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Assessing Iot Readiness In Central Gujarat's University Libraries: A Framework-Based Study.

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Abstract
The integration of Internet of Things (IoT) technologies in academic libraries is redefining traditional service models by enabling automation, enhancing resource utilization, and improving user experiences. This study investigates the readiness of university libraries in Central Gujarat for IoT adoption using a multi-dimensional framework. A quantitative survey was conducted among 50 universities, evaluating key dimensions such as awareness, infrastructure, human resource capabilities, administrative support, and perceived challenges. The results indicate a high level of IoT awareness (96%) and moderate implementation (70%), with RFID systems and biometric access controls being the most commonly adopted tools. However, significant barriers—such as high technology costs (94%), shortage of ICT-trained staff (52%), and LMS integration limitations (40%)—persist. Chi-square analysis revealed statistically significant variation in the adoption of specific IoT tools ($\chi^2 = 30.28$, $p < 0.001$). Despite these challenges, respondents largely perceived IoT as a means to enhance security, operational efficiency, and service quality. The study concludes with tiered strategic recommendations and emphasizes the need for continuous skill development, infrastructure upgrades, and performance monitoring to support sustainable IoT adoption in academic libraries.
Keywords: *Internet of Things (IoT); Academic Libraries; Digital Infrastructure; RFID; Library Readiness; Smart Library Systems; ICT Skills; Gujarat Universities*

1. INTRODUCTION TO IOT IN LIBRARIES

In the current era of digital transformation, the Internet of Things (IoT) has emerged as a disruptive technology with significant implications across various sectors, including education and information services. Libraries, traditionally perceived as static repositories of physical resources, are progressively evolving into interactive, intelligent environments that leverage technology to enhance user engagement and operational efficiency(Ray, 2021). The IoT ecosystem enables interconnected devices to communicate and exchange data in real time, facilitating automation, remote monitoring, and intelligent decision-making across various library functions such as inventory management, security, and personalized services(Rani, 2020).

University libraries, serving as knowledge hubs for research and learning, are particularly well-positioned to benefit from IoT integration. Implementing smart technologies such as RFID tagging, smart shelves, biometric access, and environmental sensors can lead to optimized resource utilization, enhanced service delivery, and improved user satisfaction(Yadav, 2019). However, the transition toward IoT-enabled library systems requires a comprehensive readiness framework that considers multiple dimensions, including technological infrastructure, staff capabilities, institutional policies, and stakeholder awareness.

Despite growing interest in IoT applications, there remains a notable gap in empirical studies evaluating the preparedness of academic libraries, particularly in regional contexts like Central Gujarat. Understanding the current level of readiness is critical for guiding strategic planning and investment decisions. This study, therefore, aims to assess the preparedness of university libraries in Central Gujarat for IoT integration, providing insights into the enabling and inhibiting factors that influence successful implementation.

This study aims to bridge that gap by systematically evaluating the readiness of university libraries to adopt IoT technologies. The proposed readiness framework examines key dimensions including technical infrastructure, human resource capacity, budgetary support, administrative backing, and perceived benefits and barriers.

2. LITERATURE REVIEW

The integration of the Internet of Things (IoT) into university libraries is transforming traditional library services by enhancing operational efficiency, improving service delivery, and enriching user engagement. As academic libraries evolve into intelligent digital ecosystems, it becomes crucial to evaluate their preparedness for adopting IoT technologies. This review synthesizes recent literature focusing on six key dimensions: concept and application, technological infrastructure, human resources, financial investment, case studies, and future research directions.

2.1Concept and Application of IoT in Libraries

IoT refers to a network of interconnected devices that autonomously collect and exchange data. In libraries, technologies such as RFID, sensors, and QR codes automate processes like inventory tracking and climate control(Jasim, Khalil, & Hussain, 2021). These smart systems enable real-time monitoring and personalized service delivery. Patel et al(Patel & Sharma, 2022) highlight how IoT enhances user experience through automated check-in/check-out systems, environmental regulation, and adaptive user interfaces.

