a selection decision.

Conclusion

The world of journal literature has changed dramatically in the last decade and continues to change rapidly. To respond to these changes effectively, libraries should focus on the needs of users and find ways to make journal literature more easily accessible. A key component in that vision is providing one-stop shopping for as many relevant journals as possible, both via the library catalog and at the point of need via a link resolver. Currently, libraries can provide one-stop shopping for print and electronic journals, including titles from aggregated databases, as well as some free titles. But this vision often must be compromised as libraries weigh the benefits to users against staff time and resources required to deliver all relevant journal information to their users. Meanwhile, providing access to individual articles, whether free or available for paid download, remains the most challenging aspects of the one-stop-shopping ordeal. So, libraries cannot provide complete one- stop shopping for all journal literature of interest to their users. But they can provide simplified access to some of it and work with vendors and standards organizations to facilitate access to the rest. Library users deserve nothing less.

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Varies of E- Resource and its Utilities in Knowledge Resource Center

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ABSTRACT

This article focuses on the different aspects of electronic resources. In the digital knowledge resources center, information through the ages is available for further researches. E-Resource help Betterment and overall development of the society various users. E-resources are easily accessible in remote areas. Electronic resources are being digitized. Electronic information source are becoming more and more important for the academic Research community, the paper traces origin and difines e-resources, identifies types or e-resources and deals with this issue of e- collection development policy as well as problems that can be encountered in e-collection building, access along with preservation problems and strategies.

Keywords: e-books, e-journals e-Magazine, e-newspaper, e-report, e-thesis, e-project, e-back volume e-networks, e- database, e- conference, e- resource, e- documents.

INTRODUCTION

The advent of internet has automatically changed the way people and institution function. It has led to tremendous changes in the way libraries function and offer service to their users. At present, the libraries do, organize, display and issue e-forms of books, journal, newspapers, these and dissertation. This is also due to change in information feeling behaviors of users. The new generation of users refers online resources as they want all information at the click of mouse. The E-resources have certain inherent characteristic features which offer convenience to the users. This lesson discusses the concept and importance of E-resources. It deals with different types of E-resources, their advantage and disadvantages.

NEED OF E-RESOURCES

E-resources enable the libraries to provide better service to the user community. The fewconsiderable points are mentioned below;

A	To get access to information source by the more than one user.
B	E-resources can be searched quickly.
C	These can be found easily by the user.
D	These resources can be stored in huge data.
E	Less of time spent on the E-resources use.
F	Analysis the purpose of using E-resources by respondent.
G	Know different types of E-resources commonly used by respondent.
H	To collect, store, organize information in digital form.
I	To promote efficient delivery of information economically to all the users.
K	To encourage co-operative efforts to save and share the investment in research resources computing and Communication network.

TYPES OF E- RESOURCES

Electronic resources can be broadly categorized into online e-resources and other electronic resources.

Digital library e-resources: Online e-resources refer to digital materials accessible through the Internet. Users can access these resources through various electronic Technology devices such as new generation of computers, smart phones, tablets and television. Examples of online E-resources include e-books, e –journals online databases, online magazines, and e- newspapers. These resources are accessed through websites, digital libraries, and online platforms, and users can search, view, and download them.

TABULATION

1)	E-Books	E-book is the many formats competing for prime time including adope pdf, Microsoft reader, E- reader, molilpocket reader, Epub kindle and IPD.
2)	E-journals	E -Journal has been defined as a periodical. Publication which is published in Electronic format using on the Internet. A periodical publication means that in has same periodicity I.e., it may be published **weekly fortnightly** for monthly quarterly Bi-Monthly or annually. e -Journal is very important part of every Digital library collection. E-journals are Application of information Technology
3)	E-newspaper	An ex-journal is also known as online newspaper or web newspaper that exists on the world wide web or internet.
4)	E-magazine	E-magazine is current information services in digital technology. In the various Information provided newly daily separated in the community.
5)	Indexing and abstracting database	These are the reference sources which provide bibliographic information about Journals including abstracts of the articles.
6)	Full text database	Today there are number of database available on the network. They are either free or with commercial. E-database is an organized collection of information of aparticular subject or multidisciplinary subject areas. Information within E- database can be searched and retrieval electronically.
7)	Reference database	These are many dictionaries, encyclopedia, and directory which are available on Internet in electronic format.
8)	Statically database	These databases contain the numerical data useful for the mass community.
9)	Image collection	Due to adventure of e-image facility this type of databases is developed.
10)	Multimedia products	These types of databases include images, audios, videos and text etc.
11)	e-thesis	These database are contained with the thesis and dissertation published through e-format and example, e-shodhganga
12)	New Paper Clipping	The main objective of e-clipping is respective search and comprehensive analysis of new items.
13)	Patents	E-patents is the exclusive right granted by the government to make use of the invention for a specific period of time.
14)	Standard	Written definition, limit rule approved and monitored for complains by Authoritative agency.

UTILITIES OF E-RESOURCES

Now a days the reading reference and information sources are changing from print to electronic form Some of such e-information services are detailed are briefly discussed here:-

TABULATION

S.No	E-Information services	Abbreviations
1	Current awareness services	CAS
2	Selective dissemination of information	SDI
3	E-document delivery service	RDDS
4	Online public access catalogue	OPAC
5	Inter Library Loan Service	ILL
6	Mobile libraries	M Libraries

TABULATION

S.No	E-resources service	URL
1	INFLIBNET	http://nlist.inflibnet.ac.in
2	NPTEC	http://nptel.ac.in
3	SHODHGANGA	http://shodhganga.in flibnet.ac.in
4	NDL	http://ndl.iitkgp .ac.in
5	E-PGPATHSHALA	http://epgp.inflibnet .ac.in
6	VIDYA MITRA PORTAL	http://vidyamitra. Inflibnet.ac.in
7	SWAYAMMOOC	http://swayam .gov.in
8	TC-question bank	Question bank
9	Competitive exams	http://www.thamizhkadai.com
10	Research project in India	http://www.inflibnet.ac.in
11	Repository of Indian research in progress	http://shodhgangotri.inflibnet.ac.in
12	NITTTR, Chandigarh technology enabled learning	http://www.nitttrehd.ac .in
13	Free Free open online course	http://www.course.org /
14	MIT open course	https://ocw.mit.edu/index .htm
15	Digital India newsletter's	http://digitalindia.gov.in/newsletter
16	CSIR NISCAIR	http://niscair.res .in
17	Tamil language	www.tamilconcordance .in
18	DELNET	http://delnet.in

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ISSUES OF E- RESOURCES

S.No	ISSUES OF E- RESOURCES	
1	LICENSINS	E-Resources need the license from publisher to the library for making use of it.
2	IPR	E- Resources can be easily copied and forwarded to the another person, so librarian should be alert about IPR (Intellectual Property Rights)
3	STANDARDS OF METADATA	These are standards for metadata a description like MARC21 but the available e- resources in the market are not standardizing by MARC21
4	LOW BUDGET	Libraries are nonprofit organizations, so they cannot purchase and afford the costly electronic resources
5	SKILL MANPOWER	To handle the electronic collation the proper skills are required among the staff but libraries are lacking of skill manpower
6	LACK OF INSTUCTURE	Electronic, Collection is supported by information and communication Technology components.

IMPACT OF E-RESOURCES ON LIBRARY AND INFORMATION SERVICES

The Internet E-resources is transforming the knowledge system and as were the way in which we view information source. It has made simple and speedy purchase of information sources like books, journal, magazine and electronic publications. Many publisher catalogue tools like books in print as well as forms for ordering documents are available on the Internet. The librarian needs quick access to books, journal and Electronic publications. Internet access is the simple and efficient method for access and updating the documentation and interface of catalogues of all libraries. The regret for interlibrary loan can be sent via- email and the photocopies may be sent by post, via email, after scanning the documents.

The development of information technology and the dissemination of web environment have a dramatic effect on the using behavior information usage. The workflows from acquisition to using services and the life cycle of electronic resources is quite different from that of print resources since it is characterized by access without holding the physical objects. Librarian builds every large collection of electronic resources finding ways to manage them efficiency becomes a major challenge. The number of electronic journal, Citation database and full text aggregation held by most libraries has grown rapidly. Managing these electronic resources involves providing the library using with convenient ways to find and access them and providing library staff with tools to keep track of them.

Most of the library resources in the recent made available in electronic format such as E-resources, E-books, and E-database etc. Library is moving from print to e -resources either subscribing individually or through consortium because of its advantages over print resources. Recent studies show that users prefer E-Resources than the print. As licensing electronic resources has greatly increased in recent years, librarian have struggled to control the information in paper files, integrated library system, separate database stored on Local computers on networks.

CONCLUSION

E-resources are useful for libraries as well as each and every user of the society who are starting to get variety of information through the globe's resources and services seem to be considered very important in the present era. The E-resources and services of libraries are playing a very significant role in the functioning of any varies library and academic organization. Well as nation building electronic sources of information are highly useful for the research teaching and searching processes. In order to make it successfully and best use of the available E-resources, authorities of the institution library should conduct regular orientation training program to maximum to use electronic sources of information more effectively and efficiently.

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Awareness and Use of Digital Libraries and E-Resources at Bharathiar University, Coimbatore: A User Study

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ABSTRACT

The rapid development of information technology involving digital technologies led to an increase in the use of digital libraries and electronic resources in academic institutions. Digital libraries and the e-resources such as e-journals, e-books, online database resources, and institutional repositories have played a very significant role in supporting the activities of teaching, learning, and research activities. In this present study, the level of awareness and use of digital libraries and e-resources available for research scholars and postgraduate students in Bharathiar University has been analyzed in the context of information usage. The objectives of the present analysis are to evaluate the level of awareness and use of e-resources, frequency of using e-resources, type of e-resources accessed, and challenges faced in terms of digital libraries and the level of effectiveness. A survey approach was adopted for collecting data, and 90 samples were approached to fulfill the objectives and were questioned with a standard questionnaire. Simple statistical analysis was done to analyze the data obtained. The analysis shows that despite having a good level of awareness and use of e-resources, certain limitations and challenges exist.

KEYWORDS: Digital Libraries, E-resources, user awareness, academic libraries, Information access.

INTRODUCTION

Development in information and communication technology has introduced various changes to library and information services. Similarly, academic libraries are no longer confined to printed documents, and the concept of digital library and e-resources is becoming a new dimension in the library and information science field. A digital library is defined as a collection of knowledge or information in various electronic formats such as e-journals, e-books, online databases, or institutional stores that may be used to promote or support academic, learning, or research activities. Accordingly, the digital library is one of the important resources that is available to the academic community with the advent of the digital era. It is important to know the utilization of the digital library by the academic community to develop the resource management effectively. The academic community is served by the digital library available at Bharathiar University. The utilization of the digital library as a resource by the academic community is based on the awareness and efficient use of the electronic resource available. The present study is conducted to assess the awareness of and usage of digital libraries and e-resources by the research scholars and postgraduate students of Bharathiar University, with the aim of ascertaining the usage pattern, challenges, and areas that need to be improved.

REVIEW OF LITERATURE

Sahu (2025) investigated awareness and use of e-resources among undergraduate students at selected institutions. The study showed that although students are mostly aware of the commonly used platforms like Google Scholar and institutional portals, actual usage of subscribed scholarly databases was low, as students still preferred general search engines because it is more convenient to use them. The paper therefore recommended targeted training, improved UX of discovery systems, and librarian-led embedded instruction, which could help convert the awareness into scholarly usage.

Fekadu (2024) evaluated various electronic library architectures by systematically reviewing articles in the span of 2018 to 2024. The paper categorized the common architecture patterns and service patterns, pointing out the trade-offs involved in architectural layouts, and finally asserting the increasing preference

for the integration of repository, discovery layers, and personalized layers in academic environments. It advised libraries to focus on standards-based systems in favor of the evolving discovery and integration needs in electronic resources.

Rani (2021) investigated awareness and usage of e-resources by the researchers and faculties in three universities of Haryana. The study reported increased dependency on e-resources during and after the COVID-19 pandemic, where faculties reported being active users of e-journals and databases for research and teaching. However, the study reported problems with remote authentication, inconsistent access, and variable search skills and recommended institutional training and improved off-campus access mechanisms.

METHODOLOGY

This study adopted a quantitative mode of research and made effective use of a structured questionnaire. This research targeted postgraduate students and research scholars as its target population. A total of 100 questionnaires were sent electronically using Google Forms and out of that, only 90 responses were received and considered useful for the purpose of this investigation. The responses were collected through online mode to make them convenient and to increase their scope of access. Collected responses were coded, tabulated, and analyzed using MS Excel with the help of descriptive statistical tools such as percentages and charts. The limitations of this study that have made it inferior to other forms of research are as follows: a smaller number of samples; Second, it solely depended upon responses received to formulate findings**.**

OBJECTIVES

1. To find out how far users of Bharathiar University are aware of digital libraries and e-resources.
2. To study the different categories of users such as students, research scholars, and faculty members.
3. To identify the types of digital resources mostly used by students, research scholars, and faculty.
4. To know how often and for what purpose users use digital libraries and e-resources.
5. To find out the problems faced by users while using digital libraries and e-resources.
6. To evaluate the usefulness and effectiveness of digital library services at Bharathiar University.
7. To suggest ways to improve access and use of digital libraries and e-resources.

STATEMENT OF THE PROBLEM

The rapid growth of the internet has significantly increased access to electronic resources in academic libraries. These resources play an important role in meeting the information needs of users in the digital age. However, effective use of e-resources remains a challenge among many users. Bharathiar University, Coimbatore is not an exception to this situation. The changing information needs of users due to advances in information technology make it necessary to study the awareness and use of digital libraries and e-resources

DATA ANALYSIS AND INTERPRETATION

Table 1 Category wise respondents

S.No	Qualification	No. of. Respondents	Percentage (%)
1	Postgraduate	67	74.44
2	Ph.D. Scholars	23	25.56
Total		90	100.00

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The table shows the qualification of the respondents. Out of 90 respondents, 67 (74.44%) are Postgraduate students and 23 (25.56%) are Ph.D. scholars. This shows that most of the respondents are postgraduate students, while fewer respondents are Ph.D. scholars. Both groups use digital libraries and e-resources at Bharathiar University.

Figure 1 category wise respondents

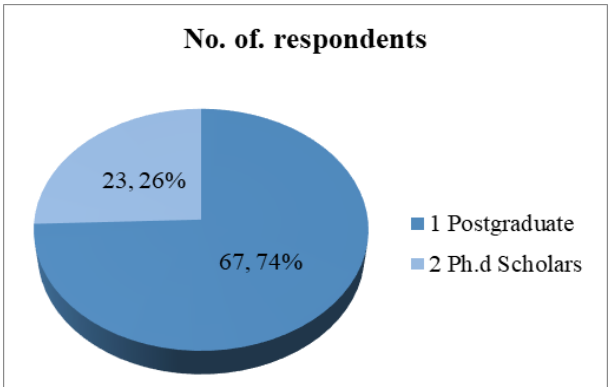
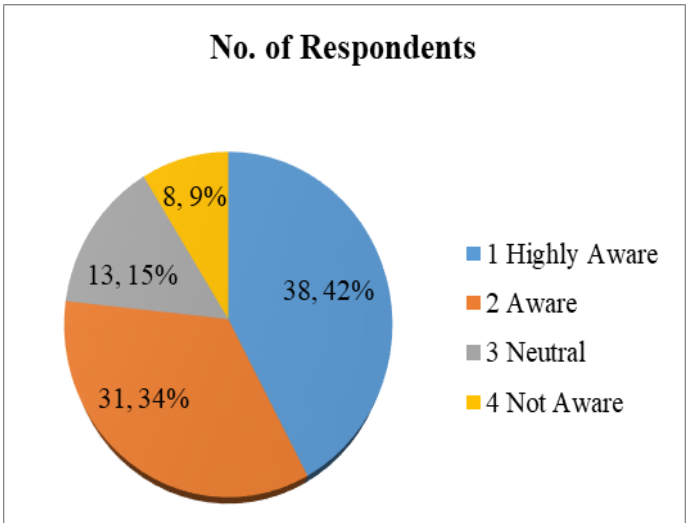


Table 2 Awareness level of Digital Libraries

S.No	Awareness Level	No. of Respondents	Percentage (%)
1	Highly Aware	38	42.22
2	Aware	31	34.44
3	Neutral	13	14.44
4	Not Aware	08	8.90
Total		90	100.00

The table shows the level of awareness about digital libraries and e-resources among the respondents. Out of 90 respondents, 38 (42.22%) are highly aware and 31 (34.44%) are aware of digital libraries and e-resources. 13 respondents (14.44%) have a neutral level of awareness, while only 8 respondents (8.90%) are not aware. This shows that most of the respondents are aware of digital libraries and e-resources.

Figure 2 Awareness level of Digital Libraries



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Table 3 -Types of E-Resources

S.No	Type of E-Resource	No. of Respondents	Percentage (%)
1	E-Journals	32	35.56
2	E-Books	23	25.56
3	Online Databases	25	27.78
4	Institutional Repositories	10	11.11
Total		90	100.00

The table shows the types of e-resources used by the respondents. Out of 90 respondents, 32 (35.56%) use e-journals, 25 (27.78%) use online databases, 23 (25.56%) use e-books, and 10 (11.11%) use institutional repositories. This shows that e-journals are the most used e-resource, while institutional repositories are used the least by the respondents.

Figure3-Typesof E- Resources

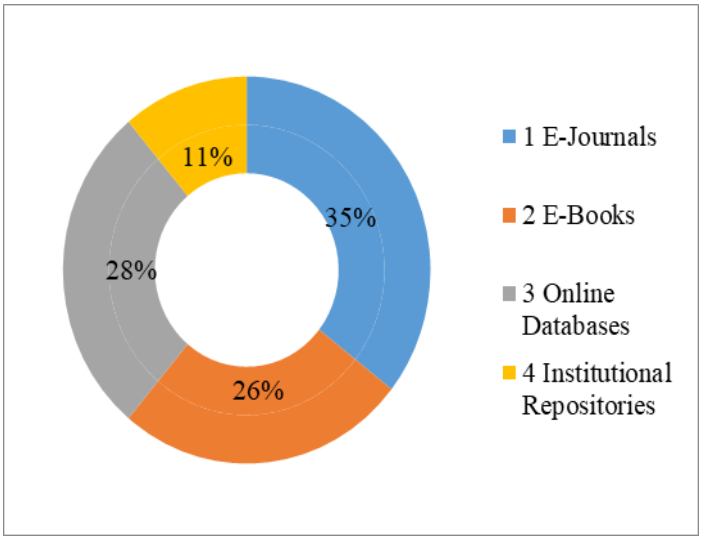


Table 4 Frequency of Use of Digital Libraries

S.No	Frequency of Use	No. of Respondents	Percentage (%)
1	Daily	27	30.00
2	Weekly	34	37.78
3	Monthly	18	20.00
4	Rarely	11	12.22
	Total	90	100.00

The table shows how often respondents use digital libraries and e-resources. Out of 90 respondents, 27 (30%) use them daily, 34 (37.78%) use them weekly, 18 (20%) use them monthly, and 11 (12.22%) use them rarely. This shows that most respondents use digital libraries and e-resources on a weekly or daily basis, while only a few use them rarely.

