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"Iot in Library Services: Adoption Readiness among LIS Professionals in Northern India's IITs"

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ABSTRACT

With the increasing global interest in smart technologies, including the Internet of Things (IoT), libraries are exploring innovative ways to enhance their services and user experience. However, in the Indian context particularly within premier institutions there remains a noticeable gap in research on how Library and Information Science (LIS) professionals perceive and adopt IoT technologies. This study addresses that gap by investigating the adoption readiness of LIS professionals toward IoT and its practical applications in library services across five Indian Institutes of Technology (IITs) in Northern India. Grounded in the Technology Acceptance Model (TAM), the research examines how perceived ease of use (PEOU), perceived usefulness (PU), and behavioral intention influence the acceptance of IoT in library settings. A stratified sampling method was used to ensure balanced representation, and a total of 63 professionals were approached, resulting in 59 valid responses. Descriptive statistics, including percentages, means, and standard deviations, were used alongside inferential tests such as ANOVA, regression, and chi-square analysis, with p-values below 0.05 indicating statistical significance. F-values were used to interpret group differences, and regression helped identify predictive factors influencing IoT adoption readiness. The findings reveal that most LIS professionals gained IoT awareness through professional exposure like workshops, conferences, and peer discussions. While there is recognition of IoT's potential for enhancing services such as self-checkout systems, digital reference services, and smart resource tracking, implementation remains limited, with less interest shown in domains like elderly care. The study highlights the need for targeted training programs, supportive infrastructure, and policy frameworks to enable effective IoT adoption in libraries. By aligning empirical findings with TAM constructs, this research not only provides actionable insights for LIS professionals but also contributes a theoretical foundation for understanding technology adoption in academic libraries, making it a pioneering study in the Indian context.

KEYWORDS

Academic libraries; internet of things; IoT applications; library automation; library services

Introduction

In today's world, many gadgets connect to the World Wide Web (WWW) to deliver new services, while reduced underlying costs enable broad data access for everyone. Instant information retrieval requires continuous Internet access from any location. Consequently, new computing paradigms such as big data, cloud computing, blockchain, and the IoT have emerged to support remote storage and information access.[1]

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IoT has transformed ideas once thought of as fantasy into reality, driving the fourth industrial revolution and significantly impacting technology, society, the economy, and the lives of both humans and machines. Scientists anticipate that IoT's potential benefits will soon materialize in a world where smart objects can sense, think, and act. As a rapidly evolving technology, IoT incorporates concepts such as fog computing, edge computing, communication protocols, electronic devices, sensors, geolocation, and more.[2] By 2025, IoT is projected to have an annual economic impact of between US$3.9 trillion and US$11.1 trillion, representing around 11% of global GDP. IoT technologies thus help organizations transition from traditional to smart business environments. This rapid expansion has resulted in over 10 billion connected IoT devices today, with estimates suggesting this will grow to roughly 75 billion by 2025.[3]

IoT has the potential to revolutionize library services, allowing libraries to enhance efficiency, security, and user-centered experiences through the technology's security, transparency, and practicality.[4] IoT could transform libraries by helping them become smart organizations, capable of managing daily tasks such as self-borrowing, self-returning, smart inventory, intelligent searching, and integrating books with information systems.[5] The first step in utilizing IoT technology in libraries is assessing its level of adoption readiness. LIS professionals play a crucial role in promoting IoT knowledge, awareness, and adoption to ensure libraries remain relevant and efficient in the digital era. Greater IoT awareness can empower LIS professionals to advocate for its adoption in libraries, secure funding for IoT projects, and effectively demonstrate its potential benefits for both users and the institution. IoT awareness is critical because it promotes understanding of the potential benefits in libraries, such as improved collection management, instruction, and data security. By raising awareness, library staff and patrons can better understand how IoT technologies can improve operations and user experiences. This knowledge drives practical implementation, allowing libraries to become Smart places that enable real-time global connections and innovative services, ultimately increasing library effectiveness and patron satisfaction.[6] IoT adoption readiness is essential for library professionals since it improves their understanding of IoT components in resources and services. This knowledge drives practical implementation by allowing libraries to assess user activities, improve service efficiency, and organize information more effectively. Educating employees about IoT and cybersecurity encourages an anticipatory reaction to user lifestyle changes and goals. The increased IoT adoption readiness results in better external services, higher user satisfaction, and a more inventive library environment that meets current demands.[7] It is crucial to look into how these IoT developments can interact with current library systems and procedures as libraries develop and modernize. It is essential to collaborate closely with library staff to pinpoint issues and potential development areas that can profit from IoT technologies. These kinds of partnerships might also involve testing how well different IoT technologies work with the library's current infrastructure, which might call for changes to the current setup. Feedback from users guarantees that changes meet their requirements and preferences. This improves the overall effectiveness of the library and helps staff members give patrons a better user experience. Staff members can save time by automating repetitive tasks like inventory management and book tracking by integrating IoT technologies into library systems.[88]

Statement of problem and rationale

In India, university libraries have not prioritized the application of IoT technology. While these libraries are aware of ICT applications in various library services to some extent, responsibility for adopting IoT in libraries remains limited. Additionally, students in IITs have had minimal exposure to IoT technology within their libraries. Therefore, exploring the potential applications of IoT in library services and understanding its role in facilitating real-time information updates for seamless information dissemination becomes essential for developing a comprehensive view of IoT's impact on library systems. The researcher selected IITs for this study due to their leading role in technological innovation.

Findings of this study will encourage to provide new technological avenues in library services with application of IoT and fulfill users requirements in real-time. Even though smart technologies are becoming more and more important worldwide, Indian academic libraries, especially those at IITs, have only recently begun to embrace the IoT. IoT may be conceptually familiar to LIS professionals, but a number of obstacles, such as a lack of funding, a lack of qualified staff, a lack of technical infrastructure, and worries about data privacy, make it difficult to put into practice.[9] In the quickly changing digital landscape of ubiquitous and mobile learning, patrons are calling for more personalized services and easy, real-time access to information, which traditional library systems find difficult to provide. IoT has the potential to revolutionize industries by facilitating data-driven decision-making, intelligent user services, automated processes, and real-time resource tracking. IoT research implementation in the library field is still lacking, despite the fact that a number of earlier studies have employed various concepts to promote emerging technology within an organization. Large systems are still conducting research and experiments for the implementation of the IoT, even though it is still in its infancy. Setting the groundwork for further research on IoT adoption in libraries is the study's primary contribution.[10] There are advantages and disadvantages to libraries implementing IoT, especially in developing nations like India.[11] The implementation of IoT is complicated by the technological lag in these areas, even though it can improve library services through increased efficiency and user engagement. The 30% drop in physical book checkouts observed in Indian libraries can be addressed by IoT, which can assist libraries in better managing both digital and physical resources.[12] However, libraries run the risk of lagging behind in providing contemporary services if their applicability, advantages, and adoption barriers are not well understood. In order to close the knowledge gap and find workable solutions for the meaningful, scalable integration of IoT in library services to satisfy changing user expectations, this study examines the awareness, adoption and readiness of LIS professionals at IITs of Northern India with regard to IoT.

In light of the above, the problem under study is stated as:

"IoT in Library Services: Adoption readiness among LIS Professionals in Northern India's IITs"

Over the years, various issues have prompted a reassessment of users' information needs in a ubiquitous environment, with a prominent factor being the rise of "ubiquitous learning" among younger generations. Ubiquitous learning, synonymous with mobile learning, enables users to access information anywhere without human assistance. To address these issues effectively and extend IoT benefits in libraries, it is essential to have a thorough understanding of the applications of IoT in libraries to meet user needs. However, the lack of research in this area has left librarians in India uncertain about how to utilize this technology efficiently. Therefore, this study is crucial to developing a comprehensive understanding of IoT's various aspects in library services. It will provide IIT librarians with potential strategies to address these issues and broaden the reach of IoT benefits to the wider user community. This study is guided by the TAM, which helps in understanding users' acceptance and usage of new technologies such as IoT within the library context. The integration of TAM and IoT can significantly improve library services by offering an organized strategy for analyzing user acceptance and adoption of technology. TAM, which is traditionally used to assess user acceptance of technology, can be tailored to address the specific difficulties posed by IoT in libraries, allowing for a more seamless transition to smart library systems.[13] Adapting TAM to library settings entails incorporating library-specific constructs and taking into account cultural differences, which can improve its applicability in advanced technology settings. TAM is an extensive framework for the use of IoT in libraries to handle operational challenges, such as resource monitoring and security, while also improving user experience through data analytics.[14]

The TAM is an important framework for understanding how users come to accept and use technology, especially via the notions of Perceived Ease of Use (PEOU) and Perceived Usefulness (PU). TAM, first proposed by Fred Davis in 1986 Figure 1, has evolved, with recent research emphasizing the significance of Attitude Toward Using (ATU) as a facilitator in technology acceptance, specifically in educational settings.[15] The TAM defines perceived ease of use as the extent to

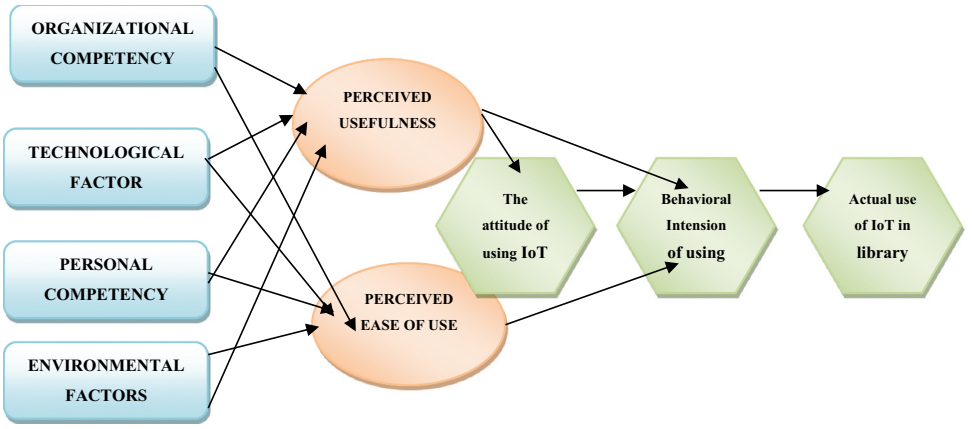

Figure 1. TAM model in the context of IoT.[17]

which a person thinks utilizing a particular technology will be effortless. Because of this, users are more likely to accept an IT application if they believe it to be easier to use than another. Perceived ease of use that influences perceived usefulness, perceived ease of use that inspires behavioral intention, and perceived usefulness that influences behavioral intention are the three fundamental relationships that the TAM aims to identify.[16] This research was conducted to explore answers to the following research questions:

RQ1 What is the extent of adoption readiness towards IoT among LIS professionals?