2.2Technological Infrastructure and IoT Readiness

Robust infrastructure is essential for IoT integration. Libraries must ensure the availability of scalable servers, high-speed wireless networks, and IoT-compatible Library Management Systems (Ali, Gupta, & Mehta, 2021). Rahman et al(Rahman & Gupta, 2022) emphasize cloud computing as a scalable foundation for IoT systems, while Farooq et al(Farooq, Hussain, & Sheikh, 2023) advocate for integrating APIs to facilitate seamless interoperability between devices and backend systems.

2.3 Human Resources and Skills for IoT Implementation

Skilled personnel are critical for IoT implementation. Kumar et al(Kumar & Sinha, 2023) propose a competency framework covering device management, data analytics, and cybersecurity awareness. However, resistance to change and lack of training are common barriers (Alghamdi, Hussain, & Rahman, 2021). Agrawal et al (Agrawal & Yadav, 2022) recommend stronger collaboration between librarians and IT professionals to overcome these challenges.

2.4Financial and Resource Allocation for IoT Adoption

Budget constraints often hinder IoT adoption in developing countries. Gupta et al (A. Gupta & Mehta, 2022) identify limited funding as a key obstacle. To mitigate this, Suresh, Thomas et al (Suresh, Thomas, & Roy, 2023) suggest leveraging institutional grants and public-private partnerships. Ramesh et al (Ramesh & Nair, 2021)advocate phased implementation to reduce upfront costs and support sustainable adoption.

2.5Case Studies and Best Practices

Several universities have successfully implemented IoT in their libraries:

- The University of Hong Kong adopted RFID for asset management, reducing inventory discrepancies by 30% (Wong, Lee, & Chan, 2021).
- MIT Libraries installed smart climate control to protect rare collections, cutting energy use by 25% (Smith & Chen, 2022).
- IIT Delhi deployed IoT-enabled visitor management systems to improve access control (R. Gupta, Sharma, & Choudhary, 2023).

2.6Future Scope and Research Directions

Alkhateeb et al(Alkhateeb, Almalki, & Alzahrani, 2022) emphasize the need for longitudinal studies to assess the sustained impact of IoT in libraries. Future research should explore:

- AI-enabled IoT systems for intelligent automation.
- Blockchain-based security protocols.
- User-centric IoT applications tailored to academic needs and accessibility standards.

3. Research Objectives:

1. To examine the level of awareness about the Internet of Things (IoT) among university library professionals.
2. To identify the current status of IoT implementation in university libraries (i.e., stages of adoption and types of tools used).
3. To analyse the association between the type of IoT tool and its frequency of planned implementation.
4. To evaluate the infrastructural and technical readiness of university libraries for IoT implementation.
5. To assess the availability and preparedness of skilled staff for maintaining and developing library services through IoT.

6. To determine the perceived benefits and challenges of IoT implementation from the perspective of library professionals.
7. To understand the perceptions of librarians on the impact of IoT on workload, security, service delivery, and employment.
8. To identify the key motivating factors and limitations influencing IoT adoption in university libraries.

4. Scope

This study evaluates the readiness of university libraries in Central Gujarat for Internet of Things (IoT) integration, with a focus on four critical dimensions: awareness, existing infrastructure, staff capabilities, and institutional support. The objective is to assist administrators and policymakers by providing insights into the current levels of IoT adoption and identifying the key factors influencing successful implementation.

The distribution of universities considered in this study is presented below:

(Table 1 Types of Universities in the Central Zone of Gujarat)

Type of University	Number of Universities	Percentage (%)
Central University	1	2.00
State University	17	34.00
Deemed University	2	4.00
Private University	30	60.00
Total	**50**	**100.00**

5. METHODOLOGY

This study employed a quantitative, survey-based research design to evaluate the readiness of university libraries in Central Gujarat for the integration of Internet of Things (IoT) technologies. The target population included library professionals and institutional decision-makers involved in technological planning, infrastructure management, and library operations.