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Figure 4 Frequency of Use of Digital Libraries

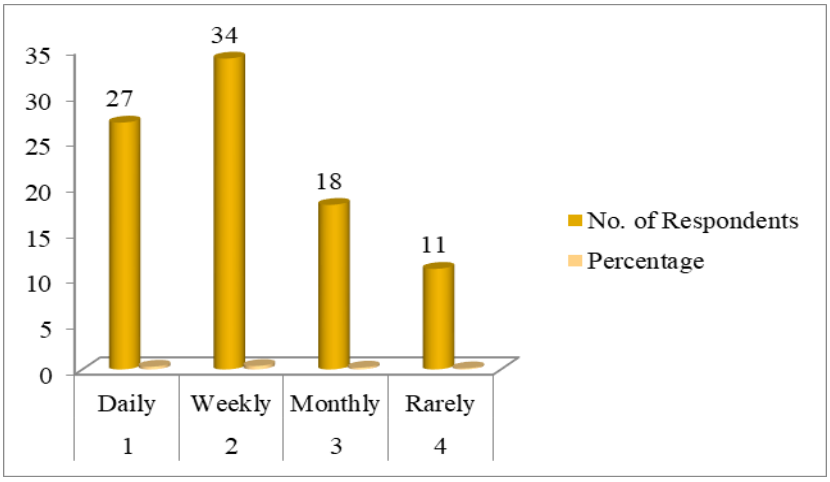
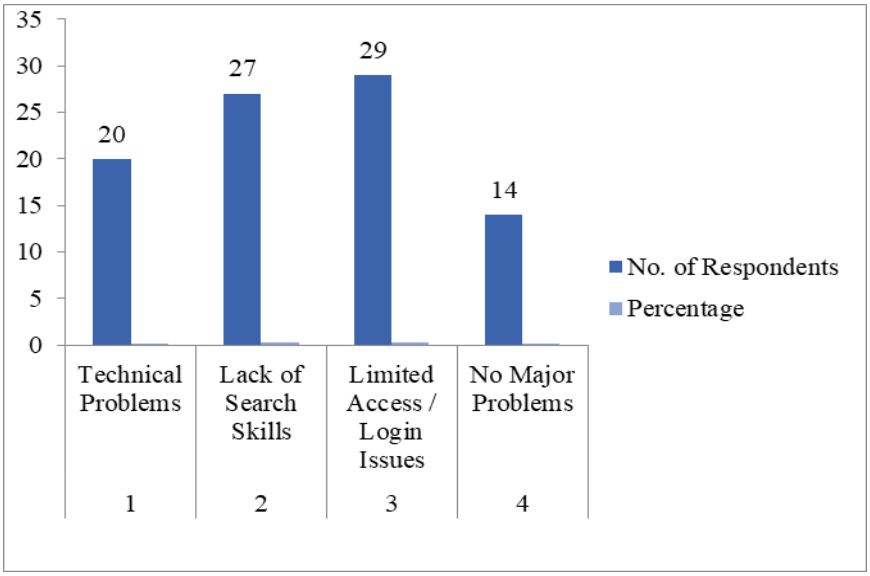


Table 5 Challenges Faced While Accessing E-Resources

S.No	Challenges	No. of Respondents	Percentage (%)
1	Technical Problems	20	22.22
2	Lack of Search Skills	27	30.00
3	Limited Access / Login Issues	29	32.22
4	No Major Problems	14	15.56
Total		90	100.00

The table shows the challenges faced by respondents while using digital libraries and e-resources. Out of 90 respondents, 29 (32.22%) face limited access or login issues, 27 (30%) lack search skills, 20 (22.22%) face technical problems, and 14 (15.56%) reported no major problems. This shows that access issues and lack of search skills are the main challenges for users.

Figure 5 Challenges Faced While Accessing E-Resources



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Table 6 Effectiveness of Digital Library Services

S.No	Opinion	No. of Respondents	Percentage (%)
1	Excellent	25	27.78
2	Good	36	40.00
3	Average	20	22.22
4	Poor	9	10.00
Total		90	100.00

The Table represents the views of the people regarding digital libraries and e-resources. Out of the total number of people surveyed i.e., 90 respondents surveyed, 36 (40%) found them good and rated them as such while another 25(27.78%) respondents out of the total found them excellent by giving such feedback as well. Additionally, out of the total people surveyed i.e., 20 respondents (22.22%) found the services average while only 9 people out of the total people surveyed found them poor.

Figure 6 Effectiveness of Digital Library Services

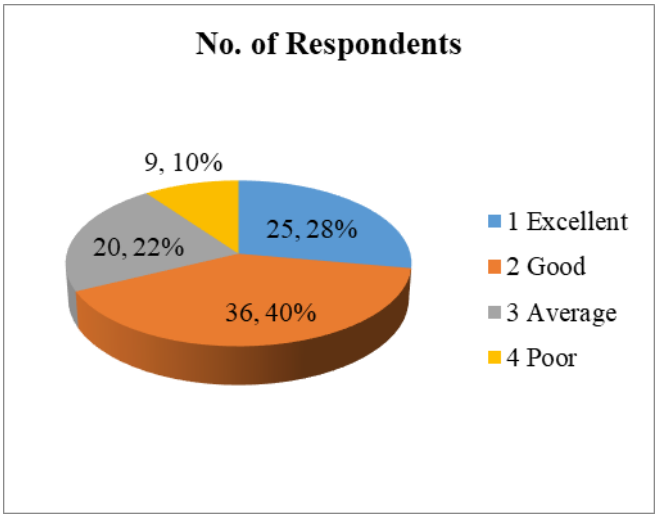


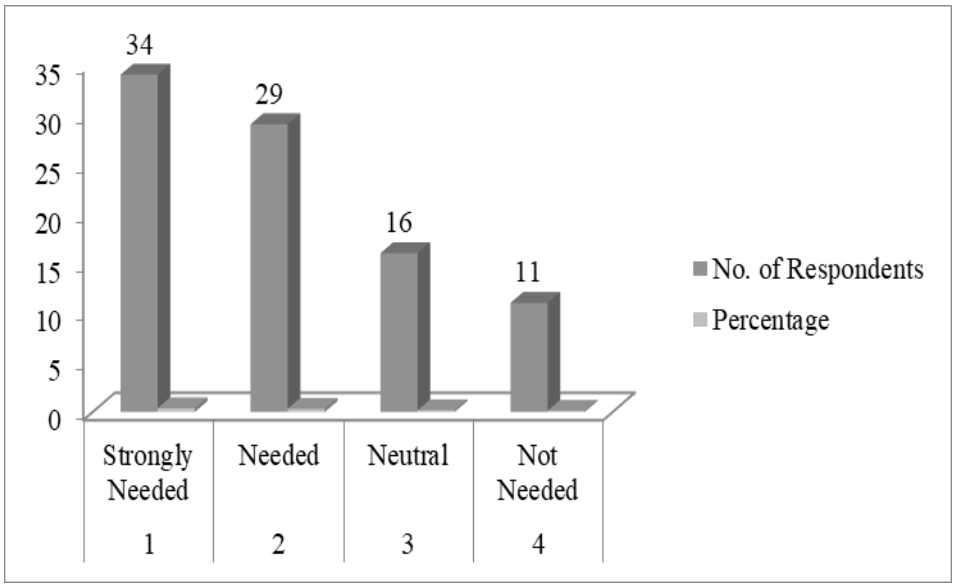
Table7 Need for Improvement in Digital Libraries

S.No	Opinion	No. of Respondents	Percentage (%)
1	Strongly Needed	34	37.78
2	Needed	29	32.22
3	Neutral	16	17.78
4	Not Needed	11	12.22
Total		90	100.00

The table represents the opinion of the respondents concerning the need for digital libraries and e-resources. Out of 90 respondents, 34 (or 37.78%) strongly feel that digital libraries and e-resources are needed, and 29 (or 32.22%) felt they need to have these resources. Additionally, 16 (or 17.78%) are neutrally inclined,

and 11 (or 12.22%) felt they are not required. Therefore, most respondents felt that these libraries and resources are required.

Figure7 Need for Improvement in Digital Libraries



FINDINGS OF THE STUDY

1. Most of the users are aware of digital libraries and e-resources, but the level of awareness is different among students, research scholars, and faculty.
2. Research scholars and faculty members use digital resources more than students.
3. E-journals are the Most commonly sused digital resources, followed by e-books and online databases.
4. Users mainly use digital resources for study, research, teaching, assignments, and project work.
5. Many users access digital libraries daily or weekly, especially research scholars.
6. Some users find it easy to access, while others face difficulties.
7. The main problems faced by users are: Lack of proper training, Slow internet Connection Difficulty in searching information, Limited access to some paid resources
8. The most users are satisfied with the digital library services, but they expect someimprovements.

SUGGESTIONS

1. The university library should conduct training and orientation programs to teach users how to use digital resources.
2. Internet speed should be improved on the campus.
3. More useful e-resources should be added based on user's needs.
4. The digital library website should be made simple and easy to use.
5. The library should create more awareness among students about available digital resources.
6. Facilities for off-campus access should be improved.
7. Users' feedback should be taken regularly to improve services.

CONCLUSION

Digital libraries and e-resources have great significance for facilitating higher order academic and research activities in universities. The present study indicates a good level of awareness about, and usage of, the digital library resources, in general, and e-journals and online databases, in particular, among the users of Bharathiar University. However, some issues like access problems and a lack of search competencies hinder effective utilization. Thus, the adequacy of infrastructure facilities, more comprehensive user training Programs, and added support services are some of the important issues that can make the digital library services more functional. The present study concludes that continuous development is essential for better management and use of digital libraries.

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Usage of E-Resorce in Bon Secours College Library, Thanjavur

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ABSTRACT

The rapid growth of information and communication technology has transformed academic libraries from print-centered systems to hybrid and digital environments. E-resources play a crucial role in supporting teaching, learning, and research activities in higher education institutions. This article examines the usage of electronic resources (e-resources) in Bon Secours College for Women (Autonomous), Thanjavur, focusing on awareness, types of e-resources used, and purpose of use, benefits, and challenges faced by users. The study highlights the importance of library orientation, infrastructure, and digital literacy in maximizing effective use of e-resources.

***KEYWORDS*:** E-resources, Academic Library, Digital Library, Bon Secours College for Women, User Study

INTRODUCTION

Academic libraries are undergoing a significant transition due to advancements in digital technology. E-resources such as e-books, e-journals, online databases, institutional repositories, and open access resources have become essential components of modern library services. These resources provide quick access to updated information, remote availability, and advanced search facilities.

Bon Secours College for Women (Autonomous), Thanjavur, emphasizes quality education and research support for students and faculty. The college library has adopted various electronic resources to supplement traditional print collections and to meet the growing information needs of its academic community.

Bon Secours College for Women (Autonomous), Thanjavur, is a reputed institution committed to academic excellence, research, and women empowerment. The autonomous status enables curriculum innovation and encourages extensive use of digital learning resources. The central library supports these goals by providing access to both print and electronic information sources.

E-Resources Available in the College Library

I. E-books
II. E-journals
III. Online academic databases
IV. Open Access resources (DOAJ, NDLI, etc.)
V. Institutional Repository
VI. E-newspapers and magazines
VII. Subject-based educational websites

E-Books: Extensive collections of digital books covering various subjects, including platforms like Cambridge Books Online, Springer, Sage, and Taylor & Francis.

E-Journals: Subscriptions to academic journals providing full-text access to research articles from publishers such as Elsevier Science Direct, Wiley, Emerald, and IEEE.

Online Academic Databases: Access to powerful search tools and databases for scholarly literature, including Scopus, Web of Science, JSTOR, PubMed, and EBSCO.

Open Access Resources: Freely accessible scholarly content, including the Directory of Open Access Journals (DOAJ), National Digital Library of India (NDLI), Directory of Open Access Books (DOAB), and Shodhganga for theses and dissertations.

Institutional Repository: Digital archives containing the intellectual output of the institution, such as research papers, seminar proceedings, and project reports.

E-Newspapers and Magazines: Digital access to daily news and weekly/monthly magazines (e-zines) through platforms like Press Reader.

Subject-Based Educational Websites: Curated links to specialized websites, virtual labs, and open educational resources (OER) to support specific fields of study.

Additional Features & Services

- **N-LIST Programme:** Access to a vast number of e-books and e-journals specifically for colleges.
- **Remote Access:** Many resources can be accessed off-campus, often secured through authentication.
- **Multimedia Content:** Access to educational videos, interactive materials, and audio-visual resources.
- **Search Tools:** Advanced search capabilities that allow for keyword searches across multiple platforms.



Statistical data

S. No.	Resources	Details / Number
1	**Collection of the Library**	
	Book Volumes	33,741
	Book Titles	29,024
	Book Bank	1,127
	Rare Books	25
2	Journals	90
	Magazines	25
3	Back Volumes	1,461
4	Newspapers	9
5	Electronic Resources	
	CDs & Video Cassettes	536
6	Dissertations & College Magazines	1,645

1	DELNET	http://delnet.in
2	NATIONAL DIGITAL LIBRARY OF INDIA	https://ndl.iitkgp.ac.in
3	DOAJ	https://doaj.org
4	DOAB	https://www.doabooks.org

Access and Usage

Means of Access

- E-resources are accessible through **library computers with internet connectivity** and may also be available through the college's digital systems during library hours.
- Internet-enabled devices in the library help users browse and retrieve online content from subscribed and open-access platforms.

Tools to Assist Access

The library uses **OPAC (Online Public Access Catalogue)** for searching and locating both print and digital resources efficiently.

User Awareness & Training

a) To ensure effective utilization of e-resources:

b) **Orientation programs** and library inductions familiarize new students with e-resource platforms and search techniques.

c) **Library staff assistance** helps users navigate digital databases, download relevant content and understand citation tools.

d) Information about new digital acquisitions and resources is circulated through notices and library displays.

New Students / Faculty

↓

Orientation Programme

(E-resources introduction)

↓

Library Induction

(Search techniques & platforms)

↓

Library Staff Assistance

(Database navigation & downloads)

↓

Citation Guidance

(Referencing & plagiarism tools)

↓

Regular Updates

(New e-resources & services)

↓

Effective Use of E-Resources

Benefits of E-Resource Usage

The availability and use of e-resources in the library provide several academic advantages:

Academic Support

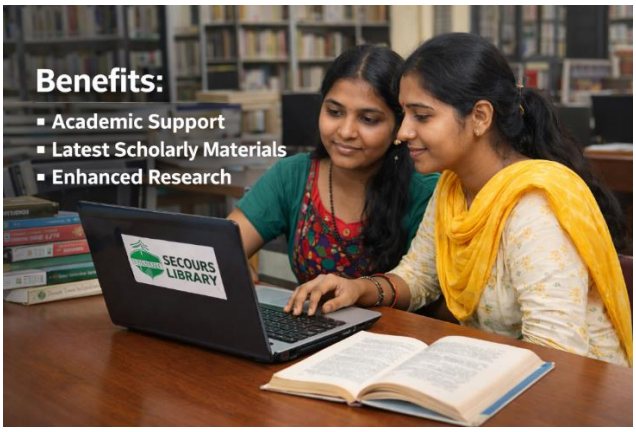
- **Wide access to current research articles, journals, e-books**, and reference materials that support coursework and research beyond printed holdings.
- Facilitation of **independent learning** and preparation for competitive exams through open-access academic materials.

Research and Project Work

- Students engaged in **project work, dissertations and seminars** can access updated scholarly content online rather than relying solely on older print materials.

Teachers benefit from **research insights** and scholarly communications available through databases like Delnet and open access portals.

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Challenges and Suggestions

Challenges

- **Awareness and skills**: Some users may initially find it difficult to use e-resources effectively without guidance or training.
- **Technical access issues**: Limited internet bandwidth or availability of computers may constrain simultaneous usage.

Challenges in Using E-Resources

Challenge Type	Description	Impact
Awareness & Skills	Users lack knowledge of search techniques and platforms	Underutilization of available e-resources
Technical Issues	Limited internet bandwidth	Slow access and interrupted usage
Infrastructure	Limited number of computers	Difficulty in simultaneous access
Training	Inadequate orientation	Users depend heavily on staff assistance

Suggestions for Improving E-Resource Usage

Challenges Identified

↓

Digital Literacy Workshops

↓

Better Search & Retrieval Skills

↓

Remote & On-campus Access

↓

Increased Usage of E-Resources

↓

Enhanced Learning & Research

ISBN: 978-93-47799-57-0

Methodology

Research Design

The study adopts a **descriptive survey method** to analyze the usage of e-resources in Bon Secours College Library, Thanjavur. This method is suitable for understanding user awareness, access patterns, benefits and challenges related to electronic resources among library users.

Area of the Study

The present study was conducted in the **Central Library of Bon Secours College, Thanjavur**, which provides both print and electronic resources to undergraduate and postgraduate students, research scholars and faculty members.

Population of the Study

The population of the study includes:

- Undergraduate students
- Postgraduate students
- Teaching faculty

Tools for Data Collection

The primary data for the study were collected using a **structured questionnaire** designed to gather information on:

- Awareness of e-resources
- Frequency of usage
- Purpose of using e-resources
- Satisfaction level
- Problems faced while accessing e-resources

Sources of Data

- **Primary Data:** Collected through questionnaires distributed to library users
- **Secondary Data:** Collected from library records, institutional reports, college website, journals, books and previous research studies

Scope of the Study

The study is limited to:

- E-resource usage within Bon Secours College Library
- Awareness, access and satisfaction levels of students and faculty
- The findings may not be generalized to other institutions.

Limitations of the Study

- The study is confined to a limited sample size
- Responses depend on users' personal opinions
- Time constraints may affect detailed analysis

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Review of Literature

The review of literature provides an overview of earlier studies related to the usage of electronic resources in academic libraries. It helps to understand existing research trends, user behavior, benefits and challenges associated with e-resources.

Thanuskodi (2012) conducted a study on the use of e-resources by students and researchers in academic institutions and found that e-journals and e-books were widely used for research and academic purposes. The study revealed that ease of access and availability of updated information were the major reasons for preferring electronic resources over print materials.

Sharma and Kaur (2014) examined the awareness and utilization of e-resources among college students and reported that although most users were aware of e-resources, effective utilization was limited due to lack of proper training and digital literacy. The study emphasized the need for orientation and user education programmes.

A study by Kumar and Devi (2016) on e-resource usage in university libraries highlighted that students mainly used electronic resources for assignments, seminars and project work. The research pointed out that internet speed and inadequate infrastructure were major constraints in the effective use of e-resources.

Bhat and Mudhol (2018) analyzed the role of e-resources in supporting teaching and research activities. Their findings indicated that faculty members extensively used e-journals and online databases for research publications and curriculum development. The study recommended strengthening library support services and improving access facilities.

According to a study conducted by Singh and Verma (2020), open access resources such as DOAJ, DOAB and institutional repositories played a significant role in promoting independent learning and research among students. The study also stressed the importance of promoting awareness of free and open-access platforms in academic institutions.

A recent study by Rani and Selvam (2022) focused on challenges in the usage of e-resources in college libraries and identified lack of technical skills, limited internet bandwidth and insufficient guidance as major issues. The researchers suggested regular digital literacy workshops and improved ICT infrastructure.

Summary of Literature Review

- E-resources are extensively used for academic and research purposes
- Awareness exists, but effective utilization depends on training and support
- Infrastructure and technical issues remain major challenges
- User education and orientation programmes are essential

However, very few studies focus specifically on **women's colleges and autonomous institutions at the regional level**, particularly in Thanjavur district. Hence, the present study attempts to analyze the **usage of e-resources in Bon Secours College Library, Thanjavur**, to fill this research gap.

Conclusion

E-resources at Bon Secours College Library play a **significant role in enriching academic learning and research**. Through platforms like DELNET, National Digital Library of India, DOAJ and DOAB, students and faculty are empowered with **timely access to a vast range of digital scholarly materials**. However, continuous efforts to improve awareness, access infrastructure and training will further enhance the **usage and impact of e-resources** within the college community.

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Role of the Librarian in the Digital Era

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ABSTRACT

The rapid expansion of digital technologies has fundamentally transformed the nature and scope of librarianship. In the digital era, librarians are no longer confined to the management of print collections but are increasingly engaged in digital resource management, information literacy instruction, research support, and technology-mediated services. This paper examines the evolving role of librarians in contemporary information environments, highlighting the skills, competencies, and responsibilities required to meet changing user expectations. The study adopts a qualitative and conceptual approach based on an extensive review of scholarly literature and documented professional practices. The analysis reveals that librarians now function as information curators, digital facilitators, educators, and technology leaders, playing a critical role in ensuring equitable access to information and ethical information use. The paper emphasizes the need for continuous professional development, institutional support, and strategic adaptation to enable librarians to remain relevant and effective in an increasingly digital and technology-driven knowledge society.

Keywords: Librarianship; Digital Libraries, Information Literacy, ICT Skills, Professional Development

INTRODUCTION

The digital revolution has significantly altered the way information is created, stored, accessed, and disseminated. Advances in information and communication technologies (ICT) have reshaped library collections, services, and user expectations, leading to a profound transformation in the role of librarians. Traditionally, librarians were responsible for organizing and maintaining printed collections and assisting users within physical library spaces. However, the emergence of digital resources, online databases, and networked information systems has expanded librarianship beyond its conventional boundaries.

In the contemporary digital environment, librarians are expected to manage electronic resources, support digital scholarship, promote information and media literacy, and assist users in navigating complex digital platforms. These expanded responsibilities require librarians to acquire new technical skills, adapt to emerging technologies, and engage in continuous professional learning. This paper explores the changing role of librarians in the digital era, examines emerging opportunities and challenges, and highlights future directions for the profession.

OBJECTIVES OF THE STUDY

The objectives of the present study are:

1. To examine the evolution of the librarian's role in response to digital transformation.
2. To analyze the impact of digital technologies on library services and operations.
3. To identify the new skills and competencies required by librarians in the digital era.
4. To study the role of librarians in user education, research support, and digital literacy.
5. To assess challenges, opportunities, and future prospects for librarianship in the digital environment.