RQ2 What is the extent of adoption readiness towards IoT-based library services among LIS professionals?

Ha There is a significant difference in the extent of adoption readiness of library and information professionals towards IoT-based library services among various IITs of Northern India.

H0 There is no significant difference in the extent of adoption readiness of library and information professionals towards IoT-based library services among various IITs of Northern India

Literature review

IoT

Kevin Ashton coined the term IoT in 1999, and it has since evolved into a rapidly growing technology spanning various fields. The IoT connects physical objects and locations to the Internet. The European Research Cluster (IERC) defines it as a dynamic global network infrastructure with self-configuring capabilities based on standard, interoperable communication protocols. IoT incorporates both physical and virtual entities with unique identities, attributes, and intelligent interfaces that integrate seamlessly into the network.[18] IoT extends Mark Weiser's vision of ubiquitous computing (UbiComp), aiming to create a global network that enables UbiComp and context-aware devices. Developments in wireless sensor networks (WSN), mobile computing (MobiComp), UbiComp, and information technologies have set the stage for IoT.[19] IoT, as an "intelligent connection of things," encompasses edge computing, fog computing (FC), big data analytics, WSN, sensor technologies, and data science, all of which have converged to form this technology.[20] It is an umbrella term describing technology, design concepts, and systems related to the growing phenomenon of online-connected entities, or

"Things," which brings Internet connectivity to physical products. In this context, "things" could be any entity or object with a unique identifier, embedded system, and data transmission capability across a network.[21] IoT's cyclical nature combines networks to connect with people and sensors, aggregates standards, and enables machines to leverage artificial intelligence (AI) to act, react, and analyze data based on context.[22] This process of creation, communication, aggregation, and analysis gives devices augmented intelligence, transforming them into smart devices within the IoT.[23] IoT sensors facilitate continuous, real-time data processing, analysis, and collection across all organizational sectors, delivering data that is exceptional due to its quality, precision, and accessibility. Autonomous data collection, processing, and display are essential for digital transformation. Due to the interconnectivity of IoT, organizations can gather, display, and share data from external and internal sources, including suppliers and customers. Real-time data transmission increases visibility, transparency, quality, and actionable intelligence.[24] IoT prioritizes characteristics such as connecting devices at a low cost, with limited hardware capacity, energy resources (such as batteries), cost-effectiveness, low latency, reliability, and security.[25] IoT architecture comprises three main layers: perception, network, and application. The perception layer, or sensor layer, interacts with the environment to collect data. The network layer, or transfer layer, facilitates communication technologies and data transmission from the perception layer to the application layer and is regarded as the most critical layer for its role in security and integrating various communication technologies. Finally, the application layer, or business layer, sits at the top of the model, delivering services to users.[26] IoT presents numerous opportunities for stakeholders, including hardware manufacturers, application developers, Internet service providers (ISPs), researchers, and industries.[27] IoT applications support decision-making, environmental monitoring, and cloud resource management, helping users select optimal solutions for their needs.[28] According to a recent prediction by the International Data Corporation (2023), global investment in the IoT is expected to reach $805.7 billion in 2023, a 10.6% increase from 2022. Investments in the IoT ecosystem are estimated to exceed $1 trillion in 2026, with a compound annual growth rate of 10.4% from 2023 to 2027. The IoT has attracted a lot of attention because of its potential in areas like smart electricity systems, smart buildings, smart cities, transportation, healthcare, commerce and industry, libraries, farming, and public administration.[29] Libraries, like other economic sectors, may employ a variety of IoT applications to boost productivity on daily chores. There is a strong argument that if libraries are successful in implementing and utilizing IoT, their future prospects will improve. This has been a topic of discussion among librarians in recent years. Libraries will be significantly changed by IoT in a number of ways, most notably by becoming intelligent institutions. Library operations like self-check-in and self-check-out, intelligent inventory, intelligent querying, and book and information system integration can be handled with the aid of emerging technologies like the IoT.[30] IoT is being used by libraries all over the world to provide improved services like automated inventory management, smart shelves, and user tracking systems. India acknowledges that IoT has the potential to revolutionize library services in line with the country's development objectives. In 2022, the global IoT market was valued at $201 billion, and libraries are progressively implementing these technologies to enhance user experience and efficiency.[31] In academic libraries, China is setting the standard for IoT research. Nonetheless, it is also suggested that both developed and developing nations are experiencing the emergence of the IoT phenomenon in academic libraries.[32]

Awareness about IoT-based Library Services

The adoption of IoT technologies has gained significant attention across sectors due to its ability to enhance efficiency, enable real-time data processing, and support user-centric service delivery.[33] In the context of libraries, IoT is increasingly recognized as a transformative enabler that can automate routine operations, optimize resource management, and deliver personalized user experiences.[34] Globally, the growing body of literature between 2010 and 2022 reflects a rising interest in IoT-driven innovations in library environments, particularly in areas such as service optimization, data

security, and intelligent infrastructure.[35] Studies consistently highlight the advantages of IoT over traditional systems, including improved operational speed, cost efficiency, reduced manual workload, and enhanced service reliability.[36] Comparative evidence from different regions further strengthens the understanding of IoT adoption in libraries. For instance, research from Hong Kong indicates generally positive attitudes among academic librarians toward IoT, particularly for improving user experience and service personalization, although concerns regarding privacy, system errors, and increased training requirements persist.[37] Similarly, a pilot project in South Africa demonstrated the effectiveness of IoT-enabled seat occupancy and reservation systems, achieving high accuracy and improving user engagement with library spaces.[38] In another innovative application, a university library-based "living lab" model integrated IoT with digital twin technology to optimize environmental conditions such as lighting and air quality, showcasing the potential of IoT in intelligent facility management.[39] These international cases illustrate that while technological applications vary, the core objective remains consistent: enhancing efficiency, transparency, and user satisfaction. In academic libraries, IoT applications commonly include RFID-based circulation systems, real-time tracking of resources, user authentication, and data-driven decision-making through integration with cloud computing, big data analytics, and artificial intelligence.[40] These technologies support the transition toward smart libraries, which function as dynamic, interactive, and user-centered knowledge environments. Additionally, IoT facilitates services such as location-based access, usage analytics, automated notifications, and personalized information delivery, aligning library services with the expectations of digitally native users.[41] Despite these advancements, several challenges continue to hinder large-scale adoption. Studies across regions consistently report barriers such as inadequate infrastructure, limited funding, lack of technical expertise, and concerns related to data privacy and ethical use.[42] In the Indian context, similar issues are evident, particularly the gap between awareness and practical implementation, as many LIS professionals lack hands-on skills despite being conceptually familiar with IoT.[43] These challenges highlight the need for comprehensive institutional strategies, including infrastructure development, capacity building, and policy frameworks to support sustainable IoT integration. The global literature indicates that IoT-enabled libraries are evolving into innovation hubs that integrate emerging technologies such as AI, cloud computing, and big data to support smart learning ecosystems.[44] However, the extent of adoption and readiness varies across regions depending on institutional capacity, technological maturity, and policy support. In this context, examining IoT awareness and adoption readiness in Indian IIT libraries provides valuable insights into how developing countries are positioning themselves within the global trajectory of smart library transformation.

IoT-based library services case studies

Intelligent libraries are actively promoting sustainability knowledge systems, as demonstrated by real-world case studies and best practices. These illustrations provide insightful information about how libraries, equipped with cutting-edge technology, are actually promoting sustainability practices and awareness. One interesting case study, though, centers on the Singapore National Library, which has taken a progressive stance in sustainability education. Based on their reading habits and preferences, the library has put in place a recommendation system that provides users with customized reading lists on sustainability-related subjects. As a result, the library's sustainability-themed events and workshops saw a notable increase in attendance as well as a notable surge in the circulation of books related to sustainability.[45] A relevant case study demonstrating practical implementation of IoT in smart libraries is presented by researchers who proposed an IoT-based low-cost architecture integrated with Software Defined Networking (SDN) for intelligent library management. The study emerged from the identified need for more efficient, scalable, and cost-effective solutions for managing modern library operations. The proposed architecture combined IoT and SDN technologies to automate and optimize RFID-based library functions, including user authentication, circulation

management, and book loan tracking. The system architecture incorporated components such as SDN controllers, RFID tags and readers, sensors, and a centralized data centre to enable seamless communication and real-time monitoring of library resources. By integrating RFID with SDN, the system minimized the need for continuous human supervision and enhanced operational efficiency in library environments. The architecture was designed to be scalable and adaptable for large academic libraries and smart campus ecosystems. The study further validated the model through a two-phase investigation involving both practical implementation in a small-scale library setting and simulation testing using MATLAB 2021. This case study highlights how IoT-enabled smart library infrastructures can improve automation, resource management, and service delivery while reducing operational complexity and costs, thereby providing a practical framework for future smart library initiatives.[46] Libraries are able to create advanced inventory and finding systems thanks to the integration of IoT technology. The locations of items within the library are continuously monitored by networks of sensors and RFID readers. A number of libraries have showcased systems that allow users to navigate to a book's shelf location using a mobile application based on the strength of RFID signals.[47] Smart lighting, occupancy sensors, and thermostats provide sophisticated environmental control in smart library settings. By automatically modifying lighting and heating, ventilation, and air conditioning (HVAC) systems based on room occupancy detected by motion sensors, these systems enhance comfort and energy efficiency. For instance, when a room is empty, the HVAC system and lights may turn off or dim.[48]

Library of Things at Hillsboro Public Library is a checkout service offered to patrons from Arduino kits. Hillsboro Main Library and the Hillsboro Shute Park Branch both have a Library of Things collection. The device installed for this purpose receives, picked up, and returned books at their respective location. Book-O-Mat, is also part of this is an automated book kiosk.[49]