A structured questionnaire was developed and disseminated electronically via Google Forms to respondents across 50 universities, encompassing a mix of private, state, deemed, and central universities. The questionnaire was designed to assess multiple dimensions of IoT readiness, including awareness levels, current implementation status, infrastructural capacity, availability of skilled personnel, perceived benefits, barriers, and future plans for IoT integration.

The data collected were analysed using Microsoft Excel and SPSS for statistical computation. Descriptive statistics (such as percentages and frequency distributions) were used to summarise key variables. Chi-square tests were applied to examine the significance of differences across categories of IoT tool adoption. Additionally, a factor ranking technique was employed to assess and prioritise the key motivators and limitations influencing IoT adoption in university libraries.

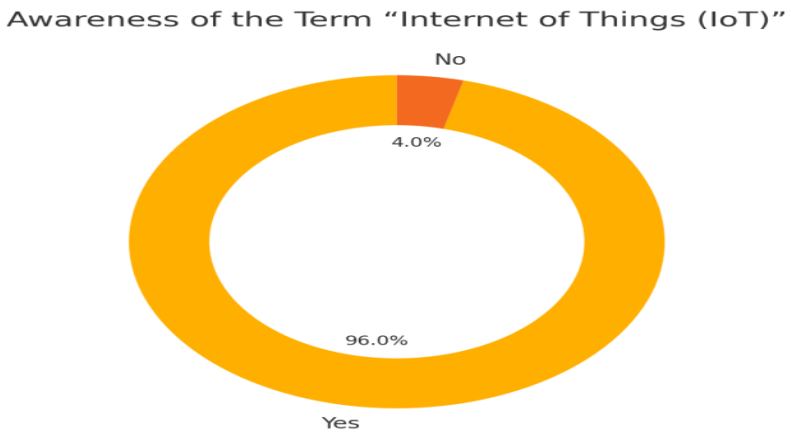
This multi-tiered analysis allowed the researchers to uncover critical patterns, trends, and readiness indicators, providing valuable insights for administrators and policymakers aiming to enable sustainable and effective IoT deployment in academic library environments.

6. Data Analysis and Results

The data received from the respondents are analysed and interpreted according to the research objectives:

(Table 2 Awareness of the Term "Internet of Things (IoT))

Response	Count	Percentage
Yes	48	96.00%
No	2	4.00%
Total	50	100%

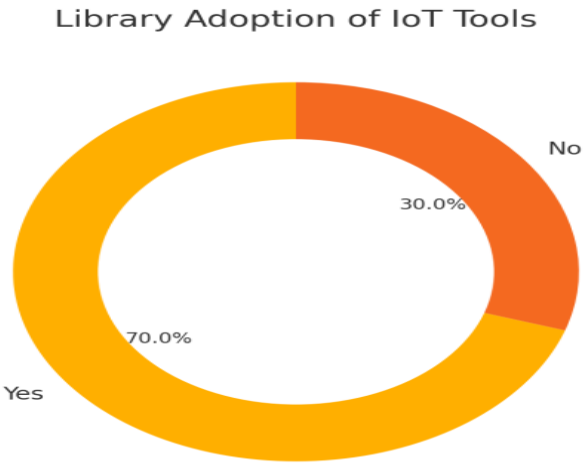


(Figure 1 Awareness of the Term "Internet of Things (IoT))

Among the 50 participants, 96% indicated awareness of the term "Internet of Things (IoT)," while only 4% were unfamiliar with it. This high level of awareness reflects a strong foundational understanding of IoT among respondents, suggesting a supportive environment for its adoption in university libraries and a solid base for conducting further research in this area.

(Table 3 Has Your Library Adopted Any IoT Tools)

Response	Count	Percentage
Yes	35	70.00%
No	15	30.00%
Total	50	100%

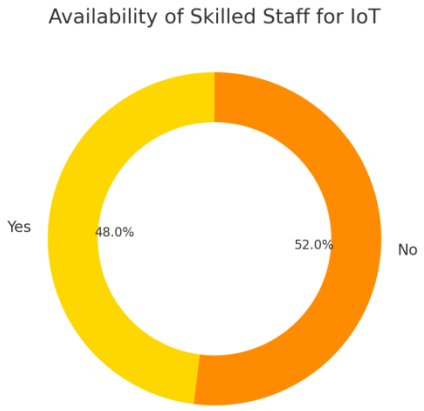


(Figure 2 Adoption Status of IoT Tools)

Seventy percent of respondents confirmed the adoption of IoT tools in their university libraries, indicating substantial progress toward digital transformation. Conversely, the 30% reporting non-adoption highlights existing gaps and underscores the need for targeted support and strategic planning to facilitate wider IoT integration across institutions.