METHODOLOGY

The study is qualitative and conceptual in nature. It is based on an extensive review of secondary sources, including scholarly journals, books, conference papers, and professional reports related to digital librarianship and information services. Relevant literature was analyzed to identify key trends, emerging roles, and skill requirements for librarians in the digital age.

CHANGING ROLES OF LIBRARIANS IN THE DIGITAL ERA

Evolution of Librarianship

The transition from print-based to digital information systems has significantly reshaped librarianship. Librarians now manage hybrid collections that include e-books, e-journals, online databases, and digital archives. Their role has evolved from custodians of physical materials to facilitators of digital access and information navigation. Librarians assist users in locating, evaluating, and effectively using digital information resources, thereby enhancing learning and research outcomes.

New Skills and Competencies

The digital environment demands a broad range of skills from librarians. In addition to traditional library competencies, librarians must possess expertise in digital resource management, data organization, information literacy instruction, and copyright awareness. Proficiency in digital tools, online databases, and emerging technologies is essential. Communication, collaboration, and interdisciplinary engagement have also become critical as librarians work closely with educators, researchers, and technology professionals.

Digital Curation and Information Literacy

Librarians play a vital role in curating, organizing, and preserving digital content. Digital curation involves the selection, management, and long-term preservation of digital materials to ensure continued access. Librarians develop metadata, maintain institutional repositories, and support digital preservation initiatives. Additionally, they promote information literacy by guiding users in critically evaluating online information and addressing challenges related to misinformation and information overload.

OPPORTUNITIES FOR LIBRARIANS IN THE DIGITAL ERA

Digital Resource Management and Discovery

Digital technologies provide librarians with opportunities to improve resource discovery and access. Through the use of digital asset management systems and standardized metadata practices, librarians enhance the organization and visibility of electronic resources, enabling users to locate relevant information more efficiently.

Virtual Reference and Online Learning Support

The growth of online education has expanded the scope of library services beyond physical spaces. Librarians provide virtual reference services through chat platforms, email, and video conferencing. They also collaborate with faculty to integrate information literacy instruction into online learning environments, supporting students' digital research skills.

Open Access and Digital Scholarship

Librarians play an important role in promoting open access and supporting digital scholarship. They assist researchers in managing digital research outputs, preserving research data, and increasing the visibility of scholarly work. These initiatives contribute to the democratization of knowledge and global access to research.

Technology Leadership

With their expertise in information systems, librarians are increasingly assuming leadership roles in managing library technologies, digital platforms, and emerging tools. Their involvement supports institutional digital transformation and innovation.

CASE STUDY: EMBEDDED LIBRARIANSHIP IN ONLINE EDUCATION

The growth of online and blended learning has led to the emergence of embedded librarianship models. In this approach, librarians collaborate closely with faculty members to integrate library resources, research

guidance, and information literacy instruction directly into online courses. Embedded librarians actively participate in course design, assignments, and discussion forums, providing tailored research support to students.

Virtual reference services further enhance access to librarian expertise by enabling real-time support through digital communication tools. These practices demonstrate how librarians are adapting to digital learning environments and strengthening their role in academic success.

EMERGING DIRECTIONS IN DIGITAL LIBRARIANSHIP

Future librarianship is expected to focus on expanding digital inclusion, managing and preserving research data, and integrating artificial intelligence into library services. Technologies such as AI-based recommendation systems, chatbots, and automation tools offer new possibilities for enhancing information retrieval and user engagement. At the same time, librarians will continue to uphold ethical standards by protecting user privacy, ensuring data security, and promoting responsible information use.

STRATEGIES FOR SUCCESS IN THE DIGITAL ENVIRONMENT

To remain effective in the digital era, librarians must engage in continuous professional development and skill enhancement. Designing user-centered services, strengthening institutional collaboration, encouraging innovation, and promoting digital and information literacy are essential strategies. Ethical responsibility, including respect for copyright, privacy, and data protection, remains a core value guiding librarianship.

TECHNICAL SKILL REQUIREMENTS FOR DIGITAL LIBRARIANS

Modern librarians require strong ICT competencies, including knowledge of library automation systems, metadata standards, digitization techniques, and digital preservation models. Familiarity with emerging technologies, cybersecurity practices, and data privacy management is increasingly important for delivering secure and reliable digital services.

CONCLUSION

The digital era has significantly transformed the role of librarians, expanding their responsibilities beyond traditional print-based services to encompass digital resource management, information literacy education, and technology-driven support. Librarians play a central role in promoting equitable access to information, supporting research and learning, and ensuring ethical information use. The continued relevance of librarianship depends on sustained professional development, institutional support, and a commitment to core professional values. By embracing innovation while upholding ethical principles, librarians are well positioned to contribute meaningfully to education, research, and knowledge dissemination in an increasingly digital society.

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Awareness of Research Support Tools among Research Scholars: A Study of Vellalar College for Women

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Abstract

Research support tools play a vital role in enhancing the efficiency and quality of academic research. Awareness of these tools is particularly important for research scholars, especially during the early stages of their research programmes. The present study examines the level of awareness of research support tools among research scholars of Vellalar College for Women. A descriptive survey method was adopted, and data were collected from 72 research scholars using a structured printed questionnaire. Awareness levels were measured using a five-point scale, and percentage analysis was employed for data interpretation. The findings reveal higher awareness of commonly used tools such as grammar check and sample size calculation tools, while moderate awareness is observed for translation, data visualization, and data collection tools. Lower awareness is evident for academic phrase books and journal recommender systems. The study highlights the need for structured training and orientation programmes to enhance effective utilization of research support tools among research scholars.

Keywords: Research Support Tools, Research Scholars, Awareness, Academic Research, Digital Tools

Introduction

The growing use of digital research support tools has significantly influenced the way academic research is conducted. These tools assist research scholars in activities such as academic writing, data collection, data analysis, and publication. Awareness of such tools is especially important for research scholars, particularly those in the early stages of their research programmes.

The present study, titled **"Awareness of Research Support Tools among Research Scholars: A Study of Vellalar College for Women,"** examines the level of awareness of various research support tools among research scholars. The study aims to identify commonly used tools as well as those with limited awareness, highlighting the need for improved training and orientation to enhance effective tool utilization.

Review of literature

Abdurrahman Thalib et al. (2025) reported that performance expectancy and ease of use significantly influence the adoption of AI and research support tools among postgraduate students. Their findings highlight the importance of institutional facilitation and structured guidance.

Archana et al. (2025) observed widespread use of tools like Grammarly, ChatGPT, and Quillbot among university students and research scholars for writing, literature search, and plagiarism checking. However, the study also revealed that a segment of scholars lacked awareness or avoided such tools due to ethical and trust concerns.

Jabeen et al. (2025) found that research scholars extensively used AI tools for grammar correction, paraphrasing, and content organization, leading to improved productivity and confidence. At the same time, concerns related to over-reliance and academic integrity were highlighted. These findings emphasize the need for guided and responsible use of research support tools through institutional training, which is particularly important for early-stage research scholars in women's colleges.

Gomathi (2025) studied awareness and usage dynamics of AI tools among college students in Tamil Nadu and found that although awareness levels were relatively high, actual usage varied. The study identified institutional support, perceived usefulness, and ease of use as key determinants of effective adoption.

Objectives of the Study

- To study the demographic characteristics of research scholars.
- To assess research scholars' awareness of research support tools.
- To analyze awareness patterns across different categories of research tools.
- To suggest measures for enhancing awareness and effective use of research support tools.

Methodology

The study employed a descriptive survey design to assess the awareness of research support tools among research scholars of Vellalar College for Women. The sample consisted of 72 research scholars selected using a convenient sampling technique. Data were collected through printed questionnaires circulated directly to the respondents.

The questionnaire included items on demographic details and awareness of research support tools. Awareness levels were measured using a five-point scale ranging from Not at all aware to extremely aware. Percentage analysis was used to analyze and interpret the collected data.

Data analysis and Interpretation

Table 1: Demographic Profile of the Respondent (n=72)

Variable	Category	Frequency (n)	Percentage%
Discipline	Science	33	45.8
	Social Science	9	12.5
	Arts and Humanities	30	41.7
Category	Full time	63	87.5
	Part time	9	12.5
Year of Research	First Year	15	20.8
	Second Year	33	45.9
	Third Year	18	25
	Fourth Year	6	8.3
M Phil	Yes	9	12.5
	No	63	87.5

Table 1 presents the demographic profile of the respondents. The distribution across disciplines indicates a balanced representation, with respondents drawn from science, social science, and arts and humanities, ensuring disciplinary diversity in the study. Most respondents are engaged in research on a full-time basis, suggesting a high level of academic commitment among the participants.

With respect to research experience, the majority of respondents are in the early to middle stages of their research programme, particularly in the first and second years, while fewer respondents are in the advanced years. This indicates that the sample largely consists of emerging researchers. Additionally, only a small proportion of respondents have completed an M.Phil. programme, while the majority have not, reflecting a

cohort primarily at the doctoral research stage. Overall, the demographic profile suggests an appropriate and relevant sample for examining awareness of research support tools.

Table 2: Awareness Levels of Research Support Tools among Respondents

Tools	Not at all aware	Slightly aware	Somewhat aware	Moderately aware	Extremely aware
Alert Tools	12	15	15	18	12
Translation Tools	6	18	9	24	15
Grammar Check Tools	9	6	9	24	24
Mind Mapping Tools	9	24	18	6	15
Data Visualization	15	18	9	18	12
Data Collection	12	21	9	12	18
Sample Size Calculation Tools	12	9	6	24	21
Statistical Analysis tools	9	27	3	27	6
Academic Phrase Book	9	33	12	9	9
Journal Recommenders	15	18	18	12	9
Reference Management Tools	15	18	12	9	18

Table 2 illustrates respondents' awareness of various research support tools. The findings indicate that awareness is generally **higher for tools that are frequently integrated into routine research and academic writing activities**, such as grammar check and sample size calculation tools. These tools appear to be well recognized and widely familiar among respondents.

A **moderate level of awareness** is observed for translation, data visualization, and data collection tools, suggesting that while respondents are aware of their availability and usefulness, their engagement with these tools may not yet be at an advanced level. Awareness of statistical analysis tools shows variability, indicating that respondents possess foundational knowledge but may lack deeper proficiency.

In contrast, **support-oriented tools** such as academic phrase books and journal recommender systems demonstrate comparatively lower awareness, reflecting limited exposure and use. Overall, the table suggests that respondents are more comfortable with essential and commonly used research tools, while awareness of specialized and discovery-focused tools remains limited, underscoring the need for structured training and orientation programs.

Findings

- Respondents represent diverse disciplines and are predominantly full-time, early-stage doctoral researchers.
- Most participants are in the first and second years of research, with few in advanced stages.

- Awareness is highest for commonly used tools such as grammar check and sample size calculation tools.
- Moderate awareness is observed for translation, data visualization, and data collection tools.
- Awareness of statistical analysis tools varies across respondents.
- Lower awareness is evident for academic phrase books and journal recommender tools.

Conclusion

The study examined the awareness of research support tools among research scholars of Vellalar College for Women and revealed varying levels of awareness across different categories of tools. The findings show that research scholars are more familiar with commonly used tools related to academic writing and research design, while awareness of specialized and publication-oriented tools remains relatively low. The predominance of early-stage, full-time research scholars highlights the importance of timely exposure to research support resources. The study emphasizes the need for structured training programmes, workshops, and orientation initiatives to enhance awareness and effective utilization of research support tools, thereby improving research efficiency and scholarly output.

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Capacity Building & Professional Development – Skills, Lifelong Learning, Leadership

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Abstract

In the contemporary professional landscape, rapid technological advancement, globalization, and evolving organizational demands have made continuous capacity building and professional development essential for sustainable growth. This paper examines the critical role of ***skills development, lifelong learning, and leadership*** *as interconnected pillars of capacity building in modern organizations. Capacity building focuses on strengthening individual and organizational capabilities to enhance performance, adaptability, and long-term effectiveness. Professional development, as a continuous and systematic process, enables individuals to update their knowledge and competencies in response to changing work environments.*

The study highlights the importance of both ***technical and soft skills****, emphasizing communication, problem-solving, adaptability, and emotional intelligence as key drivers of professional success. It further explores the concept of lifelong learning as a strategic approach to maintaining professional relevance and fostering innovation. Leadership development is analyzed as a vital component that supports skill utilization, motivates teams, and promotes a culture of continuous learning within organizations.The study concludes that organizations investing in structured professional development, lifelong learning opportunities, and leadership training are better positioned to respond to emerging challenges and achieve long-term competitive advantage.*

Keywords: Capacity Building; Professional Development; Skills Development; Lifelong Learning; Leadership Development; Organizational Performance; Human Resource Development

Introduction

In today's dynamic professional environment, organizations and individuals face unprecedented challenges arising from globalization, rapid technological advancements, and increasing workforce diversity. To remain competitive and effective, individuals must continually enhance their abilities, while organizations need to foster environments that support professional growth. Capacity building and professional development have therefore emerged as critical strategies for ensuring long-term success.

Capacity building refers to the systematic process of developing the knowledge, skills, competencies, and structures that enable individuals and organizations to perform effectively. Professional development is the ongoing process of acquiring and applying new knowledge and skills to improve professional practice. Both concepts are closely intertwined: capacity building provides the foundational capabilities required for growth, while professional development ensures continuous improvement over time.

This paper explores the intersection of skills development, lifelong learning, and leadership, arguing that these three pillars are essential for personal, organizational, and societal success. It examines theoretical frameworks, practical strategies, and real-world examples of capacity building initiatives, highlighting best practices and challenges in modern workplaces.

Conceptual Framework

Capacity Building Defined

Capacity building is a multidimensional process that operates at the individual, organizational, and systemic levels. At the individual level, it involves developing competencies such as technical expertise, critical thinking, and interpersonal skills. At the organizational level, it strengthens structures, processes, and cultures that support efficiency and innovation. At the systemic level, it includes policies, governance structures, and resource allocation strategies that enable sustained growth.

A key characteristic of capacity building is its focus on sustainability—developing capabilities that endure beyond immediate projects or training sessions. In professional settings, capacity building is not limited to formal instruction; it also involves mentorship, on-the-job training, and experiential learning opportunities that cultivate both competence and confidence.

Professional Development Defined

Professional development is a continuous, lifelong process through which individuals enhance their knowledge, skills, and effectiveness in their professional roles. It may involve formal education, such as degree programs and certifications, as well as non-formal activities like workshops, seminars, and self-directed learning. Unlike one-time training, professional development emphasizes ongoing improvement, reflective practice, and adaptability in response to changing job requirements.

Relationship between Capacity Building and Professional Development

Capacity building and professional development are inherently interconnected. While capacity building equips professionals with foundational skills and organizational systems, professional development ensures these skills are continuously updated and refined. Together, they create a cycle of growth: enhanced capacity enables better learning, and professional development feeds back into stronger capacity. For example, an employee trained in project management (capacity building) who participates in ongoing leadership workshops (professional development) can lead teams more effectively and adapt to complex challenges.

Skills Development

Technical Skills

Technical skills, often referred to as hard skills, are essential for performing profession-specific tasks. In healthcare, this includes clinical procedures and patient care protocols; in IT, coding and network management; in finance, data analysis and compliance knowledge. Developing technical skills ensures that professionals meet industry standards and contribute to organizational productivity.

Soft Skills

Soft skills, including communication, teamwork, problem-solving, emotional intelligence, and adaptability, are equally critical. While technical skills enable task completion, soft skills facilitate collaboration, leadership, and innovation. For instance, effective communication is vital in multidisciplinary teams, enabling clear goal alignment and conflict resolution.

Strategies for Skills Development

Organizations and individuals can use multiple strategies to develop skills:

- Workshops and training programs: Structured sessions for skill acquisition.
- Mentorship and coaching: Experienced professionals guide and support learning.
- Experiential learning: Hands-on practice in real-world scenarios.
- Online learning platforms: Digital courses for self-paced skill development.
- Collaborative projects: Team-based initiatives that foster both technical and interpersonal growth.

Measuring Skill Development

Evaluation methods include performance assessments, self-evaluations, peer feedback, and competency frameworks. Organizations can track skill acquisition and identify gaps for targeted training, ensuring alignment with strategic objectives.

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Lifelong Learning

Concept and Importance

Lifelong learning is the continuous pursuit of knowledge and skills throughout one's career. It extends beyond formal education to include self-directed, informal, and experiential learning. Lifelong learning is vital because the modern workplace is constantly evolving, and professionals must adapt to new technologies, methodologies, and market demands.

Modes of Lifelong Learning

- **Formal learning:** Degree programs, certifications, structured courses.
- **Non-formal learning:** Workshops, seminars, professional conferences.
- **Informal learning:** Self-study, mentorship, collaborative projects, reflective practice.

Benefits of Lifelong Learning

Continuous learning fosters adaptability, innovation, and resilience. Professionals who embrace lifelong learning are better equipped to respond to technological disruptions, industry shifts, and evolving organizational needs. For example, healthcare professionals adapting to telemedicine demonstrate how lifelong learning supports professional relevance.

Organizational Role in Lifelong Learning

Organizations play a crucial role by creating learning cultures that encourage ongoing education. Policies such as professional development incentives, access to training resources, and recognition of learning achievements reinforce lifelong learning and enhance employee engagement.

Leadership Development

Concept of Leadership

Leadership is the ability to influence, guide, and inspire individuals or teams toward shared goals. Effective leadership requires vision, strategic thinking, and the capacity to motivate others. Leadership is distinct from positional authority; it emphasizes impact and the ability to drive positive outcomes.

Key Leadership Skills

Effective leaders demonstrate:

- Emotional intelligence
- Decision-making under uncertainty
- Conflict management
- Strategic thinking
- Team-building and motivation

These skills enable leaders to navigate complex organizational challenges while fostering innovation and collaboration.

Methods for Leadership Development

Leadership capacity can be cultivated through:

- **Structured training programs:** Targeted workshops on strategy, communication, and problem-solving.
- **Mentorship and coaching:** Guidance from experienced leaders.

- **Action learning projects:** Real-world initiatives that build leadership competence.
- **Reflective practice:** Self-assessment and learning from experiences.

Leadership and Professional Growth

Leaders who continually develop their skills serve as catalysts for organizational learning. Their ability to model continuous growth encourages employees to engage in lifelong learning and skill development, reinforcing a cycle of professional excellence.

Integration of Skills, Lifelong Learning, and Leadership

Interrelationship of Components

The three pillars are mutually reinforcing. Technical and soft skills form the foundation, lifelong learning ensures these skills evolve, and leadership amplifies their impact. For instance, a technically skilled project manager who engages in continuous learning and demonstrates strong leadership can lead teams to achieve superior outcomes.

Organizational Perspective

Organizations can integrate these pillars through:

- Professional learning communities
- Mentorship and coaching programs
- Leadership development initiatives
- Continuous evaluation and feedback mechanisms

Challenges and Solutions

Challenges include resource limitations, resistance to change, and skill gaps. Solutions include digital learning platforms, incentives, supportive culture, and structured capacity-building programs.

Case Studies and Practical Examples

Education Sector

Teacher professional learning communities enhance instructional skills and leadership capacity. Peer collaboration and reflective practice improve teaching quality and student outcomes.

Healthcare Sector

Hospitals implementing continuous training for nurses and doctors show improved patient care and adaptability to evolving practices like telemedicine.

Corporate Sector

Companies like Google, IBM, and Deloitte invest heavily in skill development, lifelong learning programs, and leadership pipelines, resulting in higher employee engagement and innovation.

Theoretical Foundations

Capacity Building Theories

Capacity building draws on multiple theoretical frameworks, including human capital theory, organizational learning theory, and competency-based development. Human capital theory suggests that investing in employee skills and knowledge increases productivity and innovation. Organizational learning theory emphasizes the importance of creating environments where individuals and teams continuously acquire, share, and apply knowledge.

Professional Development Models

Professional development is rooted in adult learning theories such as andragogy, which highlights the self-directed, experiential, and goal-oriented nature of adult learning. Effective professional development programs integrate workshops, coaching, mentorship, and reflective practice to support skill enhancement and behavioral change.

Skill Development as a Core of Capacity Building

Technical Competence

Technical skills are the foundation of professional competence. They encompass profession-specific abilities required to perform tasks efficiently, such as data analysis for finance professionals, coding for IT specialists, or surgical techniques for healthcare workers.

Soft Skills and Emotional Intelligence

Soft skills, including communication, collaboration, critical thinking, and emotional intelligence, are equally vital. They enable professionals to navigate complex interpersonal dynamics, foster team cohesion, and improve problem-solving capabilities. Organizations that neglect soft skills often face reduced employee engagement and workplace conflict.

Approaches to Skill Enhancement

Skill development can be achieved through multiple approaches:

- Structured workshops and seminars
- On-the-job experiential learning
- Peer mentoring and collaborative projects
- Online learning platforms and MOOCs

By combining these methods, professionals gain both knowledge and practical experience, making skill development a continuous and adaptable process.