The concept of smart libraries has been increasingly adopted by academic and public libraries worldwide to enhance operational efficiency and improve user experiences through the integration of IoT and automation technologies. DTU Library represents a significant example of this transformation, where the smart library ecosystem is structured around three major dimensions: learning environment, data innovation and skills, and facility management. The library enables users to monitor real-time environmental conditions such as temperature, humidity, CO_2 levels, sound, and lighting across different zones, thereby allowing students to choose or customize study spaces according to their requirements.[50] The infrastructure also supports data-driven learning by permitting students to install sensors and other technological devices within library spaces for academic projects, assignments, and entrepreneurial activities. Furthermore, the facility management system ensures efficient inventory monitoring and staff management for better utilization of resources. The library incorporates advanced technologies such as ModCam systems for generating anonymous heat and tracking maps to optimize furniture placement, services, and staff allocation, while sensor boxes continuously record environmental parameters including light, sound, humidity, pressure, and temperature for both live and historical analysis.[51] Adaptive LED lighting systems further enhance user comfort by adjusting brightness and color schemes according to seasonal and individual preferences. Similarly, the Joe and Rika Mansueto Library at the University of Chicago demonstrates the application of IoT-enabled automation in library circulation and storage management through an automated book return and sorting system integrated with robotic retrieval technologies, where requested books are automatically located in underground storage and delivered to readers efficiently.[52] Another notable example is the Russian State Library for Young Adults, which utilizes RFID-enabled robotic devices managed through web-based interfaces. These systems can be remotely controlled through any internet-enabled device using either dedicated applications or standard web browsers, thereby highlighting the growing integration of IoT, RFID, and remote-access technologies in modern library services.[53]

Research methodology and research design

Research Design

This study employed a quantitative research design, utilizing a structured survey questionnaire to capture comprehensive insights into the awareness, adoption readiness, perceptions, and implementation of IoT among LIS professionals in IIT libraries. The questionnaire was meticulously developed to align with the research objectives, encompassing multiple dimensions such as demographic information, IoT awareness, adoption readiness, and perceived applicability in library services. The questionnaire underwent expert validation and pilot testing with a small group of LIS professionals to ensure clarity, relevance, and reliability, with a Cronbach's alpha score calculated to assess internal consistency. The study's survey instrument's reliability analysis shows a high degree of internal consistency, as evidenced by the 40 items' Cronbach's Alpha value of 0.963 as shown in Table 1. The reliability of the scale is considered to be reliably indicated by a Cronbach's Alpha value greater than 0.70.[54]

Sample Collection Methodology

A stratified random sampling technique was employed to enhance the representativeness of the study and reduce sampling bias. The target population included academic librarians from five leading IITs in Northern India. Stratification criteria included years of professional experience, level of responsibility (e.g., junior staff, middle management, senior professionals), and self-reported familiarity with IoT concepts. The size of each stratum was proportionate to its representation within the total population, and random selection within each stratum was conducted using a random number generator. This method ensured a balanced representation of diverse professional profiles across the institutions.

Sampling Process

The sampling process involved the compilation of a comprehensive list of potential participants through institutional directories, faculty listings, and professional networks. Within each stratum, participants were selected using random sampling techniques to maintain objectivity. The finalized list of respondents received the survey in person during visits to the selected IITs (IIT Delhi, IIT Kanpur, IIT Roorkee, IIT BHU, and IIT Ropar), ensuring high engagement and minimizing response bias. The hands-on approach facilitated clarification of queries and contributed to a high response rate. This direct method improved response accuracy and minimized ambiguity in interpretation, leading to a high response rate and reduced non-response bias.

Data Collection Procedure

Data collection was conducted between April 1 and July 30, 2023, targeting five IITs selected based on NIRF rankings. A total of 63 questionnaires were distributed, with 59 valid responses received, resulting in a response rate of 93.65%. The survey process upheld strict ethical standards, ensuring respondent anonymity and data confidentiality. Participants were briefed on the study's purpose, and informed consent was obtained prior to participation. No personally identifiable information was collected, and all responses were stored securely.

Table 1. Reliability Statistics of LIS Professionals.

Reliability Statistics	
Cronbach's Alpha	N of Items
.963	40

Data Analysis

Following rigorous data cleaning and validation, both **descriptive and inferential statistical techniques** were applied. Descriptive statistics (frequencies, percentages, means, and standard deviations) were used to summarize demographic data and Likert-scale responses. The areas of IoT implementation and library services were measured using a 5-point Likert scale, where respondents rated their level of agreement with each statement. The scale was defined as follows: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree. Based on this scale, mean and SD was calculated to capture the central tendency and variability of responses. For inferential analysis, ANOVA, regression and chi-square tests were performed to identify statistically significant associations among variables, with an alpha level of 0.05. The regression analysis was employed to determine the predictive power of various independent **v**ariables (e.g., institute affiliation, work experience, general IoT awareness, and adoption readiness) on professionals' perceived applicability of IoT in libraries. The reliability of the scale was tested using Cronbach's alpha, and the data was analyzed using SPSS (v26) and Microsoft Excel to ensure robust and replicable findings.

Ethical Considerations

Ethical research practices were rigorously followed. Participants were clearly informed about the study's aims, and explicit consent was secured before data collection. The confidentiality and anonymity of respondents were strictly maintained, and ethical clearance was obtained where applicable. The study adhered to academic and institutional ethical guidelines throughout all stages of the research process.

Limitations of the Study

This study acknowledges several limitations, including potential self-selection bias due to the voluntary nature of participation, which may not entirely represent the broader population of academic librarians. Additionally, reliance on self-reported data could introduce response bias. Future studies could address these limitations by expanding the respondent base and employing a mixed-methods approach to validate findings across different contexts.

Results

Demographic distribution of Library and Information Science Professionals

Gender Wise Distribution

The gender distribution of library professionals in this study holds significance for several reasons, as outlined in Table 2. Analyzing gender demographics among library professionals provides valuable insights into the sector and can inform the development of policies, practices, and support systems. Examining gender diversity within the profession allows for an assessment of inclusivity, helping to determine whether individuals of all genders are fairly represented in library roles. The findings from

Table 2. Institution wise distribution of gender.

		Institute					
		IIT Delhi N(%)	IIT Kanpur N(%)	IIT Roorkee N (%)	IIT BHU N (%)	IIT Ropar N (%)	Total N (%)
Gender	**Male**	9 (50%)	13 (68.4%)	12 (92.3%)	2 (100%)	4 (57.1%)	40 (67.8%)
	Female	9 (50%)	6 (31.6%)	1 (7.7%)	0 (0%)	3 (42.9%)	19 (32.2%)

this analysis can serve as a foundation for advocating policy changes or library reforms that promote gender equity and equal opportunity.

Table 2 shows that, out of 59 LIS professionals, the majority of respondents were male (40; 67.8%), while female respondents accounted for 19 (32.2%). Institution-wise, the highest number of responses was received from IIT Delhi (18), whereas IIT BHU recorded the lowest, reflecting underlying differences in sample distribution and response rates across institutions. Interpreting these findings, the gender imbalance suggests potential structural or contextual factors influencing participation, rather than simply individual choice. The comparatively lower representation of female respondents may be associated with institutional dynamics, availability, or engagement levels, pointing to a need for more inclusive participation strategies in future studies. Additionally, the variation in institutional response rates indicates that access, communication channels, and organizational support may significantly affect survey participation.

Age-Group Wise Distribution

In the current study, the age group distribution of library professionals is crucial for understanding the demographics and dynamics of the library and information science field, as shown in Table 3. Examining age group demographics provides valuable insights into the workforce, guides policy decisions, and supports the development of programs for professional growth. By analyzing the age distribution of library professionals, organizations and institutions can plan for workforce shifts. Understanding this distribution helps shape professional development programs, as different age groups may have varying needs and interests regarding training, mentorship, and ongoing education. Additionally, age group data can be combined with other demographic information to assess diversity within the profession.

Table 3 indicates that the majority of LIS professionals fall within the 41–50 years age group (37; 62.7%), followed by 31–40 years (9; 15.3%), 21–30 years (8; 13.6%), and above 50 years (5; 8.5%). Interpreting these results, the sample is clearly dominated by mid-career professionals, suggesting that the findings largely reflect the perspectives of individuals with substantial professional experience and institutional familiarity. This concentration may influence the overall orientation of responses toward practical, experience-driven insights on technology adoption, while comparatively fewer early-career and senior professionals could indicate limited representation of emerging or legacy viewpoints. Such a distribution has implications for understanding awareness and adoption patterns, as mid-career professionals often play a pivotal role in bridging innovation and implementation within academic library environments.

Designation Wise Distribution

In this study, designation-wise distribution was utilised to categorise and analyse respondents based on their job titles or functions within an organization as shown below in Table 4. This method can provide valuable insights on how various employee groups view and engage with specific subjects, products, services, or policies. One can target advice, plans, or interventions to specified groups inside

Table 3. Institution wise distribution of age group.

		Institute					
		IIT Delhi N (%)	IIT Kanpur N (%)	IIT Roorkee N (%)	IIT BHU N (%)	IIT Ropar N (%)	Total N (%)
Age Group (in Years)	21-30	4 (22.2%)	1 (5.3%)	0 (0%)	0 (0%)	3 (42.9%)	8 (13.6%)
	31-40	7 (38.9%)	1 (5.3%)	0 (0%)	1 (50%)	0 (0%)	9 (15.3%)
	41-50	5 (27.8%)	17 (89.5%)	11 (84.6%)	0 (0%)	4 (57.1%)	37 (62.7%)
	>50	2 (11.1%)	0 (0%)	2 (15.4%)	1 (50%)	0 (0%)	5 (8.5%)

Table 4. Designation Wise Distribution in IITs.

Designation	Institute					Total N (%)
	IIT Delhi N(%)	IIT Kanpur N(%)	IIT Roorkee N(%)	IIT BHU N(%)	IIT Ropar N(%)	
Librarian	1 (5.6%)	1 (5.3%)	1 (7.7%)	1 (50%)	1 (14.3%)	5 (8.5%)
Deputy Librarian	1 (5.6%)	1 (5.3%)	1 (7.7%)	0 (0%)	0 (0%)	3 (5.1%)
Assistant Librarian	3 (16.7%)	2 (10.5%)	4 (30.8%)	1 (50%)	0 (0%)	10 (16.9%)
Library and Information Officer	1 (5.6%)	12 (63.2%)	6 (46.2%)	0 (0%)	2 (28.6%)	21 (35.6%)
Library and Information Assistant	11 (61.1%)	3 (15.8%)	1 (7.7%)	0 (0%)	2 (28.6%)	17 (28.8%)
Other	1 (5.6%)	0 (0%)	0 (0%)	0 (0%)	2 (28.6%)	3 (5.1%)

the organisation using designation-based distribution. The survey findings are more likely to address the specific demands of each based on designations of LIS professionals.