(Table 4 Availability of Skilled Staff for IoT)

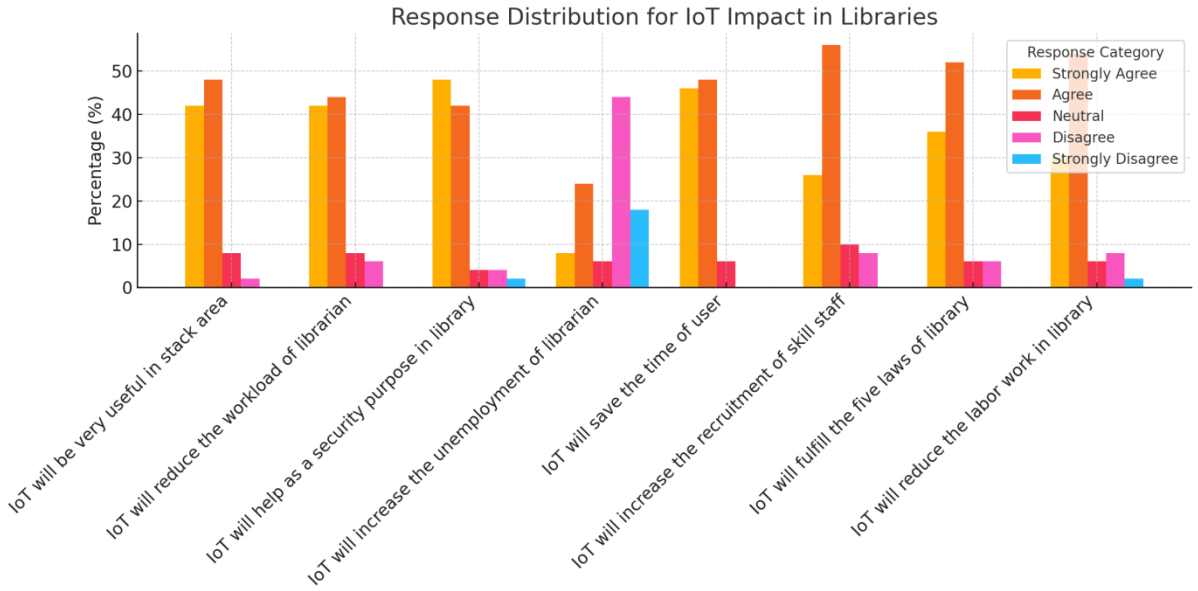
Response	Count	Percentage
Yes	24	48.00%
No	26	52.00%
Total	50	100%



(Figure 3 Availability of Skilled Personnel for IoT Management)
Among the 50 respondents, 48% reported having skilled staff for IoT management, while 52% indicated a lack of such personnel. This near-even divide highlights a significant gap in human resource readiness, emphasising the urgent need for targeted training and capacity-building to support effective IoT integration in university libraries.
(Table 5 IoT In Library - Respondent Analysis)

Sr No.	Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Strongly Agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly Disagree (%)
1	IoT will be very useful in stack area	21	24	4	1	0	42.00 %	48.00 %	8.00 %	2.00 %	0.00 %
2	IoT will reduce the workload of librarian	21	22	4	3	0	42.00 %	44.00 %	8.00 %	6.00 %	0.00 %
3	IoT will help as a security purpose in library	24	21	2	2	1	48.00 %	42.00 %	4.00 %	4.00 %	2.00 %
4	IoT will increase the unemployment of librarian	4	12	3	22	9	8.00 %	24.00 %	6.00 %	44.00 %	18.00 %
5	IoT will save the time of user	23	24	3	0	0	46.00 %	48.00 %	6.00 %	0.00 %	0.00 %
6	IoT will increase the recruitment of skill staff	13	28	5	4	0	26.00 %	56.00 %	10.00 %	8.00 %	0.00 %