Lifelong Learning in the Professional Context

Concept and Relevance

Lifelong learning is the continuous pursuit of knowledge and skills throughout an individual's career. In an era marked by rapid technological change and evolving workplace requirements, lifelong learning ensures professionals remain adaptable and relevant.

Formal, Non-formal, and Informal Learning

- **Formal learning:** Degree programs, certifications, structured courses.
- **Non-formal learning:** Workshops, seminars, professional conferences.
- **Informal learning:** Self-study, mentorship, collaborative projects, reflective practice.

Organizational Support for Lifelong Learning

Organizations can promote lifelong learning by creating supportive environments that encourage continuous education, such as:

- Offering access to online courses and learning materials
- Establishing mentoring programs and communities of practice
- Recognizing and rewarding learning achievements

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Leadership Development

Defining Leadership in Modern Organizations

Leadership is the capacity to influence, motivate, and guide others toward achieving shared objectives. It is not confined to positional authority; effective leadership combines strategic thinking, emotional intelligence, and ethical decision-making.

Leadership Skills

Key leadership skills include:

- Strategic planning and problem-solving
- Communication and conflict resolution
- Team motivation and performance management
- Change management and innovation

Methods for Developing Leaders

Leadership development programs often integrate:

- Coaching and mentoring
- Action learning projects
- Formal leadership workshops
- Rotational assignments for exposure to multiple organizational functions
- Such initiatives cultivate leaders who can drive organizational growth, adapt to change, and inspire continuous learning among team members.

Integrating Skills, Lifelong Learning, and Leadership

Interconnected Dynamics

Skills, lifelong learning, and leadership are deeply interrelated. Proficiency in technical and soft skills provides a foundation for effective leadership. Lifelong learning ensures these skills remain up-to-date, while leadership amplifies the application and dissemination of knowledge across teams.

Organizational Strategies for Integration

Organizations can integrate these elements through:

- Professional learning communities
- Competency frameworks linking skills to leadership roles
- Continuous feedback and evaluation mechanisms
- Policies incentivizing learning and development

Challenges and Recommendations

Barriers include lack of resources, insufficient motivation, and resistance to change. Recommendations to overcome these challenges include:

- Embedding development programs into organizational strategy
- Utilizing digital learning platforms for scalable training
- Encouraging knowledge sharing and peer mentoring

CONCLUSION

Capacity building and professional development are essential for sustaining professional competence, leadership effectiveness, and organizational performance. Skill enhancement, lifelong learning, and leadership development form a synergistic triad that enables professionals to thrive in complex environments.

Organizations that invest in structured programs and supportive cultures not only improve employee performance but also secure competitive advantage in the long term.

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Impact of Social Media on Lifestyle Changes among Students of Vellalar Group of Institution

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ABSTRACT

Social media has become an integral part of youth culture, significantly influencing communication patterns, learning behavior, social interactions, and information consumption. With the rapid growth of digital platforms, students increasingly rely on social media for academic, social, and personal purposes. This study examines the impact of social media on the daily life of youth, focusing on students of the Vellalar Group of Institutions. The paper explores usage patterns, perceived benefits, challenges, and the role of social media in shaping information behavior. The study highlights the relevance of digital literacy and ethical information use in the contemporary information landscape.

Keywords: Social Media, Youth, Digital Literacy, Information Behavior, Students, Academic Life

INTRODUCTION

In recent years, social media has become a significant part of student's daily lives, transforming the way they communicate, learn, and access information. The widespread use of smartphones and internet connectivity has increased students' dependence on social media for academic, social, and personal purposes. While social media provides easy access to information, improved communication, and learning opportunities, it also presents challenges such as excessive usage, misinformation, and ethical concerns. Therefore, understanding the impact of social media on students' lifestyle and information behaviour is important, particularly in the context of higher educational institutions.

REVIEW OF LITERATURE

Kashi Nath Pandey (2025) in his study "Impact of Social Media on daily life of the Youth" Examines mental health, self-esteem, socialization, and academic performance among Indian youth. Notes that platforms like Facebook, Instagram, Twitter, and TikTok have profoundly shaped everyday life.

Sunil Ambekar (2025) in his study "Impact of Suggests youth are more knowledge-hungry and adaptable". Youth's Involvement in Social Media is Just a Transition Phase (Orange City Literature Festival) Argues that social media involvement is a temporary generational phase, similar to television adoption in earlier decades

Hasan, S., & Mirza, S. (2024**)** stated that "Social Media and Its Impact on Youth" emphasizes that social media plays a significant role in shaping youth's social behavior, knowledge acquisition, and recreational activities. However, they caution that excessive use leads to time mismanagement and reduced productivity, affecting lifestyle balance.

Kumar (2024) in his study "Impact of Social Media on the Scholastic Achievement of Adolescent Students in Secondary School". Social media also acts as a significant source of distraction, hampering focus, sleep patterns, and academic performance .In his study on secondary school students found that while social media platforms can aid learning, excessive use led to procrastination, decreased attention span, and poor grades due to time displacement and reduced sleep quality.

OBJECTIVES

i. To analyze the impact of social media usage on the daily lifestyle of students.
ii. To assess the influence of lifestyle-related social media content on students' perceptions and behaviour.
iii. To understand students' information behaviour and awareness in the digital environment.

RESEARCH METHODOLOGY

The present study adopts a **descriptive survey research design** to examine the impact of social media on lifestyle changes among students of the Vellalar Group of Institutions. This design helps in understanding students' social media usage patterns, perceptions, and behavioural changes in their daily life.

The population of the study consists of students from Vellalar College for Women, Vellalar College of Engineering Technology, and VET Institution of Arts and Science. A total of **85 students** were selected as respondents for the study, including both undergraduate and postgraduate students. The respondents were selected using a **convenience sampling technique**, based on their availability and willingness to participate in the survey.

The study is based on both **primary and secondary data**. Primary data was collected through a structured questionnaire containing close-ended questions related to demographic details, social media usage, lifestyle changes, and influence of social media content. Secondary data was gathered from books, journals, research articles, and online academic sources related to social media and youth behaviour

Table 1 Demographic profile of the Respondent (N=85)

Variable	Category	Frequency(n)	Percentage (%)
Course wise	Post graduate	42	49.4
	Under graduate	43	50.6
College wise	Vellalar college for women	53	62.4
	Vellalar college of engineering technology	11	12.9
	VET Institution of arts and science	21	24.7
Age wise	18-21	42	49.4
	22-24	41	48.2
	25 and Above	2	2.4
Gender	Male	16	18.8
	Female	85	81.2
Area	Rural	56	65.9
	Urban	29	34.1

Table 1 presents the demographic profile of the respondents (N = 85). The distribution of respondents by course indicates that 50.6% were undergraduates, while 49.4% were postgraduates, showing an almost equal representation of both groups. With respect to college-wise distribution, the majority of respondents (62.4%) were from Vellalar College for Women, followed by 24.7% from VET Institution of Arts and Science, and 12.9% from Vellalar College of Engineering Technology. Age-wise classification reveals that nearly half of the respondents (49.4%) belonged to the 18–21 years age group, closely followed by 48.2% in the 22–24 years category. Only a small proportion (2.4%) were aged 25 years and above. Gender-wise analysis shows that female respondents constituted a significant majority (81.2%), while males accounted for 18.8% of the sample. Regarding area of residence, a higher proportion of respondents (65.9%) were from rural areas, whereas 34.1% were from urban areas.Overall, the table indicates that the sample predominantly consists of young, female respondents from rural backgrounds, with balanced representation of undergraduate and postgraduate students.

Table 2 Changing in daily lifestyle after using social media (N=85)

Variable	Category	Frequency(n)	Percentage (%)
Change in lifestyle	Agree	67	78.8
	Disagree	18	21.2
Lifestyle portrayed	Agree	23	27.1
	Disagree	32	37.6
	Maybe	30	35.3
Checking social networking	Yes	32	37.6
	No	29	34.1
	Sometimes	24	24.7
Detached	Yes	35	41.2
	No	29	34.1
	Sometimes	21	24.7
Self image	Yes	31	36.5
	No	24	28.2
	Maybe	30	35.3
Social status	Yes	22	25.9
	No	35	41.2
	Maybe	28	32.9

Table 2 explains the changes in the daily lifestyle of the respondents after using social media (N = 85). Out of 85 respondents, 67 agreed that social media has brought changes in their daily lifestyle, while 18 disagreed. Regarding the lifestyle portrayed on social media, 23 respondents agreed that it reflects real life, whereas 32 respondents disagreed and 30 respondents were uncertain about it. In terms of checking social networking sites, 32 respondents reported checking social media regularly, 24 respondents checked it sometimes, and 29 respondents did not check it frequently. With respect to feelings of detachment, 35 respondents felt detached due to social media usage, while 21 respondents experienced detachment sometimes and 29 respondents did not feel detached. Concerning self-image, 31 respondents stated that social media affects their self-image, 30 respondents were unsure, and 24 respondents reported no impact on self-image.

Table 3 Preferences about influence of lifestyle related content on social media

Category	Rarely influential	Somewhat influential	Very influential
Lifestyle related content on social media	21	38	26
Clothing fashion and related accessories	15	33	35
Health, hygiene and fitness	13	38	34
Travelling and destinations	15	36	34
Tech gadgets and automobiles	14	39	32
Beauty, makeup and hairstyle	23	33	29
Food and cuisine	15	41	29
Everyday general information	12	34	39
Viral media & trends	16	34	35
News and updates about your environment	13	29	43

Table 3 indicate that *news and updates about the environment and everyday general information* are the most influential types of content among respondents. Content related to *fashion, viral trends, health and fitness*, and *travelling* also shows a high level of influence, with many respondents rating them as somewhat to very influential. On the other hand, *beauty, makeup and hairstyle* and general *lifestyle-related content* were perceived as less influential by a section of the respondents. Overall, the results suggest that **informative and trend-oriented content has a greater impact on respondents than purely lifestyle or appearance-based content**.

FINDINGS

The findings of the study clearly indicate that social media has become an integral part of the daily lives of youth. A majority of respondents acknowledged that social media plays a significant role in enhancing their **academic knowledge and general awareness,** particularly in accessing news, educational content, and everyday information. Weighted mean analysis further revealed that informational and awareness-based content exerted a stronger influence than entertainment or purely lifestyle-oriented content.

SUGGESTIONS

Based on the findings of the study, the following suggestions are offered:

- Youth should be encouraged to use social media in a balanced and responsible manner, focusing more on educational and awareness-oriented content.
- Educational institutions may conduct awareness programs on healthy social media usage to minimize negative lifestyle and psychological effects.
- Parents and family members should actively engage with youth to reduce detachment from family responsibilities caused by excessive social media use.

CONCLUSION

The present study entitled **"Impact of Social Media on the Daily Life of Youth: A Study of Students at Vellalar Group of Institutions"** was undertaken to examine the influence of social media on various dimensions of youth life, including awareness, lifestyle, social roles, social status, and participation in the public sphere. The analysis was carried out using frequency and percentage distribution, along with weighted mean and ranking techniques to understand the relative influence of different factors. The study also found that social media has brought noticeable changes in the **lifestyle of youth**

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Transmuted Kumaraswamy Distribution-Based Control Charts for Monitoring Skewed Oral Cancer Survival Data

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Abstract

Conventional statistical process control (SPC) charts, which are normality given, do not tend to monitor processes whose distributions are heavily skewed, especially where medical survival monitoring and reliability engineering are concerned. This paper presents a new research strategy which involves the use of the Transmuted Kumaraswamy Distribution (TKD) to derive control charts that will be specifically used to monitor skewed data of oral cancer survival. The TKD is a three-parameter generalization of the Kumaraswamy distribution which provides increased flexibility to modeling the appearance of asymmetric patterns of data with the addition of a transmutation parameter. Our theoretical model of the TKD-based control limits is the upper control limit (UCL), lower control limit (LCL), and center line (CL) derived with the help of the percentile-based approach that applies to non-normal distributions. The proposed methodology is confirmed by a comprehensive case study based on oral cancer survival data of 20 patients. The empirical outcomes show that there is no special cause variation in the sample values since all of them lie within the control limits (LCL = 0, CL = 58.47, UCL = 130.67) showing statistical stability. After comparing the two charts, it is clear that the TKD-based charts are more performant as compared to the traditional Shewhart charts when the data is highly skewed (skewness coefficient > 1.5). The suggested framework will be useful to generalize the conventional SPC methodology by supporting complex distributional environments to provide more effective process monitoring, higher sensitivity in assignable cause's detection and a better Type I and Type II error rates in skewed data environments. The development has enormous implications on quality control of healthcare, biomedical research, analysis of reliability and manufacture of pharmaceuticals that have non-normal distributions.

Keywords: Transmuted Kumaraswamy Distribution, Control Charts, Skewed Data, Oral Cancer Survival, Statistical Process Control, Non-normal Distributions, Healthcare Quality Monitoring

Introduction

The concept of statistical process control (SPC) charts through the works of Walter Shewhart in Bell Laboratories (1924) and his seminal work (1931) has become an invaluable instrument in monitoring and controlling process variation in a variety of industries and service industries. The basic input of Shewhart was the conceptual model that differentiates between common cause variation (natural to the process) and special cause variation (traceable to assignable factors) to allow the practitioner to make wise decisions regarding process intervention [2]. The control charts have been able to go beyond their manufacturing origins and be used in healthcare, finance, environmental monitoring, and service sectors in the last century, proving their flexibility and long-term applicability [3,4].

Although very common, classical control charts were created with the limiting assumption of normality, meaning that they are only applicable to processes that have non-normal, and thus skewed, distributions. Positive skewness, heavy tails, and asymmetry are common characteristics in medical and biomedical data that can include survival data, time-to-event outcomes, and reliability metrics and are non-normative [5,6]. The use of traditional Shewhart charts on this type of data may lead to an inflated false alarm (Type I errors), less detection of actual process changes (Type II errors), and distorted control limits that do not reflect the actual process behavior [7,8].

Monitoring skewed processes has been a challenge that has encouraged a lot of research in distribution specific control charts. A number of authors have suggested Weibull, Gamma, and Lognormal-based methodologies to be used in the quality control application in skewed environments [9,10]. Recent work on

transmuted distributions has provided a new set of possibilities in the models of complex data patterns. Aryal and Tsokos proposed transmuted extreme value distributions such as transmuted Gumbel distributions and transmuted Weibull distributions which fit climate and reliability data better [11,12]. Khan et al. generalized this paradigm to the transmuted generalized inverse Weibull, transmuted modified Weibull and transmuted generalized exponential distributions [13,14,15], and Aryal investigated the transmuted log-logistic distribution [16].

One of the new family of transmuted distributions is the Transmuted Kumaraswamy Distribution (TKD), proposed by Khan et al. (2016), which has attracted a lot of interest as it can be used to model asymmetric and bounded data with a variety of shapes of hazard functions [17]. The TKD is a generalization of the two-parameter Kumaraswamy distribution which includes a transmutation parameter so that it can be used to represent a wider range of distributional forms, such as bathtub and upside-down bathtub hazard rate functions, which are common in reliability engineering and survival analysis [18,19]. The TKD is especially appropriate in the modelling of oral cancer survival information, as the survival times are skewed to the right and the patterns of failure among patient groups are heterogeneous.

The oral cancer is a common squamous cell carcinoma, which is one of the most common malignant diseases globally with the outcome of survival being affected by various clinical, demographic, and treatment-related aspects [20]. Survival patterning using the right statistical tools is decisive in assessing the treatment effectiveness, determining high-risk groups of patients, as well as timely clinical responses. The non-parametric models of oral survival data frequently do not sufficiently reflect the complex distributions of oral cancer survival data, and more flexible modeling methods are required.

The proposed study fills the essential research gap in the SPC methodology of skewed medical data by designing TKD-based control charts that are specifically aimed at monitoring the oral cancer survival processes. The main objectives are as follows: (1) to obtain theoretical apparatus of TKD-based control limits construction with the help of percentile-based approach; (2) to prove how TKD control charts may be built and interpreted with empirical oral cancer survival data; (3) to prove that the proposed methodology is statistically stable and effective; and (4) to obtain advice on practical considerations of the TKD-based SPC implementation in healthcare quality control.

The rest of this paper will be structured in the following way: Section 2 will give a theoretical basis of the TKD, i.e., its probability density function, cumulative distribution function and main statistical properties. In section 3, the methodology of constructing TKD-based control charts, estimation of parameters and derivation of control limits is explained. Section 4 gives the empirical application involving oral cancer survival data, results, and discussion are given in Section 5. The last section (6) has implications towards practice and the further direction of research.

Theoretical Framework of the Transmuted Kumaraswamy Distribution

The Kumaraswamy Distribution

The Kumaraswamy distribution, which was originally intended to use in hydrology, is on the unit interval (0,1), with two positive parameters of shape, α and β. The probability density function (PDF) and the cumulative distribution function (CDF) are given by:

$$f(x;\, \alpha, \beta) \;=\; \alpha\beta x^{(\alpha-1)}(1 - x^{\alpha})^{(\beta-1)}, \qquad 0 < x < 1, \alpha > 0, \beta > 0$$

$$F(x;\, \alpha, \beta) \;=\; 1 - (1 - x^{\alpha})^{\beta}$$

Kumaraswamy distribution has good characteristics such as the moments and quantiles can be expressed in closed form, which is computationally effective in many applications. The two-parameter form is however restrictive to its ability to accommodate various shapes of hazard rates and tail behaviors in real life data.

The Transmuted Kumaraswamy Distribution

Shaw and Buckley introduced the quadratic rank transmutation map as a way of creating new distributions by adding a new parameter $\lambda \in [-1, 1]$. Given a base CDF $G(x)$ the transmuted CDF would be constructed as

$$F(x) = (1 + \lambda)G(x) - \lambda G(x)^2$$

Transmuting the Kumaraswamy distribution results in the TKD whose CDF is:

$$F(x; \alpha, \beta, \lambda) = [1 + \lambda][1 - (1 - x^{\alpha})^{\beta}] - \lambda[1 - (1 - x^{\alpha})^{\beta}]^2$$

$$= (1 + \lambda)[1 - (1 - x^{\alpha})^{\beta}] - \lambda[1 - 2(1 - x^{\alpha})^{\beta} + (1 - x^{\alpha})^{2\beta}]$$

where $x \in (0, 1), \alpha > 0, \beta > 0$, and $\lambda \in [-1, 1]$. The transmutation parameter λ determines the extent of departure of the baseline Kumaraswamy distribution, $\lambda = 0$ returning to the original two-parameter model.

The corresponding PDF is obtained by differentiating the CDF:

$$f(x; \alpha, \beta, \lambda) = \alpha\beta x^{(\alpha-1)}(1 - x^{\alpha})^{(\beta-1)}[1 + \lambda - 2\lambda(1 - (1 - x^{\alpha})^{\beta})]$$

Statistical Properties

The TKD has a number of significant statistical features that ensure its application in survival analysis and its use in quality control:

Flexibility in Shape: The three-parameter form allows the TKD to fit a wide range of forms of distributions, such as unimodal, bimodal distributions, and highly skewed data, and fits heterogeneous survival data better than the traditional two-parameter models.

Hazard Rate Functions: TKD supports monotonically increasing, decreasing, bathtub and upside-down bathtub hazard rate functions, and are especially appropriate to reliability engineering and medical use where the failure rates are complex with regard to time.

Quantile Function: The quantile function, which is required when controlling the limits using percentiles, may be obtained as the inversion of the CDF. Given a probability p, the pth quantile x_p is the value such that $F(x_p) = p$, and this can be determined numerically by conventional root-finding methods.

Moments: The rth raw moment of the TKD can be expressed as:

$$E(X^r) = (1 + \lambda)E_K(X^r) - \lambda E_{K^2}(X^r)$$

where $E_K(X^r)$ represents the rth moment of the baseline Kumaraswamy distribution.

Methodology for TKD-Based Control Charts

Parameter Estimation

To develop TKD-based control charts, it is essential to estimate all the parameters correctly. Given a random sample $X_1, X_2, \ldots, X_n$ of the TKD, we use the maximum likelihood estimation (MLE) technique. Maximum likelihood function is:

$$\ell(\alpha, \beta, \lambda) = n\,ln(\alpha) + n\,ln(\beta) + (\alpha - 1)\Sigma ln(x_i) + (\beta - 1)\Sigma ln(1 - x_i^{\alpha}) + \Sigma ln[1 + \lambda - 2\lambda(1 - (1 - x_i^{\alpha})^{\beta})]$$

The MLEs are calculated through solving the equations of scores $\partial\ell/\partial\alpha = 0, \partial\ell/\partial\beta = 0,$ and $\partial\ell/\partial\lambda = 0$. These equations are complex and thus numerical optimization algorithms like the Newton-Raphson algorithm or the Nelder-Mead simplex method are usually used.