Observation of Table 4 indicates that the majority of LIS professionals are positioned as Library and Information Officers (21; 35.6%), followed by Library and Information Assistants (17; 28.8%), Assistant Librarians (10; 16.9%), Librarians (5; 8.5%), and Deputy Librarians (3; 5.1%) across the IITs. Interpreting this distribution, the sample is largely composed of operational and mid-level staff who are directly involved in day-to-day library functions, which may shape the findings toward practical and implementation-oriented perspectives on IoT adoption. This dominance suggests that insights into IoT are grounded in service delivery realities rather than purely strategic viewpoints. From a policy and management perspective, such data is valuable for informed decision-making, as it highlights the need to design targeted capacity-building programmes, allocate resources effectively, and develop role-specific strategies that empower these key functionaries to facilitate the successful integration of IoT in library services across IITs.

Working Experience Wise Distribution

In this study focusing on the application of IoT in library services, experience-based distribution is an essential variable as listed below in Table 5. It entails classifying library workers based on their years of experience. This segmentation enables a more sophisticated examination of survey responses and can provide significant insights into how people with different levels of experience perceived effects there competency to use and implement IoT in libraries. The data analysis based on experience level may aids to identifying unique training requirements. Novices may require more basic IoT fundamentals training, whereas experienced professionals may benefit from advanced courses or workshops.

Table 5. Work experience of LIS Professional.

Working Experience	Institute					Total N (%)
	IIT Delhi N(%)	IIT Kanpur N(%)	IIT Roorkee N(%)	IIT BHU N(%)	IIT Ropar N(%)	
<5 Years	7 (38.9%)	0 (0%)	1 (7.7%)	0 (0%)	3 (42.9%)	11 (18.6%)
6-10 Years	3 (16.7%)	3 (15.8%)	3 (23.1%)	1 (50%)	1 (14.3%)	11 (18.6%)
11-15 Years	1 (5.6%)	1 (5.3%)	3 (23.1%)	0 (0%)	0 (0%)	5 (8.5%)
16-20 Years	1 (5.6%)	15 (78.9%)	2 (15.4%)	0 (0%)	2 (28.6%)	20 (33.9%)
21-25 Years	0 (0%)	0 (0%)	4 (30.8%)	0 (0%)	1 (14.3%)	5 (8.5%)
>25 Years	6 (33.3%)	0 (0%)	0 (0%)	1 (50%)	0 (0%)	7 (11.9%)

Incorporating a range of work experience in this study on IoT in library services provides IITs with a comprehensive understanding of how diverse groups of LIS professionals perceive, use, and adapt to IoT technology. As shown in Table 5, the results indicate that the majority of LIS professionals have work experience of 16–20 years (20 or 33.9%), followed by those with less than 5 years and 6–10 years of experience (11 or 18.6%). Additionally, 7 professionals (11.9%) have more than 25 years of experience, while 5 (8.5%) have 11–15 years and another 5 (8.5%) have 16–20 years of experience. Among the IITs, the most experienced staff belong to IIT Kanpur, where 15 professionals (78.9%) have 16–20 years of experience, and IIT Delhi has 6 LIS professionals (33.3%) with more than 25 years of experience. This pattern reflects the establishment dates of the IITs, as these two belong to the first set of established IITs. These findings can inform strategic planning, training programs, resource allocation, and overall decision-making regarding the use of IoT technologies in library services.

Awareness and adoption readiness of LIS professionals towards IoT and its applications in library services

For understanding IoT and its applications in library services is increasingly becoming vital. LIS personnel may use IoT to improve library user experience. It is critical for LIS professionals to keep up with IoT advances and applications. They can serve as educators, instructing library staff and users on how to properly use IoT-based services and equipment

Sources of familiarity about IoT

Knowledge of IoT sources is essential for LIS professionals interested in IoT integration in library services as listed below in Figure 2. Being aware about IoT sources and being current on important advancements is critical to properly incorporating IoT in libraries. Professional discussions, research articles, reports, on job training and browsing on Internet can provide insights into how IoT can be used in libraries around the world. This data assists professionals in identifying potential use cases and best practices for IoT integration in their particular library environments. IoT-specific online forums, social media groups, and community platforms are excellent sources of information and knowledge sharing. These forums allow LIS professionals to ask questions, seek assistance, and learn from colleagues and experts.

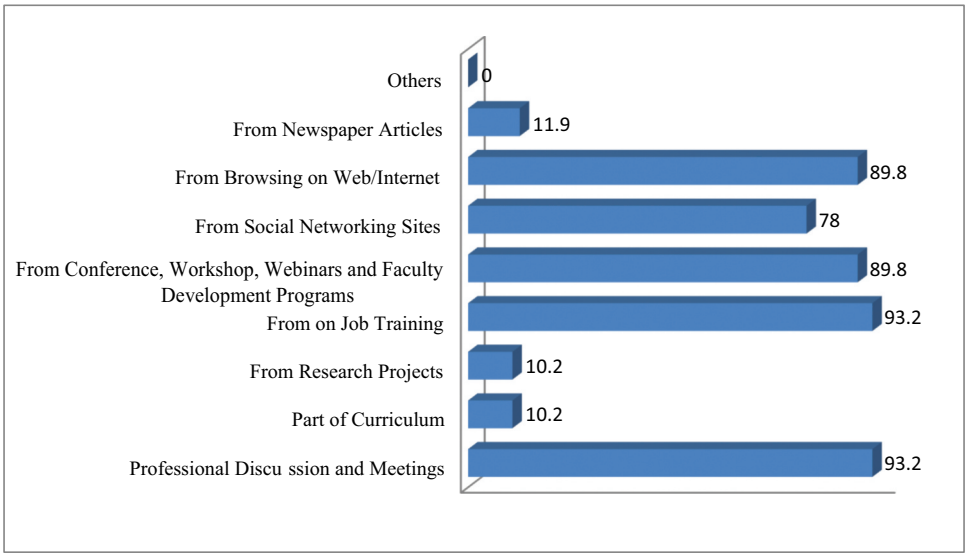

Figure 2. Sources of familiarity about IoT.

Figure 2 indicates that most LIS professionals became familiar with IoT primarily through professional discussions, meetings, and on-the-job training (55; 93.2%), followed by conferences, workshops, webinars, and faculty development programmes, as well as browsing the web/internet (53; 89.8%), while social networking sites (46; 78%) played a comparatively lesser role. Interpreting these findings, it is evident that formal and semi-formal professional environments remain the dominant channels for knowledge acquisition, suggesting that institutional ecosystems and peer networks play a critical role in shaping technological awareness and adoption readiness. This reliance highlights the importance of structured professional development initiatives and continuous training mechanisms in facilitating digital transformation within libraries. At the policy level, it underscores the need for stronger institutional support, including funding for training, capacity-building programmes, and incentives for participation in professional forums. Furthermore, the relatively lower dependence on social networking platforms suggests that while informal digital spaces contribute to awareness and adoption readiness, they are not yet fully leveraged for professional learning, indicating an opportunity to integrate these platforms more strategically into knowledge dissemination and skill development frameworks in the context of evolving smart and IoT-enabled library systems.

Areas where IoT can be implemented

IoT can enhance efficiency, collect data, improve user experiences, and enable automation across a variety of services. Examples of IoT devices include smart thermostats, lights, security cameras, and voice assistants, which allow homeowners to control and monitor their home settings remotely. In healthcare, IoT facilitates remote patient monitoring, wearable health devices, smart medicines, and equipment management, enabling healthcare practitioners to provide better care and more effectively track patient data. In the manufacturing industry, IoT optimizes operations, monitors machinery health, and predicts equipment problems, reducing downtime and boosting overall productivity. IoT sensors are also used in agriculture to track animals, monitor crop health, and observe weather and soil conditions, allowing farmers to make informed decisions and use resources more efficiently. Retailers utilize IoT devices like beacons and RFID tags to track inventory, customize consumer experiences, and optimize store layouts.

Furthermore, IoT can monitor and manage energy use in households, businesses, and industries, helping to lower costs and consumption. In the electricity distribution sector, IoT improves monitoring and management, reducing power outages and enhancing grid reliability. In educational institutions, IoT supports campus security, attendance monitoring, and smart classrooms equipped with interactive displays and online learning resources. These applications, outlined in Figure 3, represent just a fraction of the potential uses of IoT, which is expected to expand into more sectors and domains as technology evolves.

Observing Figure 3, the findings show that LIS professionals perceive IoT as most effectively applicable in smart grid systems particularly in electricity supply and industrial processing (Mean = 4.69, SD = 0.534) followed closely by medical and healthcare applications (IoMT) (Mean = 4.68, SD = 0.539), and domains such as public safety, environmental monitoring, and education (including teaching, learning, and libraries) (Mean = 4.63, SD = 0.522). Applications related to smart homes, transportation, and environments also receive strong support (Mean = 4.59, SD = 0.561), while comparatively lower preference is observed for independent living for older adults (Mean = 4.41, SD = 0.853). Interpreting these patterns, the results suggest that LIS professionals tend to prioritize large-scale, infrastructure-driven, and system-oriented applications of IoT over more individualized or assistive-use contexts. This inclination reflects a techno-functional orientation aligned with institutional efficiency, automation, and resource optimization key elements in the transformation toward smart campuses and intelligent library ecosystems. The relatively lower emphasis on IoT for independent living may indicate limited exposure to or engagement with user-centric and socially assistive technologies, pointing to a potential gap in awareness that professional training and policy interventions could address. Institutional comparisons further reinforce this trend, with respondents from IIT BHU and IIT Kanpur demonstrating particularly strong preference for