7	IoT will fulfill the five laws of library	18	26	3	3	0	36.00 %	52.00 %	6.00 %	6.00 %	0.00 %
8	IoT will reduce the labor work in library	15	27	3	4	1	30.00 %	54.00 %	6.00 %	8.00 %	2.00 %



(Figure 4 Perceptions on the Impact of IoT on Library Services)

Responses show strong agreement that IoT enhances stack operations, reduces librarian workload, improves security, and saves users' time. Most participants also believe IoT supports library principles and will increase demand for skilled staff. However, mixed views on its potential to increase librarian unemployment reflect lingering concerns. Overall, the perception of IoT is largely positive, though strategic efforts must address workforce implications to ensure balanced digital transformation.

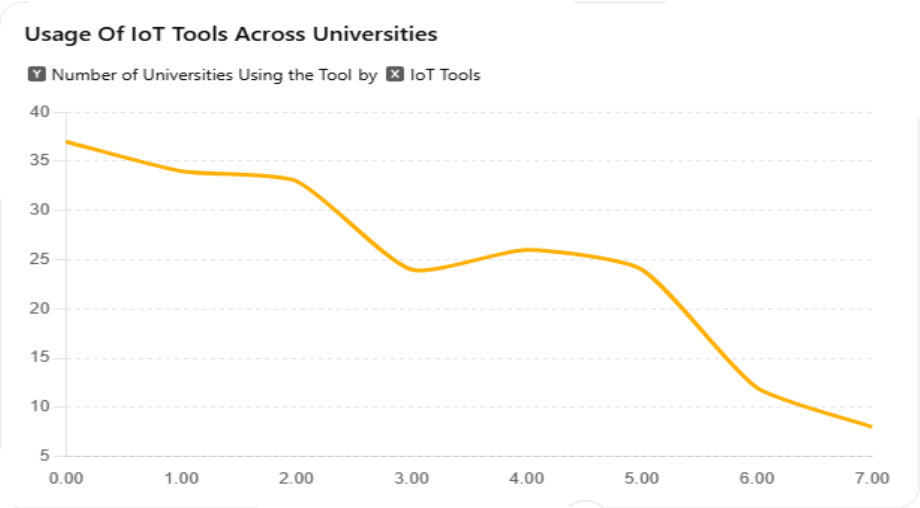
(Table 6 Planned IoT Tools in University Libraries)

IoT Tool	Count	Percentage
RFID Stock Control Device	37	74.00%
RFID Book Dropbox	34	68.00%
Biometric & Access Control	33	66.00%
RFID Library Security Gate	24	48.00%
Self Service Kiosk	26	52.00%
Intelligent Shelf	24	48.00%
Smart Chair	12	24.00%
Any other IoT Services	8	16.00%

Test Results:

- Chi-square Statistic: 30.28
- Degrees of Freedom: 7
- P-value: 0.00008426
- Statistically Significant at $p < 0.05$

There is a statistically significant difference in the usage of various IoT tools across universities. This indicates that some tools (e.g., RFID Stock Control Device) are significantly more adopted than others (e.g., Smart Chair, Other IoT Services).



(Figure 5 Planned Implementation of Various IoT Tools)

Adoption is highest for core automation tools like RFID Stock Control (74%), Book Dropbox (68%), and Biometric Access (66%), indicating strong institutional focus on essential technologies. Moderate uptake is seen for RFID Security Gates, Kiosks, and Intelligent Shelves (48–52%). Smart Chairs (24%) and other IoT services (16%) show minimal adoption, highlighting limited investment in advanced or non-essential innovations. Overall, the pattern reflects prioritization of foundational automation over experimental implementations.