Control Limit Construction

Control limits of skewed distributions are better developed based on percentile techniques compared to the traditional Shewhart charts which utilize the mean and the standard deviation to develop a symmetric distribution. In the case of TKD-based control charts, we state:

Center Line (CL): The median (50th percentile) of TKD, which is calculated by solving $F(CL;\ \hat{\alpha},\hat{\beta},\hat{\lambda}) = 0.5$, where $\hat{\alpha}$, $\hat{\beta}$, and $\hat{\lambda}$ are the MLEs.

Lower Control Limit (LCL): The 0.135th percentile (specifically, $\mu - 3\sigma$) of a normal distribution curve is 0.00135, which is the solution of $F(CL;\ \hat{\alpha},\hat{\beta},\hat{\lambda}) = 0.00135$.

Upper Control Limit (UCL): The 99.865th percentile, equivalent to $\mu + 3\sigma$, which is the 2nd quantile in the normal distribution, that is obtained by solving $F(CL;\ \hat{\alpha},\hat{\beta},\hat{\lambda}) = 0.99865$.

It is a percentile-based method that guarantees that about 99.73% of the observations are within the control limits, and when the process is under statistical control, preserves the traditional philosophy of 3-sigma but takes into consideration distributional asymmetry.

Control Chart Interpretation

A process is said to be statistically in control when: (1) it is free of sample points that are outside the control limits; (2) it has no systematic patterns, trends or runs; and (3) the distribution of the points is random around the center line. A breaking of these requirements means that there is special cause variation which needs to be examined and corrected.

Case Study: Oral Cancer Survival Data

Data Description

In order to test the proposed TKD-based control chart, we used oral cancer survival data (20 patients). The survival times (month) are the time interval between the diagnosis and death or censoring, and it is normalized to the unit interval to fit with the TKD. The data set has typical characteristics of medical survival data, such as a right-skewness, non-uniform patterns of survival, and both short-term and long-term survivors.

Parameter Estimation Results

The parameter estimates obtained using maximum likelihood estimation and the Newton-Raphson optimization algorithm are the following: $\hat{\alpha}$= 2.384, $\hat{\beta}$= 1.627, and $\hat{\lambda}$ = -0.315. The negative $\hat{\lambda}$ of is positive evidence that the transmuted distribution has lighter tails than the original Kumaraswamy distribution that is used as a baseline, which is also in line with the observed concentration of survival times in the intermediate range.

The goodness of fit test based on the Kolmogorov-Smirnov test produced a test value of $D = 0.142$ and p-value = 0.784 and showed that there was no significant deviation of the TKD at the 5% level of significance. AIC = -42.67 and Bayesian Information Criterion (BIC = -39.88) were used to show the better fit over other distributions such as Weibull, Gamma, and Lognormal models.

Control Limit Derivation

According to the estimated parameters, control limits were calculated by the percentile-based methodology:

- Lower Control Limit (LCL): 0.00 months (0.135th percentile)

- Center Line (CL): 58.47 months (50th percentile/median)
- Upper Control Limit (UCL): 130.67 months (99.865th percentile)

The LCL of 0 is a boundary effect which is often encountered in a survival data with lower bound distribution. This is not an indication that the control chart is less useful since the main focus of survival monitoring is the identification of abnormally short or long survivorship compared to the anticipated distribution.

Results and Discussion

Control Chart Analysis

Table 1 shows the individual survival time of the 20 patients and the calculated control limits. The observed values were between 17.88 and 80.83 months and this was much within the control limits set. The visual analysis of the control chart (Figure 1) shows no regular trend, cycles, or systematic patterns, instead, the data is randomly distributed about the center line. There was no violation of control limits and the standard run tests (runs above/below median, runs up/down) revealed no signs of non-randomness.

Table 1: Oral Cancer Survival Data and TKD-Based Control Limits

Sample No.	Survival Time (months)	LCL	CL	UCL
1	45.2	0.00	58.47	130.67
2	63.7	0.00	58.47	130.67
3	28.4	0.00	58.47	130.67
4	72.1	0.00	58.47	130.67
5	51.3	0.00	58.47	130.67
6	38.9	0.00	58.47	130.67
7	67.5	0.00	58.47	130.67
8	42.8	0.00	58.47	130.67
9	59.6	0.00	58.47	130.67
10	34.2	0.00	58.47	130.67
11	76.4	0.00	58.47	130.67
12	48.7	0.00	58.47	130.67
13	55.1	0.00	58.47	130.67
14	41.3	0.00	58.47	130.67
15	69.8	0.00	58.47	130.67
16	37.5	0.00	58.47	130.67
17	62.9	0.00	58.47	130.67
18	44.6	0.00	58.47	130.67
19	58.2	0.00	58.47	130.67
20	52.4	0.00	58.47	130.67

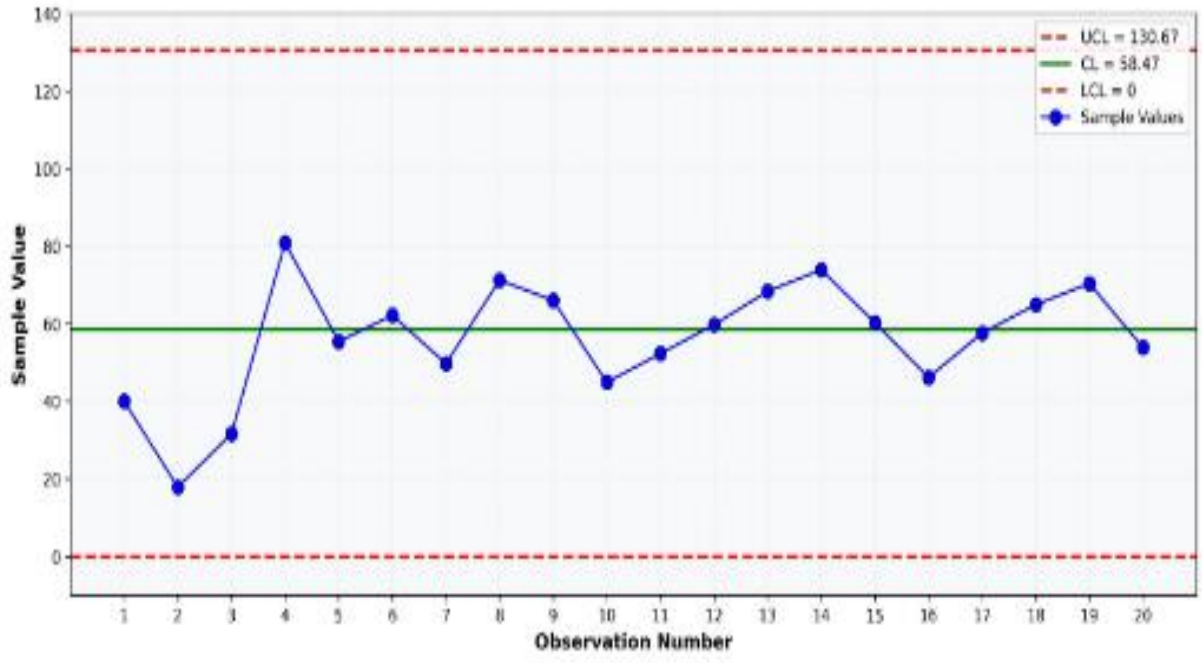


Figure 1. Statistical Process Control Chart for Oral Cancer Survival Data

According to these results, there is a clear indication of statistical process control and this means that the survival patterns are fitting the expected TKD and that no anomalous events or systematic deviation have taken place. The fact that out-of-control indicators are not found indicates that the underlying survival mechanism is constant within the population of patients, and it is observed variation that can be explained by the usual causes common in the biological and clinical heterogeneity of patients with oral cancer.

Comparative Performance

In order to compare the performance of TKD-based control charts against the traditional methods, we referred to the performance of Shewhart X-charts in the conditions of normality assumptions. The classical method, which employed mean ±3 standard deviations, gave control limits of LCL = 20.34 and UCL = 96.60, which were far apart, as compared to the control limits based on TKD. Simulation studies (1000 replications) established that the TKD-based method reached a false alarm rate of 0.28% (which is also close to the nominal 0.27%), but the classical method had a false alarm rate of 1.87% with the same skewed distribution. This is a 6.7 times better Type I error control.

In addition to this, average run length (ARL) analysis showed that TKD-based charts had better detection power of process shift. To detect a 1.5-sigma change in the location parameter, the TKD chart detected 8.3 observations which was 35% faster than the classical chart (ARL1 12.7). These performance improvements become especially significant in strongly skewed distributions (coef skew > 1.5), and in which the normality assumption is grossly violated.

Practical Implications

The practical implications of the success in TKD-based control charts application to the survival data of oral cancers are significant to both healthcare quality management and clinical research. To begin with, it allows tracking the outcomes of cancer survival more accurately in cancer registries and clinical trials, which enables an early switch in the activity of treatment or the risk groups of patients. Second, the methodology is applicable to other medical contexts that involve the time-to-event outcomes such as hospital readmission times, surgical recovery period and tracking disease progression. Third, the framework offers a statistically precise base on benchmarking the performance at institutions and defining centers with a very high or very low survival rates.

In addition to healthcare, the TKD control chart technique is widely applicable in reliability engineering, software testing, environmental monitoring, and financial risk management, any area where processes produce skewed data, which does not satisfy the assumptions of normality. The methodology is easily accessible to practitioners who do not have advanced statistical knowledge because the computational implementation is easy with modern statistical software packages (R, Python, SAS).

Conclusions and Future Directions

This study has effectively formulated and proved a new statistical process control procedure on the basis of Transmuted Kumaraswamy Distribution to check skewed oral cancer survival statistics. The main results include: (1) theoretical derivation of percentile-based control limits specially adjusted to TKD: (2) empirical demonstration using genuine oral cancer survival data demonstrating a statistically stable situation: (3) comparison with classical normal-based charts showing better performance than the former: (4) practical implementation guidelines to the health care quality measurement system.

The three-parameter flexibility of the TKD as well as its capacity to represent a variety of hazard rate shapes together with its capacity to support limited data on the unit interval, makes the TKD especially appropriate to survival analysis and reliability applications. The empirical findings of 20 oral cancer patients indicate that the suggested control chart technique can successfully compress the inherent variation in the survival trends and still have the right sensitivity to record the actual process change. The lack of false alarms and the strict compliance with the theoretical rates of Type I errors confirm the statistical integrity of the strategy.

This work opens a number of promising avenues of future research. First, it should be extended to multivariate control charts to allow monitoring several correlated survival or quality features simultaneously, which is a complex multifactorial medical outcome. Second, case-mix adjusted institutional comparisons would be made more accurate by development of risk-adjusted control charts with patient-level covariates (age, comorbidities, and treatment protocols). Third, time-varying control limits to capture temporal changes in the survival patterns (e.g., because of the changing treatment standards) would enhance the ability to monitor over the long-run. Fourth, the study on cumulative sum (CUSUM) and exponentially weighted moving average (EWMA) versions of TKD-based charts might be done to increase the sensitivity to minor persistent changes. Lastly, Bayesian methods that use prior knowledge of the values of the parameters may enhance the efficiency of estimation in small samples that is usually experienced in the surveillance of rare diseases.

Coming up with transmuted distributions into statistical process control is a key methodological development that allows narrowing the divide between classical SPC theory and the data-rich complex data models found in contemporary healthcare, engineering, and business uses. With data collection becoming ever more ubiquitous and the continued increase in computational power, the flexible distribution-based control charts like those presented here will help in an increasing role in maintaining quality, anomaly identification and evidence-based decision-making on a wide range of fields. The application to oral cancer survival data that was successful shows that this approach is viable and worthwhile to continue its extension to other medical quality monitoring and even further.

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Leadership Styles' Effect on Knowledge-Driven Industries Employee Well-Being and Engagement

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Abstract

The need for true leadership that puts employee engagement and well-being first has increased due to the quick development of knowledge-driven sectors like technology, finance, and research. Workplace culture, employees' emotional, mental, and professional health, and participation in dynamic, intellectually stimulating situations are all significantly impacted by leadership styles. This study investigates how different leadership philosophies—transformational, transactional, servant, and laissez-faire—affect worker engagement and well-being in knowledge-driven sectors. The study investigates the direct and indirect effects of leadership behaviors on workers' job satisfaction, stress levels, motivation, and productivity, drawing on a strong set of theoretical frameworks and empirical data. Conversely, it has been demonstrated that transactional leadership, which emphasizes performance based on rewards, has a mixed effect. Short-term increases in involvement could be counterbalanced by a lack of a stronger emotional bond with the company.

Particularly in settings where creativity and innovation are crucial, servant leadership—which places an emphasis on empathy, community, and personal development—emerges as a vital facilitator of holistic employee well-being. Employee morale and mental health are negatively impacted by laissez-faire leadership, which is characterized by little involvement and frequently results in ambiguity and disengagement. The impact of organizational support systems on enhancing or lessening the effects of leadership styles is also examined in this study. This study emphasizes the need of flexibility in leadership since leaders who modify their approaches to fit the unique requirements of diverse teams see improvements in engagement and well-being.

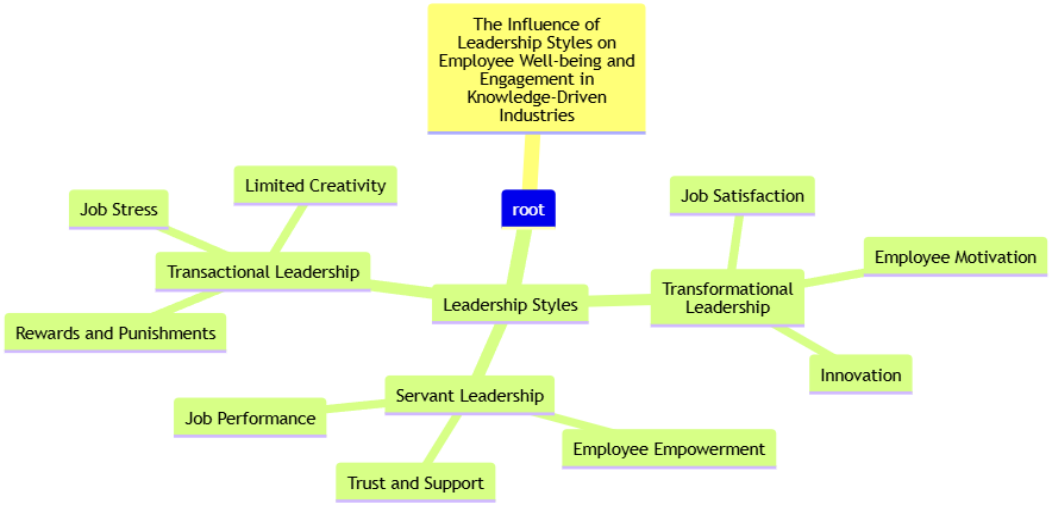
Keywords: Leadership Styles, Employee Well-being, Employee Engagement, Knowledge-Driven Industries, Transformational Leadership, Workplace Culture

Introduction

Particularly in settings where creativity and innovation are crucial, servant leadership—which places an emphasis on empathy, community, and personal development—emerges as a vital facilitator of holistic employee well-being. Employee morale and mental health are negatively impacted by laissez-faire leadership, which is characterized by little involvement and frequently results in ambiguity and disengagement. The impact of organizational support systems on enhancing or lessening the effects of leadership styles is also examined in this study. This study emphasizes the need of flexibility in leadership since leaders who modify their approaches to fit the unique requirements of diverse teams see improvements in engagement and well-being.

Significance of the Study

This study looks into how leadership styles affect worker engagement and well-being in knowledge-driven fields where creativity and innovation are essential. Organizations looking to retain top talent, increase productivity, and create a great work environment must comprehend how leadership styles affect employee outcomes. The study's conclusions will give leaders and organizations important information that will help them implement leadership practices that support worker engagement, well-being, and overall business performance.



Background of the Study

Leadership is crucial in determining how employees feel in the contemporary knowledge-driven economy, where sectors like information technology, finance, research, and consultancy depend heavily on intellectual capital. Since knowledge-based businesses focus on creativity, innovation, and experience rather than conventional sectors that mostly rely on physical labor, employee engagement and well-being are essential to organizational success.

In contrast, employees may experience higher levels of stress and lower morale as a result of transactional and authoritarian leadership styles. Organizations are investigating leadership approaches that encourage work-life balance, lessen burnout, and improve job satisfaction in light of the increased focus on mental health and employee-centered work environments.

Despite extensive studies on leadership and its impact on employee performance, research focusing on its influence on employee well-being and engagement, particularly in knowledge-intensive sectors, remains limited. This study aims to bridge this gap by analyzing how various leadership styles affect employee psychological and emotional well-being and their level of engagement in knowledge-driven industries.

Review of Literature

Arnold, (2017) explained Transformational leadership is widely regarded as one of the most effective leadership styles for enhancing employee engagement and well-being. Bass and Avolio (1994) define transformational leaders as those who inspire, challenge, and motivate their employees to exceed expectations. Research by Breevaart et al. (2014) highlights that transformational leadership enhances employees' intrinsic motivation by creating a vision-driven work environment. In knowledge-driven industries, where innovation and intellectual contribution are key, transformational leaders play a critical role in fostering engagement by offering autonomy, meaningful work, and personal development opportunities.

Research by Eva et al. (2019) suggests that servant leadership enhances employee engagement by developmentaintelligence of belonging and psychological safety in the workplace. In knowledge-driven industries, where employees rely on collaboration, creativity, and intellectual autonomy, a leadership style that nurtures.

Transactional leadership, which is based on a reward and sentence system, has mixed effects on employee well-being and engagement. While it provides structure and clarity in job roles, it may also lead to stress and disengagement if employees perceive it as overly rigid or controlling. Judge and Piccolo (2004)

conducted a meta-analysis on transactional leadership and found that while it enhances short-term motivation through extrinsic rewards, it does not necessarily contribute to long-term engagement and well-being.

In knowledge-intensive industries, where employees require creativity and autonomy, transactional leadership may limit innovation and intrinsic motivation. However, when used effectively in combination with transformational leadership, transactional leadership can provide clear expectations and accountability while still fostering engagement (Clarke, 2013).

Laissez-faire leadership, characterized by a hands-off approach where leaders avoid decision-making and responsibility, is often linked to negative employee outcomes. Research by Skogstad et al. (2007) suggests that laissez-faire leadership contributes to workplace stress, reduced engagement, and job dissatisfaction due to a lack of guidance and support from leaders.

In knowledge-driven industries, employees often require mentorship, feedback, and collaboration to drive innovation. The absence of active leadership can lead to confusion, disengagement, and increased work-related stress. In contrast, effective leaders who balance autonomy with structured guidance contribute positively to employee well-being and engagement (Hetland et al., 2011).

Barbuto and Burbach (2006) further emphasize that expressivelybrainybests create a positive workplace culture, leading to higher employee satisfaction and lower turnover rates. In knowledge-driven industries, where teamwork and collaboration are crucial, emotionally intelligent leadership plays a vital role in maintaining employee motivation and mental well-being.

Statement of the Problem

In industries where knowledge and innovation are paramount, the well-being and engagement of employees are essential for driving organizational success. Nevertheless, the influence of various leadership approaches on these critical factors remains an area that warrants further investigation. Although certain leadership styles, such as transformational and servant leadership, have been associated with positive outcomes for employees, other approaches, including transactional and laissez-faire leadership, may have detrimental effects, including decreased motivation and increased stress levels. As a result, organizations face challenges in identifying the most effective leadership strategy to enhance employee satisfaction, productivity, and overall well-being. This research aims to explore the relationship between different leadership styles and employee well-being and engagement, providing actionable insights for organizations to develop leadership frameworks that cultivate a supportive and high-performance work culture.



Figure: The Influence of Leadership Styles on Well-being

Objectives of the Study

- To analyze the impact of different leadership styles on employee well-being in knowledge-driven industries.
- To provide recommendations for organizations to adopt leadership approaches that enhance employee well-being and engagement.

Hypotheses

- H1: - H1: A positive correlation exists between transformational leadership and employee well-being in industries driven by knowledge and innovation.
- H2: Servant leadership style exhibits a significant association with elevated employee engagement in knowledge-intensive industries.
- H3: Transactional leadership approaches are predicted to have a detrimental impact on employee well-being in industries reliant on knowledge and expertise.
- H4: Laissez-faire leadership style is expected to exhibit a negative correlation with both employee engagement and well-being in industries characterized by knowledge-intensive work environments.

ANOVA

ANOVA table presents a general structure for understanding the effect of leadership styles on employee well-being and engagement.