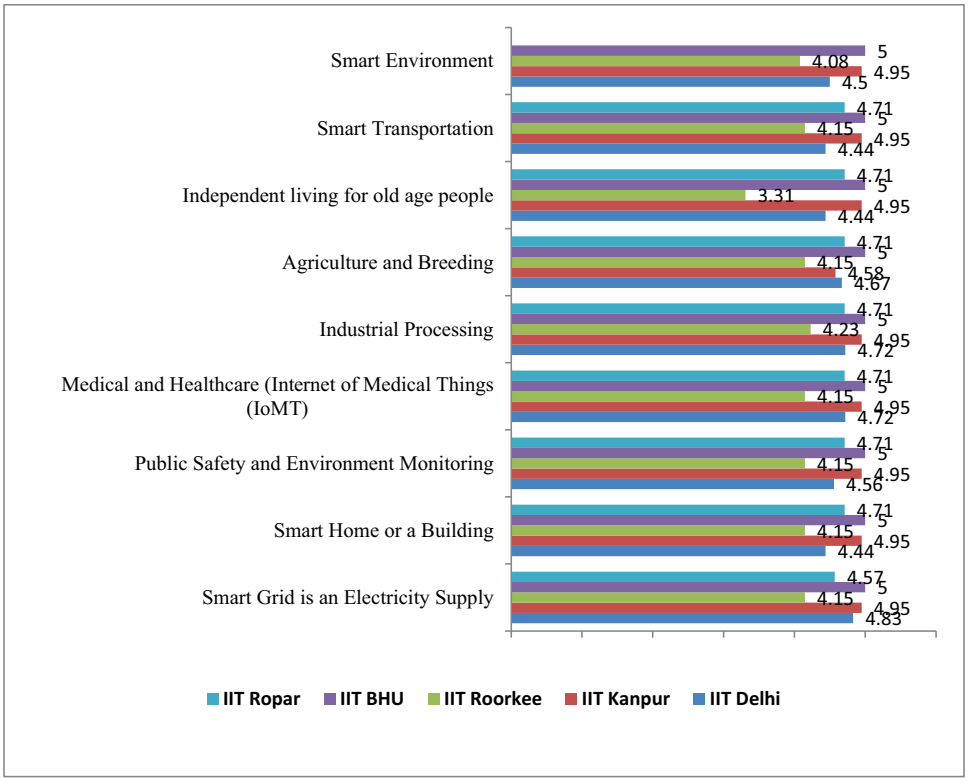

Figure 3. Areas where IoT can be implemented.

smart grid applications, suggesting that institutional culture and technological exposure significantly influence perceptions.

Areas in the library services where IoT can be implemented

LIS Professionals are critical to the successful adoption of IoT in libraries as they can assist in bridging gap between IoT technology and library operations, resulting in a smooth integration process. Their awareness and perception of IoT can have a significant impact on the selection of acceptable IoT applications and tactics. Specific areas in library services where IoT can address difficulties or improve user experiences can be identified by LIS professionals. They can work with other library employees to understand operational and user needs. It is vital to integrate IoT systems with existing library management software and other systems. Figure 4 shows the perception of LIS professionals regarding areas in library services where IoT can be implemented.

The findings indicate that IoT has strong potential to enhance operational efficiency, user experience, and resource optimization across diverse library services. LIS professionals identify self-issue /return systems with real-time updates and mobile-based fine payment (Mean = 4.64, SD = 0.483) as the most impactful application, followed by marketing of library products and services (Mean = 4.59, SD = 0.591), reference services (Mean = 4.58, SD = 0.532), and digital library services (Mean = 4.56, SD = 0.501). Other key areas include book reservation systems, mobile reference, remote monitoring of resources, user authentication, and inventory management (Mean = 4.54, SD = 0.502), along with live occupancy monitoring, virtual library tours, context-aware services, security systems, and disaster management (Mean = 4.51, SD = 0.537). Newspaper clipping services receive comparatively lower preference (Mean = 4.36, SD = 0.713). Interpreting these results, it becomes evident that LIS professionals prioritize IoT applications that streamline core library operations, enhance accessibility, and

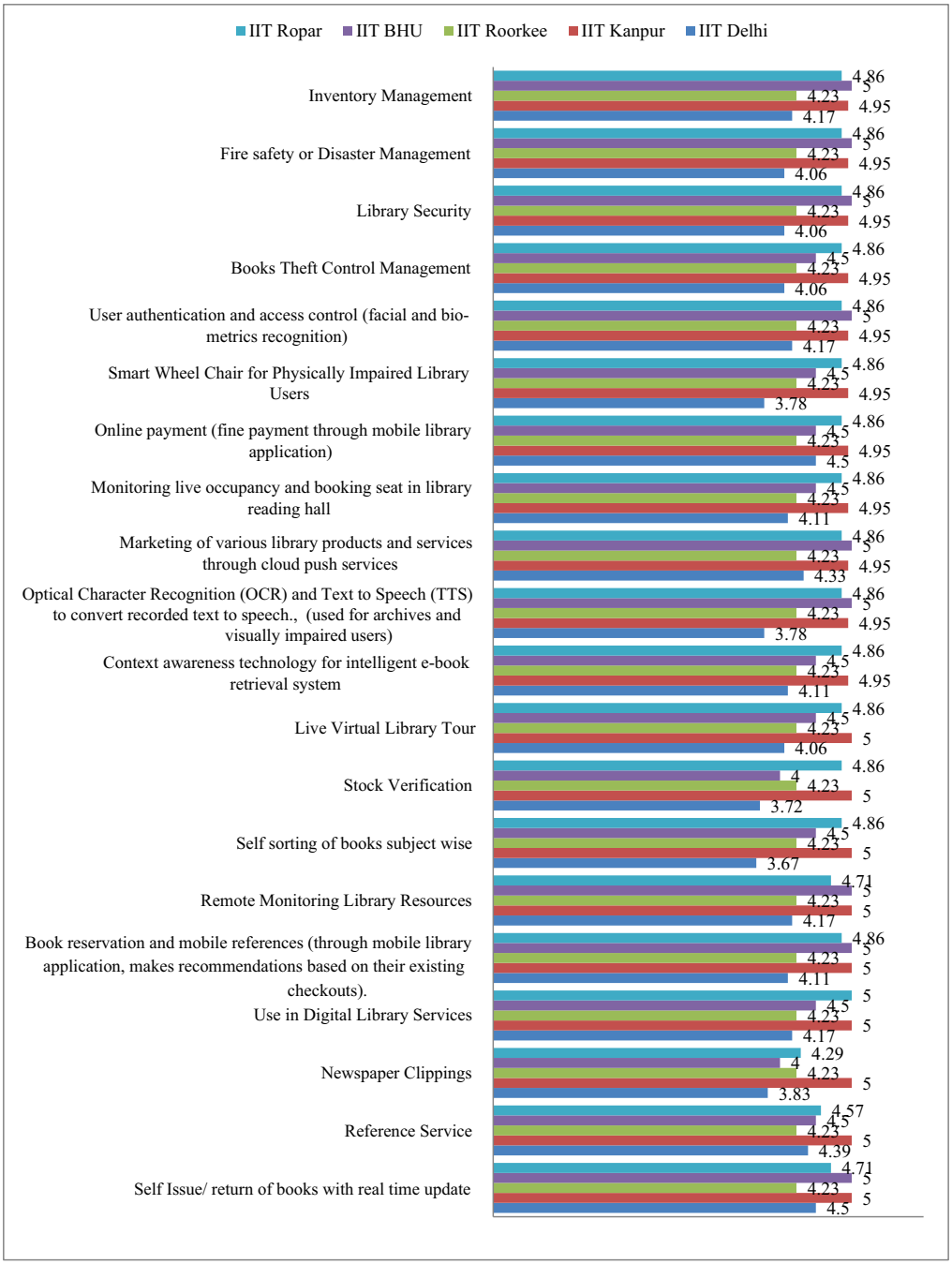

Figure 4. Areas of library services to implement IoT.

support real-time, user-centric service delivery key dimensions of smart library transformation. The emphasis on automation, remote access, and personalized services reflects a shift toward digitally integrated, responsive library ecosystems aligned with evolving user expectations. Conversely, the lower preference for traditional services such as newspaper clippings suggests a declining relevance of legacy practices in an increasingly digital environment. Institutional comparisons further highlight

that IIT Kanpur and IIT BHU strongly favor automated circulation systems, while IIT BHU emphasizes marketing-oriented applications and IIT Ropar prioritizes digital library services, indicating that local institutional priorities and technological readiness shape adoption patterns. These insights underline the need for targeted digital policies and continuous professional development initiatives to support the effective integration of IoT, ensuring both technological advancement and user-focused service innovation in academic libraries.

Awareness and adoption readiness about Future Planning of Institute

The findings suggest that integrating IoT into library services is widely recognized as a strategic pathway to enhance user experience while improving operational efficiency. An interpretive reading of Table 6 indicates a strong institutional commitment toward future adoption, with all five IITs expressing plans to develop or integrate IoT-based library services most notably IIT Roorkee and IIT BHU (Mean = 5, SD = 0), followed by IIT Delhi (Mean = 4.67, SD = 0.686) and IIT Kanpur (Mean = 4.63, SD = 0.496), while IIT Ropar shows comparatively moderate readiness (Mean = 3.29, SD = 0.756). These variations reflect differing levels of institutional preparedness, resource availability, and strategic prioritization. From a broader perspective, the strong inclination toward IoT integration signals a shift toward future-ready, smart library ecosystems aligned with digital transformation agendas in higher education. At the policy level, this underscores the need for sustained investment in technological infrastructure, capacity building, and institutional support systems to translate intent into implementation. Additionally, the comparatively lower readiness in some institutions highlights the importance of addressing disparities through targeted interventions, collaborative frameworks, and knowledge-sharing mechanisms to ensure more uniform and inclusive advancement of IoT-enabled library services.

In reference to the research question the underneath hypothesis was constructed.

Ha There is a significant difference in the extent of adoption readiness of LIS professionals towards IoT-based library services among various IITs of Northern India.

H0 There is no significant difference in the extent of adoption readiness of LIS professionals towards IoT-based library services among various IITs of Northern India.

Table 7 presents the calculated values of Mean, Standard Deviation, t-test and p-value for the extent of awareness and adoption readiness of LIS professionals towards IoT-based library services among various IITs of Northern India.

The calculated value in Table 7 indicate that difference among LIS professionals of IITs, were IIT Delhi (Mean = 38.28, SD = 7.89), IIT Kanpur (Mean = 20.58, SD = 2.52), IIT Roorkee (Mean = 35.38, SD = 8.77), IIT Varanasi (Mean = 25.50, SD = 2.12) and IIT Ropar (Mean = 23.86, SD = 6.64) for the extent of adoption readiness of LIS professionals towards IoT-based library services among various IITs of Northern India is significant; thus calculated f-value (df) = (20.529, p = .000), revealing the significant difference.

Table 6. Awareness and adoption readiness about Future Planning of Institute.

Future plan for developing or integrating IoT based library services		Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
	IIT Delhi	4.67	.686	.162	4.33	5.01
	IIT Kanpur	4.63	.496	.114	4.39	4.87
	IIT Roorkee	5.00	0.000	0.000	5.00	5.00
	IIT BHU	5.00	0.000	0.000	5.00	5.00
	IIT Ropar	3.29	.756	.286	2.59	3.98
	Total	4.36	.713	.093	4.17	4.54

Table 7. Level of adoption readiness towards IoT-based library services among LIS professionals of IITs.