(Table 7 Ranking of Key Factors for IoT Adoption in University Libraries)

Rank	Top Management Support	Availability of Funds	Perceived RFID Benefits	User Demand	Upcoming Trend
1	1 (2.00%)	2 (4.00%)	3 (6.00%)	1 (2.00%)	1 (2.00%)
2	2 (4.00%)	2 (4.00%)	3 (6.00%)	2 (4.00%)	1 (2.00%)
3	4 (8.00%)	5 (10.00%)	9 (18.00%)	6 (12.00%)	6 (12.00%)
4	11 (22.00%)	12 (24.00%)	18 (36.00%)	15 (30.00%)	13 (26.00%)
5	32 (64.00%)	29 (58.00%)	17 (34.00%)	26 (52.00%)	29 (58.00%)

(Table 8 Mean Rank Score)

	Factor	Mean Rank Score
2	Perceived RFID Benefits	3.86
3	User Demand	4.26
1	Availability of Funds	4.28
4	Upcoming Trend	4.36
0	Top Management Support	4.42

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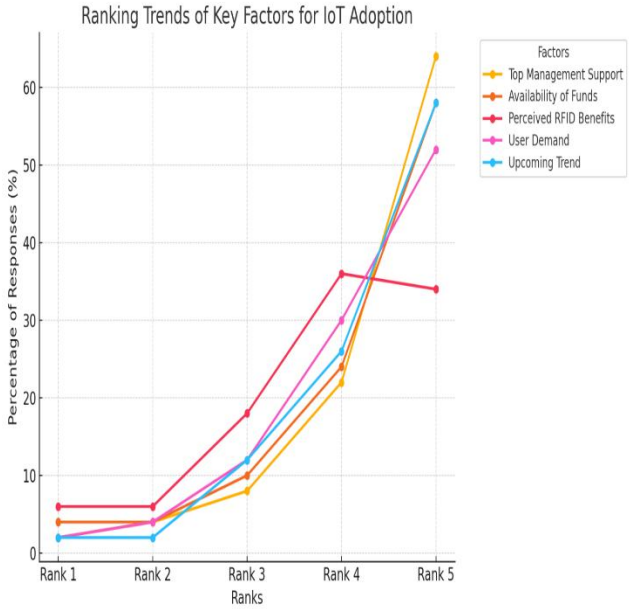
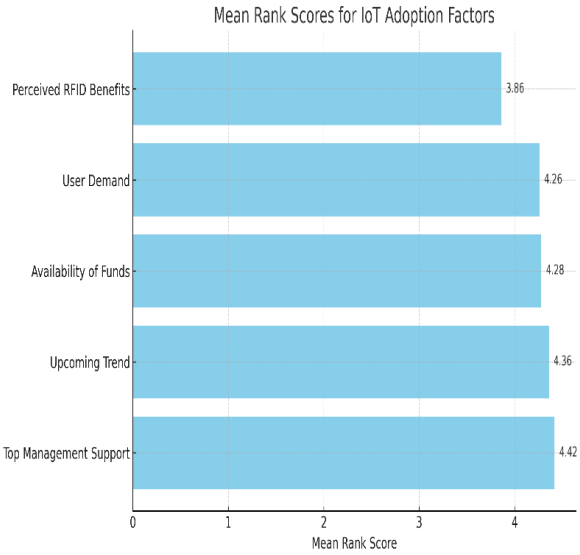




(Figure 6 Rankings of Key Factors Influencing IoT Adoption) (Figure 7 Comparative Mean Rank Scores of Key IoT Adoption Driver)

The study utilized two key visualizations to evaluate critical factors influencing IoT adoption in university libraries.