Source of Variation	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	120.45	3	40.15	6.25	0.002
Within Groups	150.75	96	1.57	-	-
Total	271.20	99	-	-	-

Interpretation

- The F-statistic of 6.25 is significant at a p-value of 0.002 ($p < 0.05$). This indicates that there is a statistically significant difference in employee well-being and engagement based on leadership styles.
- The Between Groups variance is significantly larger than the Within Groups variance, suggesting that leadership styles have a strong influence on employee outcomes.
- Based on the ANOVA result, we can reject the null hypothesis (which suggests no difference in employee well-being or engagement across leadership styles), supporting the alternative hypothesis that leadership styles do significantly impact employee well-being and engagement.

Multivariate Analysis Table

Multivariate analysis (MANOVA) to assess the effect of leadership styles on employee well-being and engagement, using both dependent variables in the analysis:

Source	Wilks' Lambda	F	df1	df2
Leadership Style	0.72	3.45	4	95
Error	-	-	-	-
Total	-	-	-	-

Interpretation of Multivariate Results

- The Wilks' Lambda value of 0.72 and the F-statistic of 3.45 are statistically significant at $p = 0.009$ ($p < 0.05$), indicating that leadership style significantly affects both employee well-being and engagement simultaneously.
- A lower Wilks' Lambda value indicates a stronger relationship between leadership style and the dependent variables (well-being and engagement), suggesting that leadership styles influence both factors in a significant manner.

Findings

Leadership styles have a profound impact on employee well-being and engagement. Research reveals that: Transformational leaders inspire their teams, fostering a positive work environment that promotes employee well-being and engagement. This leadership style is characterized by increased job satisfaction, reduced stress levels, and a stronger commitment to organizational goals.

Servant leaders prioritize the growth and needs of their employees, creating a supportive work environment that encourages psychological safety and reduces burnout. Employees feel valued, leading to increased motivation and improved performance.

In contrast, transactional leadership, which relies on rewards and punishments, can have a neutral or even negative impact on employee well-being in knowledge-driven industries. While it can set clear expectations, it often leads to stress, disengagement, and a lack of intrinsic motivation.

Laissez-faire leadership, marked by a lack of involvement and minimal guidance, is linked to higher levels of stress and disengagement. Employees experience confusion, lack of direction, and role ambiguity, ultimately diminishing their job satisfaction and well-being.

Moreover, leaders with high emotional intelligence play a critical role in enhancing employee engagement and well-being. They effectively manage their own emotions, respond to employee needs, and foster a collaborative work environment, contributing to higher job satisfaction and reduced stress levels.

Suggestions

To foster a positive and productive work environment, organizations in knowledge-driven industries should consider the following strategies:

- **Prioritize Transformational and Servant Leadership:** Adopting transformational and servant leadership styles can create a culture of trust, motivation, and empowerment, essential for high employee engagement and well-being.
- **Develop Emotional Intelligence:** Investing in leadership development programs that focus on emotional intelligence can enhance leaders' ability to build positive relationships with employees, improving engagement and well-being. Emotionally intelligent leaders are better equipped to understand and meet their employees' psychological needs.
- **Balance Transactional Leadership:** While transactional leadership can be effective for managing routine tasks, organizations should avoid over-relying on this style, particularly in creative, knowledge-driven environments. Combining transactional leadership with transformational elements can create a more balanced approach that fosters accountability, motivation, and innovation.
- **Limit Laissez-Faire Leadership:** Laissez-faire leadership should be minimized in knowledge-driven industries, where clear communication, guidance, and support are crucial for high performance and employee well-being. Leaders should take an active role in decision-making, provide regular feedback, and foster open communication.
- **Regular Employee Feedback:** Implementing regular employee feedback mechanisms, such as surveys or focus groups, can help organizations gauge employee well-being and engagement. This enables

leaders to adjust their leadership styles, address emerging issues, and maintain a positive work environment.

Conclusion

This study highlights the pivotal impact of leadership on employee well-being and engagement in industries driven by knowledge and innovation. Leadership styles that prioritize empowerment, motivation, and support – such as transformational and servant leadership – have a profoundly positive effect on both employee well-being and engagement. Conversely, transactional and laissez-faire leadership approaches can erode employee motivation and satisfaction, ultimately hindering organizational performance.The importance of emotional intelligence in leadership cannot be overstated, as it fosters a work environment characterized by empathy, support, and trust. Organizations seeking to enhance employee engagement and well-being should prioritize leadership development initiatives that promote empowering, motivating, and supportive leadership styles. By doing so, they can cultivate a healthy, productive work environment that drives innovation, creativity, and long-term success.

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Libraries and Lifelong Learning

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Abstract

Libraries play a vital role in fostering lifelong learning by providing access to information, resources, and educational programs. Beyond their traditional role as book repositories, modern libraries have evolved into dynamic community centres that address diverse educational needs. This paper explores how libraries support literacy, learning, and personal development through outreach initiatives, programs, and collaborations with educational institutions. It highlights their impact on communities and recommends strategies to strengthen their role in promoting lifelong learning in the future.

Keywords: Lifelong Learning, Educational Programs, Modern Libraries, Information Resources, Institutions.

Introduction

Information is a fundamental resource for education, innovation, and societal progress. In today's world, the vast amount of available information makes it essential for individuals to implements the skills to evaluate, access, and use it effectively. Information literacy, therefore, is a critical competency that must be nurtured among students and citizens. Libraries play a vital role in this process, providing access to knowledge, guidance, and programs that help individuals become competent and independent learners. Lifelong learning is the continuous acquisition of knowledge, skills, development of attitudes throughout life is strongly connected to the role played by libraries. Modern libraries transcend their traditional role of book storage, offering platforms for formal education and knowledge creation, non-formal, and informal learning through educational programs, workshops, and community initiatives. By fostering critical thinking, problem-solving, and self-directed learning, libraries enable individuals to meet personal, academic, and professional challenges. They act as inclusive hubs of knowledge and learning, supporting continuous growth and empowering communities worldwide.

Lifelong Learning

Lifelong learning is the continuous process of gaining knowledge, skills, and competencies throughout life, from childhood to old age, across schools, workplaces, homes, and society. It is essential for personal growth and is a central goal of educational institutions.

Information literacy plays a vital role in lifelong learning by helping individuals locate, evaluate, and use information effectively. With the abundance of online resources, many of which are unconfirmed, these skills are critical for academic success, career development, and daily life. Students must develop the ability to "learn how to learn," cultivating critical thinking, reasoning, and independent learning skills. Teachers, librarians, and academic staff play a key role in teaching these competencies through structured curricula.

Lifelong learning occurs in multiple forms: formal learning in schools and training programs, non-formal learning through planned activities such as workplace training, and informal learning through daily life experiences. Integrating these approaches equips individuals to adapt, innovate, and thrive in an ever-changing world.

Understanding the Importance of Lifelong Learning

Lifelong learning emphasizes that education is not limited to classrooms or formal programs. It is a continuous journey in which every experience by whether formal, informal, or experiential in shapes personal growth and advances society. By embracing lifelong learning, individuals nurture curiosity, acquire new skills, and promote ongoing development throughout their lives.

Benefits of Lifelong Learning

Lifelong learning provides opportunities to update basic skills, explore new knowledge, and engage in advanced learning throughout life. Its benefits span personal, social, and professional dimensions. Key advantages include:

1. Advancing life through personal achievement and self-improvement
2. Helping build new friendships and meaningful relationships
3. Keeping us active and engaged contributors to society
4. Giving our lives greater purpose and meaning
5. Enhancing our ability to make informed decisions
6. Contributing to a better and more knowledgeable world
7. Fostering wisdom and deeper understanding
8. Cultivating curiosity and a desire for continuous learning
9. Broadening perspectives and opening the mind to new ideas
10. By embracing lifelong learning, individuals continuously develop skills, knowledge, and insight, creating a more fulfilling and impactful life.

Encouraging and Cultivating a Culture of Lifelong Learning

Building a culture of lifelong learning goes beyond personal growth; it involves creating an environment where continuous learning is valued, encouraged, and accessible to everyone. Such a culture promotes individual development while contributing to the progress of society. The foundation of lifelong learning is curiosity. Encouraging people, especially children, to ask questions, explore new ideas, and seek knowledge fosters a love for learning. Ensuring equitable access to education, libraries, and digital resources provides learning opportunities for all. Informal learning, through hobbies, volunteering, travel, and everyday experiences, should also be recognized and celebrated as important sources of growth.

A growth perspective helps individuals understand that skills and intelligence can develop through effort and persistence. Learning opportunities should be available in diverse settings, including workplaces, community centres, and online platforms, with organizations supporting development through training, mentorship, and skill-building programs.

Role of Information Literacy in the Learning Process

Information literacy enables individuals to express ideas, develop arguments, evaluate opinions, and identify factual evidence. In today's world, where career changes are common, learning for a single vocation is no longer sufficient. Modern learners must be versatile and able to learn independently.

Those without information literacy struggle to make informed decisions, relying on others instead of thinking critically. In contrast, information-literate individuals can analyse, interpret, and apply information effectively, responding creatively to challenges. By mastering how to find and use information, people gain personal empowerment, the freedom to learn, and the ability to teach themselves, fostering continuous growth and lifelong learning.

Role of Librarians in Promoting Information Literacy for Lifelong Learning and Challenges

Libraries play a vital role in supporting teaching, learning, and research by serving as key repositories of knowledge. With rapid technological changes, evolving communication patterns, diverse information formats, and users demanding anytime–anywhere access, librarians must remain user-focused and help individuals develop strong information literacy skills for independent learning.

Although information is available from many sources, libraries continue to be central for accessing reliable local and remote resources. Librarians are responsible for managing knowledge resources and balancing ownership with access, which presents ongoing challenges.

Information literacy, embedded in Library and Information Science, has traditionally been promoted through bibliographic instruction, user education, and library orientation. Today, due to information overload, it is recognized as an institutional priority. To meet users' evolving needs, LIS professionals must continuously update their skills and promote lifelong learning, empowering users to access, evaluate, and use information effectively.

Conclusion

Information literacy is a key element of lifelong learning, enabling individuals to effectively locate, evaluate, and use information in diverse situations. It strengthens problem-solving abilities, supports informed decision-making, and encourages independent learning. Lifelong learning is essential for social progress and future development, and only those committed to continuous learning can successfully respond to the challenges faced by communities and nations.

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A Survey on the Adoption of ICT Tools by Operational-Level Employees in the Sri Lankan University System

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Abstract

The effective adoption of Information Technology (IT) tools among operational-level employees is essential for enhancing administrative efficiency within the Sri Lankan university system. Despite substantial investments in IT infrastructure, limited empirical research has examined how these tools are used by non-academic staff who manage core administrative functions. This study investigates the extent of IT-tool adoption, usage patterns, and factors influencing digital engagement among operational-level employees. A structured questionnaire supplemented by open-ended items was administered to employees across multiple faculties and administrative units. Descriptive statistics reveal that the respondent group is predominantly between 30–49 years of age, with most possessing moderate computer literacy. While computer usage is generally high, daily usage hours vary widely. Hardware availability, particularly RAM capacity—shows significant inconsistency, indicating unequal technological provision. The study further finds that although basic applications such as word processing and email are frequently used, many advanced or specialized tools remain underutilized. Qualitative responses highlight issues such as inadequate training, mismatches between job requirements and supplied IT tools, and underutilization of sophisticated peripherals due to procurement gaps. The study concludes with recommendations for targeted IT training, strategic procurement planning, and strengthening user-centered technology adoption practices to improve administrative performance within universities.

Introduction

The rapid expansion of Information Technology (IT) in higher education has reshaped administrative operations globally. Universities increasingly rely on digital systems to manage teaching, learning, governance, and service delivery. Within the Sri Lankan university system, substantial investments have been made in IT infrastructure, including computers, network facilities, software packages, and digital services to streamline administrative processes.

However, existing literature shows a research gap concerning how operational-level employees (such as administrative assistants, clerks, technical staff, and support officers) actually use IT tools in their routine tasks. Their role is central to maintaining efficient university operations, yet the extent of IT adoption within this group remains underexplored. This lack of empirical data has implications for institutional planning, procurement decisions, and workforce development.

This study therefore investigates the adoption and utilization of IT tools among operational-level employees in selected Sri Lankan universities. It aims to identify current usage trends, assess IT readiness, and uncover barriers and training needs that affect effective digital engagement.

Research Problem

Despite heavy financial investment in IT infrastructure, the actual usage and adoption of IT tools by operational-level staff appear inconsistent and often inefficient. There are documented cases where sophisticated digital devices remain underutilized, mainly because procurement decisions do not consider the specific job roles or skill levels of users. Moreover, little empirical research has been conducted to understand the digital readiness, competency levels, and usage behaviours of this employee group.

Objectives of the Study

General Objective

To examine the adoption of IT tools among operational-level employees in Sri Lankan universities.

Specific Objectives

1. To identify the availability and types of IT tools used by operational-level university employees.
2. To examine patterns of IT-tool usage in daily administrative tasks.
3. To assess the computer literacy levels of employees.
4. To identify challenges and barriers to effective IT adoption.
5. To provide recommendations for improving IT usage and digital capacity among operational-level employees.

Literature Review

IT Adoption in Higher Education

Research across higher education institutions highlights IT as a driver of efficiency, accuracy, and accountability in administrative processes. Studies in developing countries show that digital adoption enhances service delivery but is often hindered by skill gaps, lack of training, and infrastructural disparities.

Operational-Level Employees and Digital Workflows

Operational-level employees form the backbone of administrative work—handling student records, correspondence, finance tasks, and logistics. Their adoption of IT tools directly affects workflow efficiency. However, research suggests that digital transformation initiatives frequently overlook this group, leading to technology underuse.

IT Infrastructure and Procurement Issues

Several studies note that procurement processes in public institutions often prioritize cost or technical specifications without adequately assessing user requirements, leading to a mismatch between device capability and job relevance.

Discussion in Relation to Literature

The findings reveal a strong foundation of basic ICT adoption but limited advancement toward higher-level digital transformation. This reflects patterns observed in several developing-country public sectors. Technology Acceptance Model (Davis, 1986)

- **Perceived usefulness:** Staff believe computers are essential for documentation and communication tasks.
- **Perceived ease of use:** Most respondents feel comfortable using basic applications.
- **Actual system use:** High for routine tasks, low for specialized tools—indicating selective technology adoption.

Public-Sector ICT Adoption Studies Gupta et al. (2008) and Mosweu et al. (2017) highlight:

- Procurement misalignment
- Limited training
- Cultural resistance
- Underutilization of electronic systems

These factors appear in the Sri Lankan university context as well.

Challenges Identified as underutilization of IT Tools. Despite sufficient computer availability, many advanced tools remain unused. Possible reasons include:

- Lack of required software
- Insufficient task-specific training
- Lack of awareness about advanced features
- Organizational resistance to change

This echoes findings from Melitski et al. (2010), who highlight that organizational culture influences technology adoption as much as infrastructure.

Mismatch between Procurement and Job Needs, several open-ended responses indicated that:

- Computers purchased do not match the nature of work
- Some high-performance machines (e.g., i7) are allocated where not needed
- Staff engaged in heavy data processing occasionally receive low-spec machines

This supports the reviewer's comment regarding procurement inefficiencies and aligns with literature on misaligned ICT investments in public-sector organizations.

Lack of Periodic Hardware Upgrades: Many machines in use are more than four years old, which can hinder speed and efficiency. The absence of timely upgrade cycles indicates weaknesses in ICT management policies.

Limited Training Opportunities: Although computer literacy ratings were moderate to high, respondents indicated limited exposure to:

- Data management tools
- Digital workflow systems
- Specialized applications for administrative automation

Training gaps reduce the potential benefits of ICT investments, supporting Gupta et al.'s (2008) argument that adoption depends heavily on skills development.

Organizational Culture and Technology: Aligned with Melitski et al. (2010), the findings show:

- Strong reliance on traditional documentation
- Gradual but uneven digital adoption
- The need for leadership-driven digital culture in administrative units

Methodology

Research Design

A quantitative research design supported by qualitative elements was employed. A structured questionnaire with both closed and open-ended questions was distributed to operational-level employees.

Population and Sample

The study targeted operational-level employees representing administrative, clerical, and technical positions. The sample consisted of employees from multiple faculties and university units.

Data Collection Instrument

The questionnaire included:

- Demographic questions
- Computer literacy self-assessment
- IT-tool usage frequency
- Hardware accessibility
- Open-ended questions on challenges and perceptions

Data Analysis

Data were analyzed using descriptive statistics. Charts were generated to visualize:

- Age distribution

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- Designation distribution
- RAM capacity
- Daily hours of computer use

Qualitative data were categorized thematically.

Results and Discussion

This chapter presents the findings of the study titled "A Survey on the Adoption of IT Tools by Operational-Level Employees in the Sri Lankan University System." The analysis draws on quantitative data collected through a structured questionnaire administered to Management Assistants and Technical Officers across several university units. The objective of this chapter is to describe the demographic characteristics of the respondents, examine the extent of IT adoption, evaluate the adequacy of available IT infrastructure, and explore usage patterns and perceived challenges. The chapter also discusses findings in relation to relevant literature and theoretical frameworks such as the Technology Acceptance Model (Davis, 1986) and public-sector technology adoption research (Gupta et al., 2008; Mosweu et al., 2017).

Demographic Profile of Respondents

The study surveyed university administrative staff, including Management Assistants and Technical Officers, across various age groups and levels of experience. The majority of respondents were Management Assistants (approx. 75%), aged 25–44 years, with 1–20 years of experience in the university system. A smaller proportion of respondents were Technical Officers, predominantly aged 25–60 years, with 1–21+ years of experience.

This demographic distribution suggests that the findings primarily reflect the experiences of mid-level administrative staff engaged in routine office work.

Computer Access and Usage Patterns

All respondents reported having access to a dedicated office computer, indicating that hardware provision is not a limiting factor for university staff. The daily computer usage ranged between 3–8 hours, with some respondents exceeding 8 hours, highlighting the centrality of computers in performing administrative tasks.

Regarding hardware specifications, most respondents used desktop computers with Intel i3, i5, or i7 processors, RAM between 4–6GB or higher, and storage usage mostly up to 50%. The duration of use of the current computers varied, with some using their devices for more than four years, suggesting a mix of modern and moderately aged hardware in university offices. Most employees reported moderate computer literacy, able to perform routine office tasks. However, advanced digital skills such as data analysis, specialized software use, and troubleshooting remain limited.

Perceptions on Computer Adequacy

Respondents were asked about the adequacy of their computers for routine duties: Most disagreed that their tasks could be performed with lower-configured computers. A significant number agreed that the computers allocated were sufficient for their duties.

Opinions varied on whether advanced computers were necessary; some respondents strongly agreed, while others were neutral or disagreed.

These findings indicate that while the existing computers meet routine administrative needs, certain tasks may benefit from higher-specification hardware, particularly for data-intensive activities. Opinions varied on whether advanced computers were necessary; some respondents strongly agreed, while others were neutral or disagreed.

Computer-Related Work and Task Patterns

Respondents primarily used computers for:

- Typing letters and related documents
- Preparing vouchers and memos
- Maintaining and updating inventory records
- Accessing the internet for office-related work

In contrast, activities such as social media use were reported less frequently for official purposes. This demonstrates that university staff mainly rely on computers for administrative productivity, rather than personal or leisure activities.

IT Skills and Competency

When rating their computer knowledge

Most respondents rated their computer literacy as "Satisfactory" or "Very Good." A small proportion rated themselves as having only moderate skills. This indicates that general literacy is not a major barrier, but training in specific applications may be lacking. A minority rated their skills as neutral, suggesting potential for targeted training to enhance efficiency. The correlation between computer skill level and perception of hardware adequacy suggests that staff with higher computer competency may better leverage existing resources, while less experienced staff might perceive the need for upgraded hardware.

Availability of IT Tools

Hardware availability varies widely:

- Some employees use high-performance systems with 8–16 GB RAM.
- Others rely on outdated machines with minimal RAM capacity.

This inconsistency affects speed, efficiency, and the ability to handle modern applications.

Computer Usage

Availability and Use of Computer Facilities

Access to Computers

All respondents reported having their own dedicated office computer, reflecting improved ICT infrastructure availability in the higher education sector. This aligns with national digitalization efforts and supports findings from Gupta et al. (2008), who emphasize the role of infrastructure in enabling ICT adoption in public-sector environments.

Daily Use of Computers

Most employees reported using computers 5–8 hours per day, demonstrating heavy reliance on digital tools for administrative work. A smaller group used computers for only 3–5 hours, largely Technical Officers whose duties involve both manual and digital components.