	Institution													
	IIT Delhi		IIT Kanpur		IIT Roorkee		IIT BHU		IIT Ropar		Total			
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	F-value	p-value
Adoption readiness towards IoT-based library services	38.28	7.89	20.58	2.52	35.38	8.77	25.50	2.12	23.86	6.64	29.80	10.14	20.529	0.000

From the above interpretation it is revealed that for the extent of adoption readiness of LIS professionals towards IoT-based library services among various IITs of Northern India is significant (p-value is ≤ 0.05) among LIS professionals of IITs of Northern India.

Hence it is concluded that, the null hypothesis H0 "There is no significant difference in the extent of adoption readiness of LIS professionals towards IoT-based library services among various IITs of Northern India" stands to be rejected. Consequently, the alternative hypothesis Ha "There is a significant difference in the extent of adoption readiness of LIS professionals towards IoT-based library services among various IITs of Northern India" is accepted. Thus, we consider the alternative hypothesis as true and reject the null hypothesis.

Table 8 presents the results of independent sample t-tests examining differences in LIS professionals adoption readiness of IoT-based library services across five IITs. The analysis reveals statistically significant variations ($p < .05$) among several institutional pairs, indicating uneven distribution of adoption readiness levels. In particular, IIT Delhi demonstrates significantly higher adoption readiness compared to IIT Kanpur, IIT BHU, and IIT Ropar, while its difference with IIT Roorkee is not statistically significant. Similarly, IIT Roorkee shows higher adoption readiness than IIT Kanpur, IIT BHU, and IIT Ropar. IIT Kanpur, with the lowest mean adoption readiness, differs significantly from IIT Delhi, IIT Roorkee, and IIT BHU, but not from IIT Ropar, and no significant difference is observed between IIT BHU and IIT Ropar. Interpreting these findings, the results point to institutional disparities in exposure, digital infrastructure, and user engagement with emerging technologies like IoT. Higher awareness and adoption readiness levels in institutions such as IIT Delhi and IIT Roorkee may reflect stronger digital ecosystems, proactive user education, and greater integration of smart services, whereas comparatively lower awareness and adoption readiness in other IITs suggests gaps in outreach, training, or implementation. These differences carry important implications for digital policy and library strategy, emphasizing the need for targeted awareness programmes, user training initiatives, and inter-institutional knowledge sharing to ensure more equitable adoption and effective utilization of IoT-enabled library services across academic institutions.

Table 8. Pairwise Independent Sample t-Test Results: Awareness and adoption readiness towards IoT-Based Library Services.

Comparison	Mean Difference	t-value	p-value	Significant (p < .05)
IIT Delhi vs IIT Kanpur	17.70	6.63	0.000	Yes
IIT Delhi vs IIT Roorkee	2.90	0.81	0.426	No
IIT Delhi vs IIT BHU	12.78	3.92	0.001	Yes
IIT Delhi vs IIT Ropar	14.42	4.19	0.001	Yes
IIT Kanpur vs IIT Roorkee	−14.80	−4.82	0.000	Yes
IIT Kanpur vs IIT BHU	−4.92	−3.00	0.010	Yes
IIT Kanpur vs IIT Ropar	−3.28	−1.42	0.172	No
IIT Roorkee vs IIT BHU	9.88	2.85	0.012	Yes
IIT Roorkee vs IIT Ropar	11.52	3.05	0.009	Yes
IIT BHU vs IIT Ropar	1.64	0.81	0.430	No

Compiled by Researcher.

Regression Analysis of Factors Influencing IoT adoption readinesses in Library Services

To identify and quantify the key factors that influence how LIS professionals are adoption readiness about the applicability of IoT in library services regression analysis is used for this study. By using this method, the study could go beyond simple descriptive statistics and determine which specific demographic or professional characteristics such as institute affiliation, work experience, or general IoT adoption readiness significantly contribute to this perception. It helps in understanding patterns, relationships, and predictors in a complex dataset, offering deeper insights into the underlying drivers of IoT readiness and awareness within academic libraries.

According to Table 9 and Figure 5, the regression analysis examining factors influencing LIS professionals' adoption readiness of IoT implementation in library services reveals that institutional affiliation and professional experience are key determinants. Respondents from IIT Kanpur (β = 11.657, p = .005), IIT BHU (β = 10.250, p = .043), and IIT Ropar (β = 12.344, p = .013) demonstrate significantly higher adoption readiness compared to IIT Delhi (reference category), indicating that institutional context such as technological exposure, organizational priorities, and innovation culture plays a crucial role in shaping perceptions. Additionally, professionals with 16–20 years of experience report significantly higher adoption readiness than those with less than 5 years (β = 10.394, p = .026), suggesting that accumulated professional engagement and experiential learning enhance understanding of emerging technologies. The positive and significant effect of general IoT knowledge in society and industry (β = 0.570, p = .032) further indicates a spillover effect, where broader technological awareness and adoption readiness translates into domain-specific readiness within libraries. In contrast, variables such as age, gender, designation, and sources of familiarity do not exhibit statistical significance, implying that awareness is less influenced by demographic characteristics and more by institutional and experiential factors. With a strong model fit (R^2 = 0.817), these findings underscore the importance of institutional support, continuous professional

Table 9. Factors Influencing IoT Awareness and adoption readiness.

Areas in the library services where IoT can be implemented		Coef.	Std. Err.	t	p-value	[95% Conf.	Interval
Gender Ref. Male	Female	1.967	1.944	1.010	0.318	−1.967	5.902
AgeGroup	31-40	−4.965	3.740	−1.330	0.192	−12.536	2.607
	41-50	−5.473	5.614	−0.970	0.336	−16.837	5.892
	>50	−6.617	7.258	−0.910	0.368	−21.310	8.076
Institute Reference IIT Delhi	IIT Kanpur	11.657	3.922	2.970	0.005	3.716	19.597
	IIT Roorkee	9.201	5.297	1.740	0.091	−1.523	19.925
	IIT BHU	10.250	4.890	2.100	0.043	0.350	20.150
	IIT Ropar	12.344	4.731	2.610	0.013	2.766	21.922
Professional Designation Reference Librarian	Deputy Librarian	−0.790	4.959	−0.160	0.874	−10.828	9.248
	Assistant Librarian	3.921	4.202	0.930	0.357	−4.585	12.428
	Library and Information Officer	−1.618	3.949	−0.410	0.684	−9.612	6.376
	Library and Information Assistant	−0.661	4.275	−0.150	0.878	−9.315	7.994
	Others	0.420	5.950	0.070	0.944	−11.626	12.466
Working Experience Reference <5 Years	6-10 Years	3.968	3.069	1.290	0.204	−2.245	10.180
	11-15 Years	2.504	4.149	0.600	0.550	−5.895	10.903
	16-20 Years	10.394	4.484	2.320	0.026	1.316	19.472
	21-25 Years	−1.115	3.548	−0.310	0.755	−8.297	6.068
	>25 Years	3.359	6.363	0.530	0.601	−9.522	16.239
Source of familiarity with IoT		−0.618	1.742	−0.350	0.725	−4.144	2.908
Areas where IoT can be implemented in society/industry		0.570	0.255	2.230	0.032	0.053	1.087
Constant		59.005	12.838	4.600	0.000	33.015	84.995
R Square		0.8172					
Adjusted R Square		0.721					
AIC		381.17					
BIC		424.8					

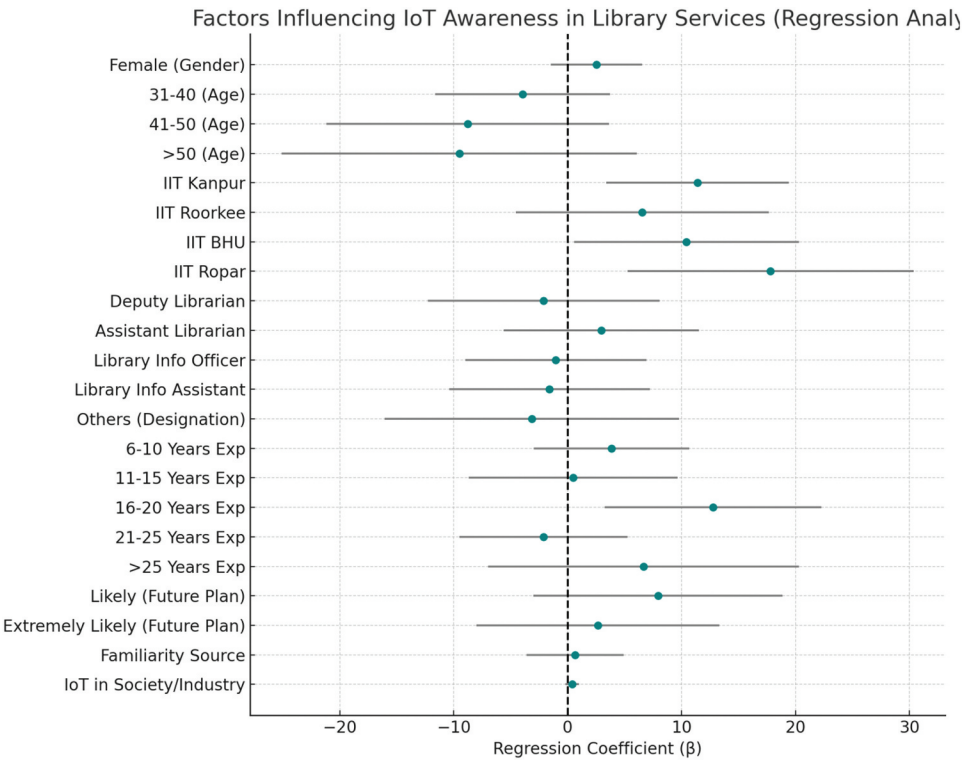

Figure 5. Regression Analysis of Factors Influencing IoT Awareness and adoption readiness.

development, and cross-sectoral exposure in advancing IoT readiness. From a policy and practice perspective, this highlights the need for targeted training programmes, inter-institutional collaboration, and strategic initiatives to bridge adoption readiness gaps and foster more uniform adoption of IoT-enabled library services.

Regression analysis was conducted to identify the factors influencing LIS professionals' adoption readiness of IoT-enabled library service areas. The results presented in Table 10 indicate that institutional affiliation and work experience are significant predictors. Respondents from IIT Ropar (β = 17.803, p = .007), IIT BHU (β = 10.420, p = .039), and IIT Kanpur (β = 11.377, p = .007) exhibit significantly higher awareness and adoption readiness compared to IIT Delhi, suggesting that institutional ecosystems such as technological infrastructure, innovation culture, and administrative support play a decisive role in shaping awareness levels. Additionally, professionals with 16–20 years of experience demonstrate significantly greater awareness than those with less than 5 years (β = 12.746, p = .010), highlighting the importance of accumulated professional exposure and experiential learning in understanding emerging technologies. Other variables, including gender, age, designation, IoT familiarity, and future integration plans, do not show statistically significant effects, indicating that awareness is less dependent on demographic attributes and more on contextual and experiential factors. The model explains a substantial proportion of variance (R^2 = 0.8305), reflecting a strong overall fit. Interpreting these findings through the lens of the TAM, the results suggest that institutional environments that better facilitate the perceived usefulness and practical integration of IoT contribute to higher awareness levels. Similarly, mid-career professionals (16–20 years of experience) are likely to possess a more refined understanding of the practical benefits of IoT, reinforcing the role of perceived usefulness in technology acceptance.

Table 10. Determinants of IoT Awareness and adoption readiness in Library Services.

Areas in the library services where IoT can be implemented		Coef.	Std. Err.	t	p-value	[95% Conf.	Interval]
Gender Ref. Male	Female	2.532	1.980	1.280	0.209	−1.483	6.548
Age Group	31-40	−3.944	3.781	−1.040	0.304	−11.611	3.723
	41-50	−8.768	6.115	−1.430	0.160	−21.169	3.633
	>50	−9.502	7.685	−1.240	0.224	−25.088	6.083
Institute Reference IIT Delhi	IIT Kanpur	11.377	3.953	2.880	0.007	3.360	19.393
	IIT Roorkee	6.552	5.475	1.200	0.239	−4.552	17.655
	IIT BHU	10.420	4.865	2.140	0.039	0.553	20.286
	IIT Ropar	17.803	6.194	2.870	0.007	5.241	30.364
Professional Designation Reference Librarian	Deputy Librarian	−2.104	5.012	−0.420	0.677	−12.269	8.061
	Assistant Librarian	2.954	4.222	0.700	0.489	−5.608	11.515
	Library and Information Officer	−1.052	3.922	−0.270	0.790	−9.007	6.903
	Library and Information Assistant	−1.595	4.347	−0.370	0.716	−10.411	7.221
	Others	−3.147	6.377	−0.490	0.625	−16.080	9.786
Working Experience Reference <5 Years	6-10 Years	3.852	3.370	1.140	0.261	−2.983	10.686
	11-15 Years	0.478	4.523	0.110	0.916	−8.695	9.651
	16-20 Years	12.746	4.686	2.720	0.010	3.243	22.249
	21-25 Years	−2.118	3.630	−0.580	0.563	−9.480	5.243
	>25 Years	6.650	6.729	0.990	0.330	−6.997	20.297
Future plan for developing or integrating IoT based library services (Reference)	Likely	7.921	5.392	1.470	0.151	−3.015	18.856
	Extremely Likely	2.653	5.248	0.510	0.616	−7.990	13.297
Source of familiarity with IoT		0.664	2.100	0.320	0.754	−3.596	4.924
Areas where IoT can be implemented in society/industry		0.400	0.293	1.360	0.181	−0.195	0.995
constant		58.084	13.333	4.360	0.000	31.044	85.124
R Square		0.8305					
Adjusted R Square		0.7269					
AIC		380.72					
BIC		428.5					

Discussion

To address RQ1 and RQ2 more comprehensively, the findings of this study move beyond assessing awareness to examining adoption readiness of IoT among LIS professionals is highlighted in Table 11 and Figure 6. The results indicate that awareness and adoption readiness levels are high and have translated into a meaningful degree of readiness, as most professionals have been exposed to IoT through professional discussions, meetings, on-the-job training, conferences, workshops, webinars, faculty development programmes, web resources, and social networking platforms.[55] This exposure has enabled respondents to recognize the applicability of IoT across diverse domains such as smart grids, healthcare (IoMT), public safety, environmental monitoring, education, and smart environments, reflecting a broad techno-functional understanding, although relatively less emphasis is placed on socially assistive applications such as independent living for the elderly.[56] In the context of IoT-based library services (RQ2), LIS professionals across IITs demonstrate strong adoption readiness, particularly for applications that enhance operational efficiency and user experience, including automated circulation systems, mobile-based services, digital resource management, real-time monitoring, and security systems, while traditional services like newspaper clippings are considered less relevant.[57] Institutional comparisons reveal that IIT Kanpur and IIT BHU show stronger orientation toward automation and infrastructure-driven applications, whereas IIT Delhi demonstrates a more service-oriented and scalable approach, indicating that institutional culture and technological maturity influence adoption readiness. However, despite this positive outlook, several structural and operational barriers constrain actual adoption, including inadequate infrastructure, financial

Table 11. Summarizes key findings and their implications.

Dimension	Key Findings (Evidence from Data)	Interpretation	Implications for Practice & Policy
Demographic Profile	Majority male (67.8%); females (32.2%)	Gender imbalance in LIS workforce participation	Encourage inclusive participation and gender-sensitive professional engagement strategies
Age Distribution	Dominated by 41–50 years (62.7%)	Mid-career professionals form the core workforce	Target this group as key drivers of IoT implementation and change management
Designation	Majority are Library & Information Officers (35.6%) and Assistants (28.8%)	Operational staff dominate sample	Focus training on mid-level staff who directly implement IoT services
Work Experience	Highest in 16–20 years (33.9%)	Experienced professionals have stronger influence	Develop advanced training modules for mid-career professionals
Source of IoT Awareness	Professional discussions/training (93.2%), conferences/web (89.8%), social media (78%)	Formal channels dominate awareness creation	Institutionalize structured training and FDPs; leverage digital platforms more effectively
IoT Application Awareness (General)	Highest: Smart grids (Mean = 4.69), healthcare (4.68), education (4.63)	Preference for infrastructure-driven applications	Expand awareness toward user-centric and assistive technologies
IoT in Library Services	Top: Automated circulation (Mean = 4.64), marketing (4.59), reference services (4.58)	Focus on efficiency, automation, and user services	Prioritize high-impact, user-centric IoT services in implementation
Low Priority Areas	Newspaper clipping (Mean = 4.36)	Decline of traditional services	Re-evaluate legacy services in digital transformation strategies
Institutional Readiness (Future Plans)	Highest: IIT Roorkee & BHU (Mean = 5.00); Lowest: IIT Ropar (3.29)	Variation in institutional preparedness	Adopt phased, institution-specific IoT implementation strategies
Adoption Readiness (ANOVA)	Significant differences ($F = 20.529$, $p = .000$)	Awareness/readiness varies across IITs	Need for standardized national-level frameworks
Pairwise Differences	IIT Delhi > Kanpur, BHU, Ropar; Roorkee > most others	Institutional ecosystem strongly influences readiness	Promote inter-institutional collaboration and knowledge sharing
Key Predictors (Regression)	Significant: Institution (Kanpur, BHU, Ropar), Experience (16–20 yrs), IoT knowledge ($\beta = 0.570$)	Awareness driven by institutional and experiential factors	Strengthen institutional support and cross-sector exposure
Non-significant Factors	Gender, age, designation	Demographics less influential	Focus policies on skills, infrastructure, and environment
Barriers Identified	Infrastructure gaps, lack of skills, financial constraints, privacy concerns	Major obstacles to implementation	Invest in infrastructure, training, and data governance policies
Model Strength	High explanatory power ($R^2 \approx 0.82$–0.83)	Strong reliability of findings	Suitable for evidence-based policy formulation

limitations, lack of integrated IoT ecosystems, and insufficient technical expertise among LIS professionals.[58] These challenges are further compounded by concerns related to data privacy, surveillance, and ethical use of information,[59] highlighting the need for robust policy frameworks and governance mechanisms. From a theoretical perspective, when interpreted through the lens of the TAM the transition from readiness to actual adoption is mediated by perceived usefulness (PU) and perceived ease of use (PEOU) while professionals recognize the utility of IoT in enhancing efficiency and service delivery (high PU), barriers such as limited infrastructure and skills reduce PEOU, thereby affecting behavioral intention. External variables such as institutional support, training, and system accessibility are therefore critical in strengthening both PU and PEOU, aligning with findings by.[60] Situating these results within a global context, similar trends have been observed in countries such as China and Malaysia[61], where IoT adoption in libraries is driven by strong institutional investment but constrained by skill gaps and integration challenges, while studies from South Africa highlight issues of digital inequality and infrastructure limitations affecting adoption readiness.[62] Compared to these contexts, IIT libraries demonstrate relatively higher awareness and strategic intent, yet face comparable implementation barriers, indicating that they are aligned with broader global smart library trends but still