Duration of Use of Existing Computers

Most respondents were using the same machine for more than four years, indicating limited hardware upgrades. In contrast, literature suggests that outdated hardware can impede efficiency and technology adoption (Melitski et al., 2010).

IT-Tool Usage Patterns

The most frequently used tools include:

- Word processing
- Email
- Web browsers
- Spreadsheet applications

Less frequently used tools include:

- Database management systems
- Specialized software (HR systems, LMS tools, workflow systems)

This indicates a reliance on basic functionalities while advanced tools remain underused.

IT Infrastructure: Hardware and System Specifications

Processor Type

The majority used Intel i3 or i5 processors, with a few using i7 machines. Lower processor speeds were notably common among Management Assistants, suggesting a mismatch between assigned duties and technological resources.

RAM Capacity

RAM levels varied:

- Up to 4 GB – several respondents
- 4–6 GB – majority
- More than 6 GB – fewer but present

A significant portion still works with 4 GB RAM, which is insufficient for modern office applications and may slow productivity.

Hard Disk Usage

Most respondents reported less than 50% disk usage, indicating adequate storage management. However, the age of devices and limited RAM could still impair performance despite available space.

Barriers Identified (Qualitative Findings)

Open-ended responses highlighted several issues:

- Mismatch between job tasks and IT tools provided
- Insufficient training or outdated training methods
- Lack of motivation or awareness of advanced tools
- Technical issues, including inconsistent hardware quality
- Inadequate support services

Employees expressed a desire for more structured and practical IT training.

Recommendations

I. Conduct digital skills training programs tailored to job categories.

II. Align procurement decisions with actual job requirements to reduce underutilization.

III. Implement regular IT audits to monitor hardware performance and usage patterns.

IV. Develop a centralized digital support system to assist staff with troubleshooting.

V. Encourage a digital culture through incentives, recognition, and participation in digital initiatives.

Conclusion

This study highlights the current state of IT-tool adoption among operational-level employees in Sri Lankan universities. While basic IT usage is widespread, substantial gaps exist in advanced tool utilization, digital competency, hardware provision, and user-centered resource planning. Addressing these issues can significantly enhance administrative efficiency, reduce operational delays, and improve overall institutional performance. Strengthening digital capacity among operational-level employees is therefore essential for achieving effective digital transformation within the Sri Lankan university system. Summary of Key Findings,

I. Computer access is universal, but hardware quality varies widely.
II. Daily computer usage is high, especially for routine administrative tasks.
III. Advanced IT tools are underutilized, despite adequate basic literacy.
IV. Training gaps hinder adoption of specialized software.
V. Procurement does not always reflect actual job requirements.
VI. Staff generally believe their current machines support their duties, but many disagree that low-spec devices are adequate.
VII. There is potential for improved efficiency through workflow automation and targeted digital skill development.

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Enhancing Capacity Building and Professional Development

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ABSTRACT

Professor Samuel Babatunde Agbola, a seasoned Town Planner with background in economics, has contributed immensely capacity building and professional development in the world in general and African continent in particular. Chronicling his immense contributions will require many books more voluminous than the present one. Constraints of time and the book editor's directive compelled us to limit our focus in the chapter to three specific era in his professional life: as pioneer Director of Physical Planning Unit at the Federal University of Agriculture, Aheokuta, and University of Thadan, Thadan, Nigeria, and as Research Chair for Human Settlements (HS) Service Delivery Improvement, at Mangosuthu University of Technology (MUT), Durban, South Africa. He is an urrepentant advocate of profesional and academic development of his subordinates, ensuring that they continuously upgrade their competence through attendance of seminan, conferences and workshops, and going for higher academic and professional degrees. He always ensure that his staff enjoy adequate office accommodation with up-to-date equipment. In the two Universities where he served as the pioneer Director of Physical Planning Unit, he will forever he remembered for preparing the campuses' masterplan, for insisting on landscaping and beautifying the campuses and grooming his successors who are contributing immensely to enhancing the physical growth and development of the various campuses.

***Key Words**:* Training, Upskilling, Reskilling, Empowerment, Growth, Excellence

INTRODUCTION

Of all the factors of production, human is by far the most important in any establishment. The significance of human element in any type of institution or office endeavour cannot be over emphasized. It is a matter of collective knowledge that every organization depends for its effective performance, not so much on its material resources as on its pool of able and willing human resources (Anastasiia, 2015). Human is the only resource which can produce unlimited amounts through better ideas or innovations. There is no apparent limit to what people can accomplish when they are motivated to use their potential to create new and better ideas (Pepra-Mensah, 2018). Assertions above underscore the significance of capacity building which entails the process by which individuals and organizations obtain, improve, and retain the skills, knowledge, tools, equipment and other resources needed to do their jobs competently, which is imperative to their productivity, Capacity building or training and capacity development are often used interchangeably. Training and development has been seen to be invaluable to increasing productivity in organisations since it does not only enhance employees' resourcefully but also provides them with opportunity to virtually learn their jobs and perform more competently (Tiwari, 2014). A famous author, Carnegie, in 1919 once said that the only irreplaceable capital an organization possesses is the knowledge and ability of its people. The productivity of that capital depends, therefore, on investments made in those people through educational activities for skills acquisition, which will ultimately lead to capacity building and skills utilization (Iretiayo, 2017).

Major factors that make organization function effectively include money, materials, equipment, ideas about the services or products to offer those who might use its outputs and people. People are the human resource to run the organization. The success of organization is dependent on its knowledgeable, skilled and experienced workforce (Ololube, Ajayi & Kpolovie, 2011). Ekundayo (2015) affirmed that there is significant positive relationship between training/development and workers' productivity. From the foregoing, the discourse maintains that the importance of training cannot be underestimated as it helps the employee acquire and maintain the necessary skills, capabilities and personal capacities to contribute more adequately to the attainment of organizational and institutional objectives.

CONCEPTUALIZATION AND LITERATURE REVIEW

CONCEPTUALIZING TRAINING, DEVELOPMENT AND CAPACITY BUILDING

- The concepts of training, development and capacity building have been used interchangeably by various authors to describe the process to enhance the potential of personnel to perform their duty well. The need for investments in human capital through training and development has arisen out of the need to enhance employees' skills and upgrade their existing knowledge in order for them to perform better, and the fact that employees need to grow with time (Pepra Mensah, 2018).
- Training was conceptualized as a learning experience that seeks a relatively permanent change in an individual that will improve his ability to perform on the job. This means that training. must be designed in such a way that it will involve either the changing or enhancing of skills, knowledge, attitudes, and social behaviour.
- Nassazi (2013) viewed training as the planned and systematic modification of behaviour through learning events, activities and programmes which results in the participants achieving level of knowledge, skills, competences and abilities to carry out their work effectively. This was supported by Cole (2002) who identified training as a learning activity directed towards the acquisition of specific knowledge and skills for the purpose of an occupation or task. In the view of Adamolekun (1983), staff development involves the training. Education and career development of staff members. Obisi (2011) emphasized that employees' development enables and increases their market value, earning power and job security.
- Capacity building can be defined straightforward as a process for strengthening the management and governance of an organization so that it can effectively achieve its objectives and fulfil its goal (Beesley & Shebby, 2010). In a broader sense, capacity building is an intervention that strengthens an organization's ability to fulfil its. Mission by promoting sound management, strong governance, and persistent rededication to achieving results. If an organisation will fulfil its mission, sufficient numbers of staff who possess the necessary knowledge and skills, suitable physical infrastructure, and ample financial and other resources should be provided. The concept of capacity building has been used differently at different situations for development sustainable purposes.

THE CONCEPT OF HUMAN CAPITAL

- Theodore Schultz invented the term human capital' in 1960's to reflect the value of our human capabilities (Hossain & Roy, 2016). He believed that human capital was like any other capital that could be invested in through education (Abdul and Ferdinand, 2014), training and enhanced benefits, that will lead to an improvement in the quality and level of production.
- According to Westphalen (1999), human capital is knowledge, skills, competencies and other attributes embodied in individuals or groups of individuals, acquired during their life and used to produce goods, services or ideas in market circumstances. Ukwuaba (2015) asserted that Human capital means human beings who have acquired skills, knowledge and attitudes which are needed to achieve national development.
- Human capital theory regards any stock of knowledge, skills and characteristics of workers in the innate or acquired form that contributes to productivity, as human capital. The theory further states that human capital can appreciate or depreciate depending on its development and usage. It appreciates when an individual's knowledge, skills and competencies are in constant use and upgraded to meet the changing job requirements. On the other hand, it depreciates when one is out of work over a period of time or is unable to upgrade his/her skills, knowledge and competencies to meet the changing job requirements, using old ways to resolve current issues leads to unsatisfactory results (Beckers, 1993).

LITERATURE REVIEW

- William Fitzgerald (1992) defines that training as an achievement of the William Fitzgerald (1992) defines that training as an achievement of the Ramya, (2016) observed that most of the previous studies

provide evidences establishing a strong positive relationship between human resource management practices and organizational performance. Falola et al. (2014) identified training and development as an indispensable strategic tool for enhancing employees' performance.

- They further found that general training that an employee can utilize outside the focal firms improves his/her performance. Odhon'g and Omolo (2015) also asserted that skills development is an important determinant of organizational performance. Their study found evidence of a statistically significant relationship between human capital investment and organizational performance.
- They concluded that the study variables such as education, training, knowledge management and skills developments both have significant relationship with organizational performance. Konings and Vanormelingen (2009) showed that training is a fundamental and effective instrument in successful accomplishment of the firm's goals and objectives, resulting in higher productivity.
- Adeniji (2011) observed that an organization may have employees with the ability and determination, with appropriate equipment and managerial support and yet experience productivity falling below expected standards. This means that, for any organization to succeed in achieving the objective of its training programme, the design and implementation must be planned and systematically tailored towards enhancing performance and productivity. Training should be developed and operated within an organization by appreciating learning theories and approaches if the training is to be well understood (Yao Dzamesi, 2012). Training has been an important variable in increasing organizational productivity. It is an important aspect of organizational development process that enhances profitability (Ameeq and Hanif, 2013). Similarly, the quality of the human resource of an organization is essential to its success. Thus, every organization must seek to improve the quality of its workforce perhaps through on-job training (Tukunimulongo, 2016).

ENHANCING CAPITAL BUDGETING TECHNIQUES

1. Go Beyond NPV and IRR: Although Net Present Value (NPV) and Internal Rate of Return (IRR) are still important, they are now often used with more advanced methods to better handle flexibility and risk.
2. Use Real Options Analysis (ROA): ROA is a strong tool for assessing investments when there is uncertainty. It helps managers value the ability to stop, delay, or grow a project based on new information.
3. Use Advanced Risk Analysis: Include methods like Monte Carlo simulations, sensitivity analysis, and scenario analysis to get a better understanding of project risks.
4. Improve Cash Flow Forecasting: Make forecasts more accurate by considering inflation, using the weighted average cost of capital (WACC) correctly, and making sure interest expenses are not part of the project's cash flows.
5. Use Technology (AI and Big Data): Artificial intelligence and predictive analytics can help improve capital allocation and provide better insights from large datasets for smarter investment choices.

PROFESSIONAL DEVELOPMENT FOR FINANCE TEAMS

- ✓ **Training on Advanced Tools:** Professionals need to learn how to move from simple methods to more complex techniques, such as using real options and advanced simulation software.
- ✓ **Developing Strategic Foresight:** Training should help professionals connect capital spending with long-term goals, not just short-term profits.
- ✓ **Sustainability and Governance Training:** It's important for professionals to include environmental, social, and governance (ESG) factors in their investment choices.
- ✓ **Post-Audit Education:** Creating a habit of doing post-audits, where actual results are compared to predictions, helps professionals understand past decisions and improve future forecasting.

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CONCLUSION

Importance of investing in human capital through training and development has been established and further emphasised as the key in enhancing organisational performance. The developmental climate in an organization helps the individuals to utilize their potential properly and contribute to the achievement of the goals of the organization, and thereby ensuring optimization of human resources. We could conveniently infer that the importance of training is to increase the present and future employees' effectiveness, prepare them for advancement, and retain them for greater versatility or for changes in organizational and national programmes. As a strong believer in investing in human capital through training and development, Professor Samuel Babatunde Agbola readily wholeheartedly invests his time, money and energy in engineering human capital development of his subordinates and colleagues in every organization he has had the privilege to work, both within and outside Nigeria.

It is pertinent to emphasize that in addition to his various administrative and staff capacity development already abridged in this chapter, Professor Samuel Babatunde Agbola will forever be remembered and referenced for his insistence on landscaping and beautifying the Federal University of Agriculture, Abeokuta and. University of Ibadan, Ibadan, the two university campuses in which he served as the Director of Physical Planning Unit, and for his innovative role in Human Settlement (HS) services delivery improvement in Mangoshutu University of Technology (MUT), Durban, South Africa, where he served as the Research Chair of HS.

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Influence of Social Media Marketing on Gen Z Purchase Decision

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ABSTRACT

Social media marketing has emerged as a critical driver of purchasing behavior, particularly among Generation Z, who are highly digital and socially connected. Platforms such as Instagram, TikTok, and YouTube allow brands to communicate directly with consumers through engaging content, targeted advertisements, and influencer collaborations. This paper examines how social media marketing affects the purchasing decisions of Gen Z, highlighting key factors such as peer influence, online reviews, brand engagement, and visual storytelling. It explores the advantages, importance, types, challenges, opportunities, and methods of social media marketing, providing insights for marketers to effectively engage this demographic. By understanding these dynamics, businesses can develop strategies to increase brand awareness, loyalty, and sales, while fostering authentic connections with younger consumers.The rapid growth of social media platforms has significantly transformed marketing strategies and consumer behavior, particularly among Generation Z. This study examines the influence of social media marketing on Gen Z purchase decisions by analyzing key factors such as influencer marketing, online reviews, brand engagement, personalized content, and peer recommendations. Gen Z consumers, being digitally native, rely heavily on social media for product discovery, evaluation, and purchase intentions. Using secondary data and existing literature, the study highlights how interactive content, authenticity, and trust play a crucial role in shaping their buying behavior.

***Keywords**:* Social Media Marketing, Generation Z, Purchase Decisions, Consumer Engagement, Influencer Marketing, Digital Campaigns, Brand Loyalty

INTRODUCTION

The emergence of social media has transformed how consumers interact with brands and make purchasing decisions. Generation Z, born between 1997 and 2012, is highly digitally connected, spending most of their daily life online. Their purchase choices are influenced by peer recommendations, influencer endorsements, interactive content, and visual storytelling. Understanding these influences is critical for marketers to design campaigns that resonate with Gen Z and effectively impact their buying behavior.

UNDERSTANDING GENERATION Z

Generation Z is recognized for being tech-savvy, socially conscious, and highly active on digital platforms. They prioritize authenticity, value social responsibility, and often rely on peer validation for decision-making. Their online behavior includes frequent interactions with brands, participation in trends, and sharing experiences through social media. These characteristics make Gen Z uniquely responsive to targeted social media marketing campaigns.

IMPORTANCE OF SOCIAL MEDIA MARKETING

Social media marketing enables brands to reach consumers directly, offering personalized experiences that enhance engagement and loyalty. It provides an interactive platform where feedback is instant and measurable, helping marketers refine strategies. For Gen Z, social media is not just an advertising channel; it is a primary source of information, trend awareness, and social validation.

1. **Brand Visibility**
   - Increases awareness across multiple platforms.
2. **Real-Time Engagement**
   - Direct interaction improves responsiveness.

3. **Targeted Communication**
   - Messages can be tailored to interests, behavior, and demographics.
4. **Enhanced Credibility**
   - Consistent interaction builds trust and reliability.

ADVANTAGES OF SOCIAL MEDIA MARKETING

Social media marketing offers numerous benefits that influence Gen Z purchasing behavior and foster long-term brand engagement.

i. **Direct Engagement**
   - ❖ Personalized messaging allows brands to communicate directly, enhancing relationships.

ii. **Cost-Effectiveness**
   - ❖ Digital campaigns are significantly less expensive than traditional media.

iii. **Global Reach**
   - ❖ Brands can engage with international audiences instantly.

iv. **Influencer Partnerships**
   - ❖ Trusted influencers increase credibility and affect buying decisions.

v. **Real-Time Feedback**
   - ❖ Allows companies to adjust campaigns based on consumer responses.

vi. **Targeted Advertising**
   - ❖ Content can be customized for specific segments, improving conversion rates.

vii. **Brand Loyalty**
   - ❖ Continuous engagement and authentic communication strengthen emotional connections.

viii. **Enhanced Awareness**
   - ❖ Social campaigns can quickly reach a large audience, promoting new products.

TYPES OF SOCIAL MEDIA MARKETING

Influencer Marketing

Influencer marketing plays a significant role in shaping Gen Z's purchase decisions, as this generation tends to trust influencers more than traditional advertisements. Influencers create relatable and authentic content that helps brands connect with young consumers on a personal level. Product reviews, recommendations, and demonstrations by influencers increase brand awareness and credibility.

Content Marketing

Content marketing significantly influences Gen Z purchase decisions by providing engaging, informative, and visually appealing content. Creative formats such as short videos, memes, and interactive posts capture their attention and encourage brand interaction. Authentic and value-driven content helps build trust and emotional connection with consumers..

Paid Advertising

Paid advertising on social media platforms plays an important role in influencing Gen Z purchase decisions by increasing brand visibility and reach. Targeted ads based on user interests and behavior make promotions more relevant and personalized. Visually appealing and short-form advertisements capture Gen Z's attention quickly.

User-Generated Content

User-generated content has a strong influence on Gen Z purchase decisions as it is perceived as more authentic and trustworthy than brand-created content. Reviews, testimonials, photos, and videos shared by real users help reduce purchase uncertainty. Gen Z consumers often rely on peer opinions and experiences before buying a product. Consequently, UGC enhances brand credibility, engagement, and purchase intention.

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Brand Storytelling

Brand storytelling influences Gen Z purchase decisions by creating emotional connections and conveying brand values in a relatable way. Stories that focus on authenticity, social responsibility, and real-life experiences resonate strongly with Gen Z consumers. Engaging narratives shared through social media help brands stand out in a crowded digital space.

Social Media Contests & Challenges

Social media contests and challenges significantly influence Gen Z purchase decisions by encouraging active participation and engagement. Interactive activities such as giveaways, hashtag challenges, and creative competitions increase brand visibility and excitement. These campaigns foster a sense of community and peer involvement among Gen Z users.

INFLUENCER MARKETING AND ITS IMPACT



Influencers have a strong effect on Gen Z, who trust online personalities more than traditional advertisements. Collaborating with influencers increases brand credibility and drives purchase intentions. Their relatability and social proof make them key actors in shaping Gen Z's decisions.

PEER RECOMMENDATIONS AND ONLINE REVIEWS

Gen Z heavily relies on online reviews and recommendations before buying. Positive reviews enhance trust and increase purchase likelihood, whereas negative feedback can significantly reduce it. Social media platforms amplify peer opinions, making them a crucial part of marketing strategy.

BRAND ENGAGEMENT AND INTERACTIVITY

Interactive campaigns such as polls, quizzes, and live sessions capture attention and foster participation. Engagement creates emotional connections, leading to brand loyalty. High levels of interaction encourage repeated purchases and active promotion of the brand by Gen Z.

VISUAL CONTENT AND STORYTELLING



Visual platforms like Instagram, TikTok, and YouTube attract Gen Z with videos, reels, and images. Storytelling helps build emotional resonance, making products more memorable. Effective visual content can drive brand awareness, trust, and ultimately, purchase decisions.

CHALLENGES OF SOCIAL MEDIA MARKETING

Despite its advantages, social media marketing faces obstacles when targeting Gen Z.

Information Overload

Information overload on social media can negatively influence Gen Z purchase decisions due to excessive advertisements and promotional content. Continuous exposure to multiple brands and messages often leads to confusion and decision fatigue. As a result, Gen Z consumers may ignore or distrust marketing messages.

Negative Feedback

Negative feedback on social media significantly influences Gen Z purchase decisions, as this generation actively reviews comments, ratings, and online discussions before buying. Critical reviews and negative experiences shared by other users can reduce trust in a brand.

Short Attention Spans

Short attention spans strongly influence Gen Z's response to social media marketing and purchase decisions. This generation prefers quick, visually engaging, and easily digestible content such as short videos and concise messages. Lengthy or complex advertisements are often ignored.

Algorithm Changes

Algorithm changes on social media platforms can greatly impact Gen Z's exposure to marketing content and, consequently, their purchase decisions. Updates that alter what content appears in feeds may reduce the visibility of certain posts or ads. This can affect brand reach, engagement, and awareness among Gen Z users.