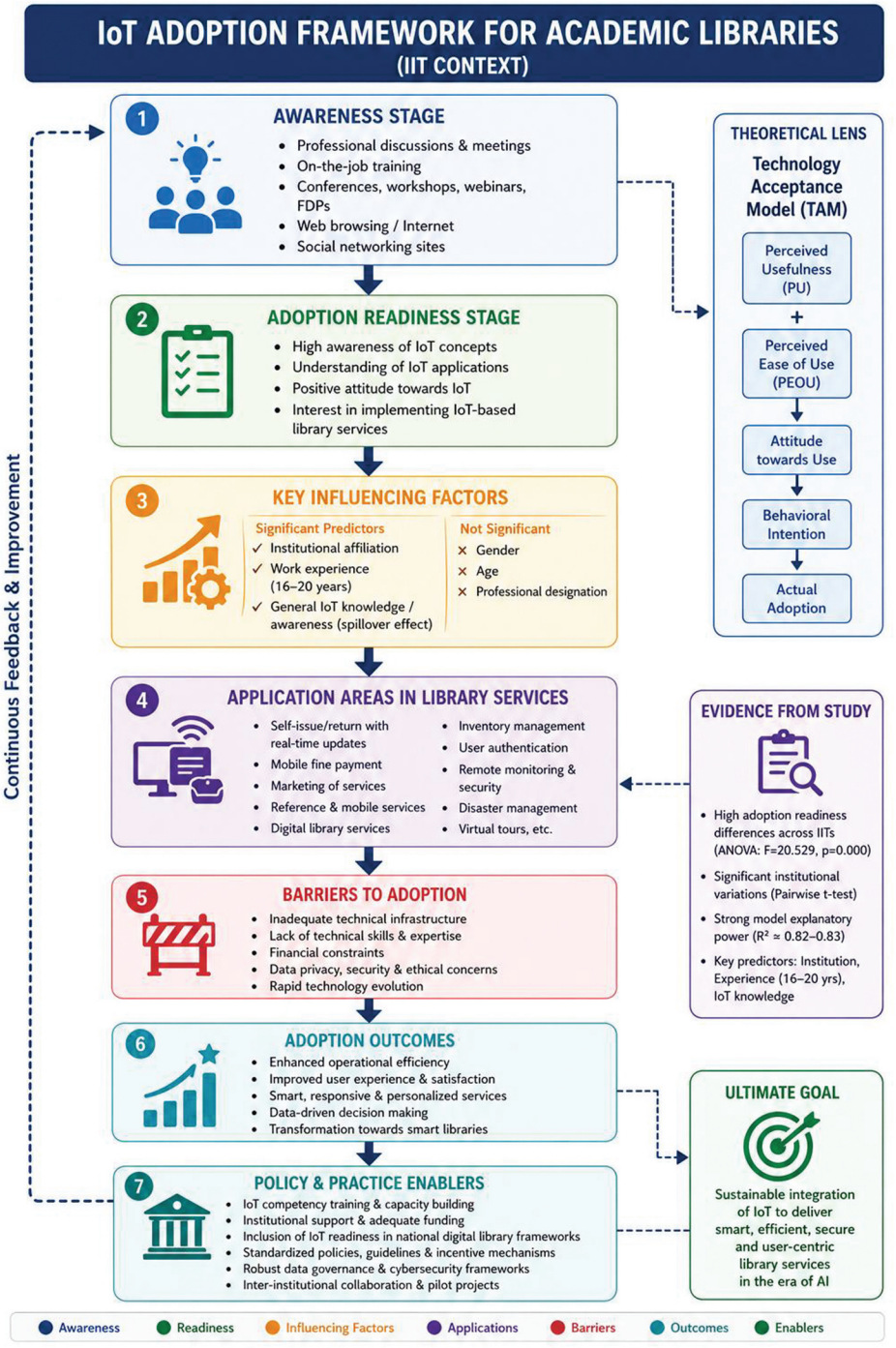

Figure 6. IoT adoption framework for academic libraries.

navigating the transition from readiness to sustained adoption. These insights underscore the need for a coordinated national strategy for smart libraries, including targeted funding, capacity-building initiatives, inter-institutional collaboration, and pilot projects within leading institutions like IITs to act as innovation testbeds. Furthermore, establishing strong data governance frameworks aligned with national and international standards.[63] fostering partnerships with technology providers, and promoting a culture of continuous learning are essential for sustainable implementation. Lessons from international experiences, such as university libraries in the UAE, further reinforce the importance of strategic planning, staff training, and cost-effective deployment.[64] Aligning IoT integration with broader developmental agendas such as the UN Sustainable Development Goals particularly SDG 4 (Quality Education) and SDG 9 (Industry, Innovation, and Infrastructure) can further strengthen the societal relevance of smart libraries. IoT readiness among LIS professionals can drive smart library development, support India's digital campus initiatives, and strengthen global understanding of technology adoption in higher education libraries.[65]

The findings of this study offer several practical implications for library administrators, policymakers, and LIS educators. First, institutions should develop phased implementation strategies that prioritize high-impact and cost-effective IoT applications such as RFID-enabled circulation, environmental monitoring systems, occupancy management, and smart access control. Pilot projects within technologically advanced institutions like IITs may serve as innovation testbeds for scalable smart library models across Indian higher education institutions. Second, targeted funding mechanisms and infrastructure support from national agencies are essential to reduce financial constraints and encourage experimentation with emerging technologies. Third, continuous capacity-building programmes, specialized training modules, and interdisciplinary collaborations should be introduced to strengthen the technical competencies of LIS professionals in areas such as IoT architecture, data analytics, cybersecurity, cloud integration, and ethical information management.[66] At the policy level, there is a pressing need for a coordinated national framework for smart libraries that establishes standards for interoperability, data governance, privacy protection, and ethical use of IoT-generated data. Partnerships between libraries, technology providers, academic institutions, and government agencies can further facilitate knowledge exchange, resource sharing, and cost-effective deployment strategies.[67]

Implications

This research highlights how the IoT has the ability to revolutionize library services and opens the door for educational institutions to implement smart library systems. A critical need for organized, ongoing professional development is highlighted by the findings, which show that LIS professionals primarily learn about IoT through conferences, meetings, professional discussions, and on-the-job training. To equip LIS professionals with the skills they need to successfully use IoT technologies, institutions must invest in focused training courses and workshops.[68] LIS professionals' preferences across IITs provide important information about regional adoption trends and needs. IIT Kanpur and IIT BHU, for instance, highlight real-world applications like online payment systems and real-time book transaction updates, highlighting the significance of user-centered service innovation. The need for data-driven resource allocation and service prioritization is contrasted by IIT Kanpur's lack of interest in newspaper clippings and IIT Ropar's emphasis on digital library services. The necessity of context-specificity, responsiveness to institutional priorities, and alignment with user expectations is emphasized by these variations in IoT implementations. The development of IoT in next-generation smart libraries is inextricably linked to new technologies like cloud computing, big data, and AI creating a synergistic ecosystem that has the potential to completely rethink the way library services are conceived and provided.[69] This study shows that IoT has already started to transform library operations by

making smart access control, remote monitoring, and real-time book transactions possible. In the future, incorporating AI will improve these capabilities even more by enabling automated cataloging, intelligent recommendation systems catered to specific learning requirements and predictive analytics for user behaviour.[70] By combining and evaluating vast amounts of user interaction data, big data plays a vital role in guiding resource allocation, collection development, and customized services. This is consistent with investigation from IITs like BHU and Kanpur, where emphasis is already being placed on user-centered innovations like online payments and real-time updates. Additionally, libraries can deploy services across multiple branches and user devices while maintaining data integrity and security thanks to cloud computing's provision of the infrastructure required for scalability, data interoperability, and seamless access.[71]

Additionally, the study highlights a number of high-impact IoT application areas in libraries, such as remote monitoring, user authentication, access control, and live virtual tours. These results provide a useful road map for organizations looking to update their library spaces. On the other hand, identifying less popular features like newspaper clipping services allows organizations to concentrate on value-generating technologies and avoid making unnecessary investments. The five IITs' dedication to creating or growing IoT-based library services is indicative of a growing understanding of the strategic significance of IoT. This acknowledgment encourages long-term planning, software, infrastructure, and technology provider partnerships. This kind of cooperation can spur innovation and guarantee that libraries develop in step with advances in technology. Importantly, the study's conclusions have ramifications for policy. With a focus on data privacy, security, interoperability, and scalability, institutions can use this research to develop thorough frameworks and guidelines that regulate IoT adoption in libraries. The potential of IoT for smart library infrastructure, the growing role of AI in data curation and discovery have the vital significance of cybersecurity.[72] By ensuring that IoT integration improves rather than complicates library operations, these policies will help protect user interests.

Conclusion and Recommendations

This study highlights the transformative potential of IoT technologies in reshaping academic library services within institutions such as the IITs, positioning libraries as integral components of smart campus ecosystems aligned with Industry 5.0. By integrating tools such as RFID, smart sensors, automated circulation systems, real-time space management, and data-driven analytics, libraries can evolve into intelligent, user-centric knowledge hubs that enhance efficiency, optimize resources, and support evidence-based decision-making. Importantly, the findings provide clear directions and action for libraries and institutional leaders should prioritize high-impact IoT applications (e.g., automated circulation and digital services), invest in robust infrastructure, and adopt phased, context-specific implementation strategies; educators and LIS professionals should develop structured IoT training frameworks, integrate emerging technologies into LIS curricula, and strengthen continuous professional development initiatives; and policymakers should incorporate IoT into national and institutional library modernization programmes while formulating comprehensive policies addressing data privacy, cybersecurity, and ethical use. The study further reveals that institutional environment and professional experience significantly influence IoT adoption readiness, underscoring the need for supportive organizational ecosystems, targeted capacity-building and inter-institutional collaboration to bridge readiness gaps. Although limited by its sample scope and reliance on self-reported data, the study offers both theoretical and practical contributions by linking technology adoption insights with actionable strategies, thereby providing a roadmap for libraries, educators, and policymakers to effectively operationalize IoT-enabled transformation in academic library systems. To translate adoption readiness into effective implementation, a coordinated, evidence-based approach

involving libraries, educators, and policymakers is essential. Library leaders should strategically integrate IoT into service design by prioritizing high-impact, user-centric applications such as automated circulation, real-time resource tracking, smart space management, and personalized digital services, while adopting phased and context-specific implementation models supported by robust infrastructure and partnerships with technology providers. At the same time, continuous assessment mechanisms should be established to evaluate performance, user satisfaction, and system scalability. For educators and LIS training institutions, there is a critical need to redesign curricula and professional development programmes to embed IoT competencies, including hands-on training in smart technologies, data analytics, system integration, and ethical data management, thereby equipping future professionals with both technical and analytical skills. Policymakers and governing bodies should incorporate IoT readiness into national and institutional digital library frameworks by developing comprehensive policies that address funding, infrastructure development, cybersecurity, data privacy, and ethical use, while also promoting inter-institutional collaboration and pilot projects particularly leveraging the technological strengths of IITs as innovation testbeds for scalable solutions. Furthermore, the establishment of clear data governance frameworks is imperative to ensure user trust, regulatory compliance, and sustainable innovation. Collectively, these measures will enable a transition from awareness and readiness to meaningful, inclusive, and scalable integration of IoT technologies in academic library ecosystems. This study underscores the transformative role of IoT-enabled libraries not only in enhancing academic library services but also in advancing the broader vision of smart campuses, digital education ecosystems, and Industry 5.0. Within institutions such as the IITs, the integration of technologies like RFID, smart sensors, automated circulation systems, real-time space management, and data-driven analytics positions libraries as intelligent, interconnected hubs that support seamless knowledge access, personalized learning, and efficient resource utilization. In this context, libraries move beyond their traditional functions to actively contribute to digitally empowered, human-centric, and innovation-driven campus environments, aligning with Industry 5.0′s emphasis on the synergy between advanced technologies and human capabilities. The findings demonstrate that IoT adoption readiness among LIS professionals provides a strong foundation for this transformation, while also highlighting the critical role of institutional support and professional experience in shaping implementation outcomes.

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Author contributions

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