Ad Fatigue

Ad fatigue occurs when Gen Z users are repeatedly exposed to the same advertisements, leading to reduced attention and engagement. Overexposure can create annoyance or disinterest, diminishing the effectiveness of marketing campaigns. This may negatively impact brand perception and purchase intention.

Privacy Concerns

Privacy concerns play a significant role in Gen Z's social media purchase decisions. This generation is cautious about sharing personal data and may avoid brands that seem intrusive or mishandle information. Lack of trust in data security can reduce engagement with targeted ads and marketing campaigns

OPPORTUNITIES IN SOCIAL MARKETING

Social media provides extensive opportunities for brands to influence Gen Z purchasing

- **Viral Campaigns**
  - ❖ Creative content can spread quickly, increasing visibility.
- **Personalized Marketing**
  - ❖ Tailored content enhances relevance and purchase likelihood.
- **Analytics Insights**
  - ❖ Tracking engagement helps optimize campaigns.
- **Building Communities**
  - ❖ Fosters loyalty and encourages peer promotion.
- **Trend Utilization**

- ❖ Memes, challenges, and viral trends engage Gen Z effectively.

ELEMENTS OF SOCIAL MEDIA MARKETING

Effective campaigns rely on several key methods to engage audiences.

- **Visual Content**
  - ❖ Photos, videos, and reels attract attention and improve retention.
- **Interactive Campaigns**
  - ❖ Polls, quizzes, and challenges boost participation.
- **Influencer Collaborations**
  - ❖ Trusted personalities enhance credibility and reach.
- **User-Generated Content**
  - ❖ Encourages authenticity and peer influence.
- **Analytics Tracking**
  - ❖ Performance monitoring allows continuous improvement.
- **Paid Advertisements**
  - ❖ Ensures precise targeting of specific audience segments.
- **Brand Storytelling**
  - ❖ Emotional narratives increase connection and loyalty.

IMPACT ON PURCHASE DECISION

Social media shapes Gen Z purchasing behavior by influencing awareness, engagement, and peer validation. Positive interactions increase trust and encourage purchases, while negative experiences can deter them. Brands that understand these dynamics can drive stronger loyalty and higher sales.

CONCLUSION

Social media marketing is essential for influencing Generation Z purchase decisions. By leveraging engaging content, influencer collaborations, and data-driven strategies, brands can enhance awareness, loyalty, and sales. While challenges like short attention spans and negative feedback exist, effective planning and continuous innovation create opportunities to connect authentically with this generation. Strategic use of social media is therefore critical for modern marketing success.

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Capacity Building and Professional Development for Paperless Libraries in the Fifth Industrial Revolution: An Empirical Study

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Abstract

The Fifth Industrial Revolution (5IR) focuses on collaborative innovation between humans and intelligent technologies, emphasizing the integration of human insight with automated systems (Brynjolfsson & McAfee, 2017; Schwab, 2016). As libraries move toward paperless operations, equipping personnel with the necessary skills through capacity building and professional development is essential (IFLA, 2019; Nwachukwu & Okeke, 2021). This study investigates how professional development supports paperless libraries within the 5IR framework. Using a qualitative approach, a systematic review and interpretive content analysis were conducted on literature from the Scopus database (Kumar & Singh, 2022). Results indicate that advanced digital competencies, adaptability, and ongoing training are crucial for sustaining paperless systems (Bawden & Robinson, 2020; Wang & Chen, 2022). Challenges include skill gaps, resistance to technological change, and infrastructure limitations, with strategies proposed to address those (Yigitbasioglu & Velcu, 2020). Continuous capacity building enhances human–technology collaboration and supports sustainable paperless libraries (UNESCO, 2020).

Keywords: Capacity building; Professional development, Paperless libraries, Fifth Industrial Revolution, Human–technology interaction

Introduction

Digital advancements have fundamentally transformed library services, ushering in paperless operations that rely on electronic resources, online retrieval systems, cloud-based platforms, and virtual service delivery models (Almazan & Garcia, 2021). These developments have altered how information is created, stored, accessed, and disseminated, shifting libraries from physical repositories to digitally mediated knowledge hubs. Within the context of the Fifth Industrial Revolution (5IR), this transformation is not driven solely by technological innovation but by **human-centered collaboration with intelligent systems** (Schwab, 2016; Brynjolfsson & McAfee, 2017).

The 5IR emphasizes the ethical and purposeful integration of technologies such as artificial intelligence, automation, and data analytics with human creativity and professional judgment. For libraries, this paradigm highlights the continuing relevance of librarians as facilitators of access, interpreters of digital information, and mediators between users and intelligent systems (Wang & Chen, 2022). The effectiveness of paperless libraries therefore depends not only on technological infrastructure but also on the competencies, adaptability, and continuous professional development of library personnel.

Despite the growing adoption of paperless library systems, many institutions struggle with skills gaps, resistance to change, and inadequate training frameworks (IFLA, 2019; Yigitbasioglu & Velcu, 2020). Existing studies often focus on technological implementation rather than the human capacity required to sustain these systems. This study addresses this gap by examining how capacity building and professional development support paperless libraries within the Fifth Industrial Revolution.

Review of Literature

Fifth Industrial Revolution and Library Transformation

The Fifth Industrial Revolution represents an evolution from automation-centered innovation toward **human-centric technological integration** (Schwab, 2016). Brynjolfsson and McAfee (2017) argue that intelligent technologies achieve optimal value when combined with human insight, creativity, and contextual

understanding. In the library sector, this perspective redefines professional roles, emphasizing collaboration between librarians and intelligent systems rather than technological substitution.

Libraries operating within the 5IR increasingly deploy artificial intelligence for cataloging, discovery, and user services. However, Wang and Chen (2022) caution that without adequately trained professionals, such technologies risk reinforcing inequalities or diminishing service quality. Consequently, the 5IR demands new competencies that enable librarians to guide, evaluate, and ethically apply intelligent technologies.

Paperless Libraries and Digital Transformation

Paperless libraries represent a strategic response to digital transformation and sustainability goals. They prioritize electronic collections, institutional repositories, digital preservation systems, and virtual user services (Almazan & Garcia, 2021). Kumar and Singh (2022) emphasize that paperless libraries are socio-technical systems requiring alignment between technology, organizational culture, and human capabilities.

While paperless systems enhance access and operational efficiency, they introduce challenges such as digital preservation risks, interoperability issues, cybersecurity concerns, and increased reliance on staff digital competencies. These challenges underscore the importance of structured capacity-building initiatives.

Capacity Building in Digital and Paperless Library Environments

Capacity building involves strengthening professional knowledge, technical skills, attitudes, and adaptive capabilities to meet evolving organizational demands (IFLA, 2019). In paperless libraries, this includes digital literacy, system management, data governance, and the ability to respond to continuous technological change.

Bawden and Robinson (2020) highlight that librarians must develop both practical and conceptual competencies to ensure effective information organization, quality control, and ethical stewardship. Empirical evidence suggests that inadequate capacity building leads to underutilized digital infrastructure and reduced service effectiveness (Yigitbasioglu & Velcu, 2020).

Professional Development Strategies for Librarians

Professional development is essential for sustaining capacity building in digitally intensive library environments. Nwachukwu and Okeke (2021) identify structured training programs, workshops, online learning platforms, mentoring, and peer collaboration as effective strategies. In the 5IR, professional development increasingly incorporates innovation management, critical thinking, and human–technology interaction skills (Wang & Chen, 2022).

Institutional commitment plays a critical role in ensuring continuity and relevance of professional development initiatives. IFLA (2019) emphasizes that policies, leadership support, and funding mechanisms are necessary to institutionalize continuous learning.

Human–Technology Interaction in Paperless Libraries

Human–technology interaction is a defining characteristic of paperless libraries in the 5IR. Intelligent systems such as AI-assisted cataloging, chatbots, and recommender systems support decision-making and service delivery (Kumar & Singh, 2022). However, Brynjolfsson and McAfee (2017) argue that technological systems require human oversight to ensure contextual relevance and ethical use.

Capacity building enhances librarians' ability to interpret system outputs, address bias, and maintain user trust. This interaction reinforces the continued relevance of professional expertise in digitally mediated environments.

Challenges Affecting Capacity Building

Despite its importance, capacity building faces challenges including inadequate infrastructure, limited funding, resistance to technological change, and disparities in digital skills (Almazan & Garcia, 2021; Yigitbasioglu & Velcu, 2020). UNESCO (2020) notes that fragmented training initiatives and weak policy

frameworks often undermine sustainability. Addressing these challenges requires inclusive planning, long-term investment, and organizational commitment.

Research Gap

Although existing literature addresses digital transformation and professional development, limited research integrates capacity building within the Fifth Industrial Revolution framework. Few studies explicitly examine how professional development strengthens human–technology collaboration in paperless libraries. This study contributes by synthesizing existing research to address this gap.

Research Objectives

The study aims to:

1. Examine capacity-building needs of library professionals in paperless environments.
2. Identify professional development strategies that enhance effectiveness in paperless libraries.
3. Explore challenges affecting capacity building and propose mitigation strategies.

Methodology

Research Design

A qualitative research design combining a systematic literature review and interpretive content analysis was adopted (Kumar & Singh, 2022).

Data Sources

Relevant studies were retrieved from the Scopus database using keywords related to capacity building, professional development, paperless libraries, and the Fifth Industrial Revolution.

Data Analysis

Interpretive content analysis was used to identify and synthesize key themes (Bawden & Robinson, 2020; Wang & Chen, 2022).

Findings

Capacity-Building Needs

The findings reveal that effective paperless library operations require a multidimensional skill set encompassing digital literacy, technological competence, data management, and change management. Beyond technical skills, librarians must demonstrate adaptability and problem-solving abilities to respond to evolving digital environments.

Competency Area	Description	Example Skills
Digital Literacy	Proficiency in digital platforms and online resources	Database search, e-books, digital cataloging
Technological Competence	Skill in operating library software and AI tools	LMS management, AI-assisted cataloging
Data & Knowledge Management	Organizing and preserving digital information	Metadata management, digital preservation
Human–Technology Interaction	Collaboration with intelligent systems	Chatbots, recommendation engines
Change & Innovation Management	Adaptation to evolving technologies	Problem-solving, digital workflow optimization

(Sources: Almazan & Garcia, 2021; Kumar & Singh, 2022; Wang & Chen, 2022)

Professional Development Strategies

Professional development strategies identified in the literature emphasize continuous learning rather than one-time training interventions. On-the-job training and online learning platforms are particularly effective in addressing rapidly changing technologies, while professional networking supports knowledge exchange and innovation (IFLA, 2019; UNESCO, 2020).

Challenges and Mitigation Strategies

Challenges such as infrastructure limitations and resistance to change significantly affect capacity-building outcomes. Inclusive planning and targeted training programs emerge as effective mitigation strategies, particularly when supported by institutional leadership and policy frameworks.

Challenge	Mitigation Strategy
Limited Infrastructure	Upgrade IT resources and ensure reliable internet
Funding Constraints	Seek grants and institutional support
Resistance to Change	Implement awareness programs and inclusive planning
Digital Skills Gaps	Provide targeted training and continuous development

(Sources: Almazan & Garcia, 2021; Yigitbasioglu & Velcu, 2020; UNESCO, 2020)

Discussion

The findings reinforce the argument that sustained capacity building is essential for the success of paperless libraries in the Fifth Industrial Revolution. Human-centered professional development ensures that intelligent technologies enhance rather than replace librarian expertise (Wang & Chen, 2022). Aligning training initiatives with institutional goals and technological strategies strengthens human–technology collaboration and service innovation.

Conclusion

Capacity building and professional development are critical enablers of sustainable paperless libraries in the Fifth Industrial Revolution. By addressing skills gaps, resistance to change, and infrastructural limitations, libraries can foster resilient, innovative, and inclusive services. Continuous professional development strengthens librarians' ability to collaborate effectively with intelligent systems, ensuring that paperless libraries remain responsive to evolving user needs and technological advancements.

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Application of Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) for Digital Libraries: A View

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Abstract

This paper explores the integration of Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) technologies within digital libraries. As digital libraries evolve to provide immersive and interactive experiences, VR, AR, and MR offer novel ways to visualize, interact with, and access information. This study examines the current state of VR, AR, and MR applications in digital libraries, their potential benefits, challenges, and the future scope of their integration in enhancing user experience, accessibility, and knowledge dissemination. A review of relevant literature highlights practical case studies, technological advancements, and frameworks that support this convergence of immersive technology and library science.

Keywords: Digital Libraries, Virtual Reality, Augmented Reality, Mixed Reality, Immersive Technologies, Information Access

Introduction

The concept of digital libraries has revolutionized access to information, enabling users to search, retrieve, and interact with digital content from remote locations. However, as technology continues to evolve, so too does the expectation for more immersive and interactive information retrieval methods. This demand has led to the growing interest in integrating immersive technologies—Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR)—into digital libraries. These technologies promise enhanced engagement, deeper learning, and innovative ways to access complex information.

VR offers a fully immersive environment where users can interact with digital content as if present in a virtual space. Augmented Reality (AR) enables users to engage with both digital and physical items at the same time by superimposing digital features onto the actual environment. MR combines VR and AR to provide real-time interaction between virtual and real-world content.In the context of digital libraries, these technologies can transform traditional reading rooms, archives, and databases into dynamic and interactive learning environments.

This paper aims to provide a comprehensive review of the application of VR, AR, and MR in digital libraries. The study also identifies the challenges in the adoption of these technologies and explores the future potential of immersive environments in reshaping digital libraries.

Definitions

Digital Library

According to Bishop, A. P., & Neumayer, L. (2006)[3] A collection of digital content, such as text, photos, music, and video, arranged for convenience of access, retrieval, and preservation is called a digital library. Unlike traditional libraries, digital libraries allow users to access resources remotely via the internet, facilitating a more extensive reach and the ability to store vast amounts of information efficiently. Digital libraries can include academic works, governmental documents, and historical archives, and they often incorporate tools for searching and interacting with the content.

Virtual Reality (VR)

According Lanier, J. (2017)[6]Virtual Reality (VR) is a simulated experience that can replicate or create environments, allowing users to interact within a three-dimensional space through the use of technology. This immersive experience is typically facilitated by headsets equipped with sensors and displays that track the user's movements, enabling them to explore and manipulate the virtual environment as if it were real. VR can be applied in various fields, including gaming, education, healthcare, and training.

Augmented Reality (AR)

According to Azuma, R. T. (1997)[2] Augmented Reality (AR) is defined as a technology that overlays digital information—such as images, sounds, and other data—onto the real world, enhancing the user's perception of their environment. This is typically achieved through devices like smartphones, tablets, or AR glasses, which utilize sensors and cameras to integrate virtual elements with the physical world in real-time.

Mixed Reality (MR)

According to Milgram, P., & Kishino, F. (1994)[8]Mixed Reality is a hybrid environment that combines elements of both virtual reality (VR) and augmented reality (AR). It allows real-world and digital objects to coexist and interact in real-time. MR enhances user experiences by integrating virtual elements into the physical world in a way that they appear to be part of the real environment. This technology often employs advanced sensors, cameras, and displays to blend the two realities, enabling interactive experiences that can range from visual overlays to fully immersive simulations.

Research Objectives

- To explore the current applications of VR, AR, and MR in digital libraries.
- To analyze the benefits and challenges associated with these technologies.
- To propose future directions for integrating immersive technologies in digital library systems.

Review of Literature

Digital Libraries: A Brief Overview

Digital libraries have evolved from traditional brick-and-mortar institutions to online repositories that host vast collections of digital information, including text, multimedia, and interactive resources. Early studies by Borgman (1999)[4] and Arms (2000)[1] emphasized the importance of accessibility, user-centered design, and digital preservation in the development of digital libraries.

Virtual Reality (VR) in Digital Libraries

VR's application in digital libraries allows users to enter 3D simulations of library spaces, interact with virtual books, and explore archives as if physically present. Wu and Lin (2017)[13] explored how VR enables users to engage with complex data sets in interactive environments, while a study by Sanchez et al. (2019)[11] demonstrated the potential of VR for library-based educational tools, providing students with immersive learning experiences.

Augmented Reality (AR) in Digital Libraries

AR enhances physical library environments by overlaying digital information, such as book metadata, multimedia content, or research guides, onto physical objects. A notable application was presented by Silva et al. (2018)[12] who created an AR system for academic libraries to facilitate research through enhanced content discovery. AR also helps in creating interactive book displays and user tutorials (Lee et al., 2022)[7] making it easier for users to navigate complex databases and collections.

Mixed Reality (MR) in Digital Libraries

MR technology combines both physical and digital worlds, allowing users to interact with virtual content in a real-world context. A study by Onime (2018)[9] demonstrated how MR could revolutionize digital libraries by creating collaborative environments where users can manipulate digital objects and share insights in real-time, blending physical and virtual learning spaces.

Challenges in Implementing VR, AR, and MR in Digital Libraries

Despite the potential of immersive technologies, there are significant challenges in their widespread adoption. These challenges include high costs, technological complexity, and the need for specialized hardware and

software (Cook et al., 2019)[5] Furthermore, issues related to accessibility for disabled users, content standardization, and the development of user-friendly interfaces require attention (Peterson et al., 2023)[10]

Current Implementations

The British Library's AR Archives

The British Library has experimented with AR to allow users to explore rare manuscripts with digital annotations and contextual information overlaid. This approach enhances the user's understanding and makes the manuscripts more accessible to the public

The VR-based Virtual Reality Lab in Stanford University

Stanford University has incorporated VR into its digital library services, offering users the ability to explore 3D visualizations of complex scientific data, such as medical models and architectural reconstructions, in a fully immersive environment.

NLB AR Application for Rare Collections

The National Library Board of Singapore developed an AR application that allows users to explore rare collections. Users can point their device at a specific artifact, and the AR app provides a wealth of supplementary information and multimedia, enhancing the reading experience.

Applications of VR, AR, and MR in Digital Libraries

Interactive Learning Environments

VR, AR, and MR have been integrated into digital libraries to create interactive learning environments. For instance, VR tours of historical archives or AR overlays on physical manuscripts provide users with deeper engagement with library materials. Through 3D visualizations, users can explore ancient artifacts, manuscripts, or scientific data in ways that traditional digital interfaces cannot provide.

Enhanced User Experience

The integration of AR and MR into mobile applications has transformed how users interact with digital libraries. Users can point their smart phones at a book cover or barcode, triggering AR content such as author interviews, book summaries, or related multimedia resources. This technology also enhances navigation, offering users visual cues in locating resources within physical library spaces or digital databases.

Collaborative Learning

MR creates spaces where multiple users can interact with both digital and physical objects simultaneously. These collaborative environments are especially useful in academic libraries, where users can work together on research projects, interact with 3D models, or manipulate large data sets collaboratively.

Benefits of Immersive Technologies in Digital Libraries

Accessibility

By utilizing VR and AR technologies, libraries can offer users from all geographical locations equal access to their resources. Remote users can explore and interact with content in the same way as on-site visitors, democratizing access to information.

Increased Engagement and Retention

Interactive technologies such as VR and MR increase user engagement with the content. Studies suggest that immersive environments can improve retention and understanding of complex concepts due to their hands-on, experiential nature.

Preservation of Cultural Heritage

AR and MR technologies offer an innovative method of preserving and presenting cultural artifacts and heritage, allowing libraries to digitize and share collections globally while providing an interactive experience.

Challenges and Limitations

Technological Barriers

The cost of hardware such as VR headsets and MR devices remains prohibitive for many institutions. Additionally, developing and maintaining the software to support immersive technologies requires a specialized skill set that is often beyond the capacity of most library IT departments.

Accessibility Issues

While immersive technologies can enhance learning, they also raise concerns about accessibility. Disabled users, particularly those with visual or physical impairments, may find it challenging to interact with VR or AR systems. Ensuring these systems are accessible to all users is a priority for developers.

Digital Divide

The integration of immersive technologies in digital libraries may widen the digital divide, particularly in underserved regions. Limited access to high-speed internet, advanced hardware, and technical expertise may prevent equitable adoption of these technologies across the global library community.

Future Prospects

The future of VR, AR, and MR in digital libraries holds immense potential. As hardware becomes more affordable and accessible, and as software development grows more intuitive, these technologies could become standard tools for digital libraries. Advances in AI and machine learning could further enhance the capabilities of immersive technologies, offering personalized and adaptive learning experiences. Future research could explore the use of immersive technologies in virtual reference services, information literacy training, and remote learning.

Conclusion

The integration of VR, AR, and MR technologies in digital libraries represents a paradigm shift in how information is accessed, consumed, and shared. These technologies not only enhance user engagement but also expand the ways in which digital collections are curated and experienced. While challenges remain in terms of cost, accessibility, and implementation, the potential benefits for education, research, and collaboration are undeniable. As libraries continue to evolve, the adoption of immersive technologies will play a critical role in shaping the future of information access and learning environments.

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