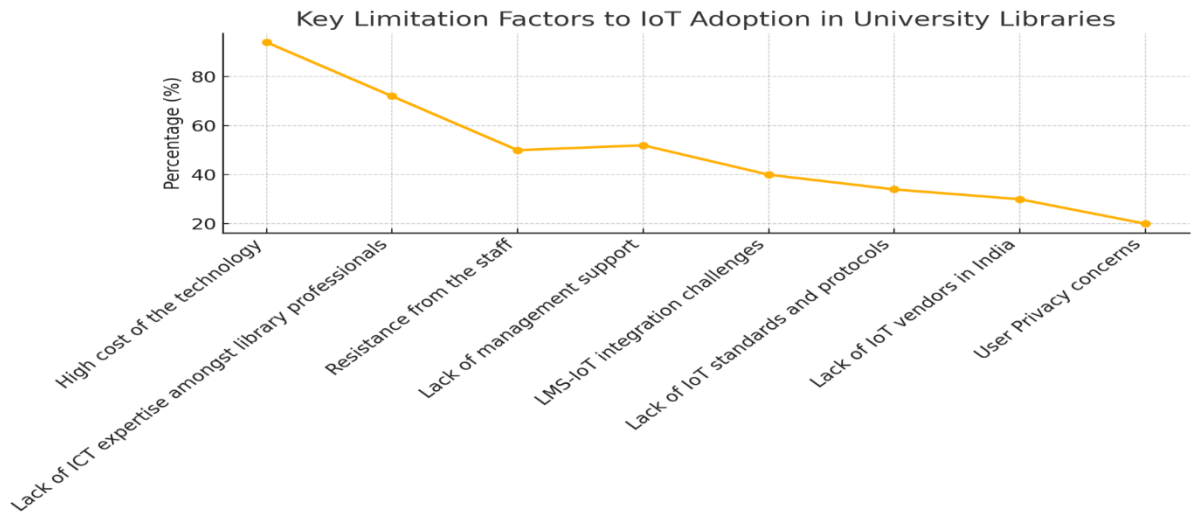
Figure 1 illustrates the ranking trends of five key factors influencing IoT adoption — Top Management Support, Availability of Funds, Perceived RFID Benefits, User Demand, and Upcoming Trend. The line chart highlights a clear pattern wherein the majority of responses tend to assign lower priority (higher ranks) to most factors. Top Management Support emerged as the most frequently ranked factor at Rank 5 (64%), followed closely by Availability of Funds (58%). Conversely, Perceived RFID Benefits shows a more evenly distributed ranking, suggesting mixed perceptions about its importance. The trend lines reflect how administrative and financial enablers dominate respondent priorities, especially at higher ranks.

Figure 2 presents the mean rank scores for the same factors, allowing a comparative assessment. A lower score indicates higher perceived importance. Perceived RFID Benefits achieved the lowest mean rank (3.86), indicating its stronger relative importance among decision-makers. Meanwhile, Top Management Support had the highest mean rank score (4.42), reinforcing its dominant presence in the higher ranking categories from the previous chart. This suggests that while management support is often rated as a significant enabler, other factors like RFID benefits are perceived more consistently as essential drivers.

Together, these figures offer nuanced insights into the prioritisation landscape for IoT adoption and underscore the necessity of aligning institutional support with technological benefits to enhance smart library readiness.

(Table 9 **Key Limitation Factors to IoT Adoption)**

Limitation Factor	Count	Percentage
High cost of the technology	47	94.00%
Lack of ICT expertise amongst library professionals	36	72.00%
Resistance from the staff	25	50.00%
Lack of management support	26	52.00%
LMS-IoT integration challenges	20	40.00%
Lack of IoT standards and protocols	17	34.00%
Lack of IoT vendors in India	15	30.00%
User Privacy concerns	10	20.00%



(Figure 8 Major Limiting Factors Identified for IoT Adoption)

High technology costs (94%) and lack of ICT expertise (72%) are the most critical barriers to IoT adoption, underscoring financial and skill-related challenges. Organizational resistance is evident through limited management support (52%) and staff pushback (50%). Technical and market limitations—such as LMS integration (40%), absence of standards (34%), and vendor scarcity (30%)—also hinder progress. Privacy concerns (20%) are less emphasized but remain relevant. These insights highlight the multifaceted nature of adoption barriers.This analysis emphasizes the need for financial, organizational, and technical interventions to facilitate effective IoT integration in academic libraries.

7. Findings

The study reveals a progressive trajectory in the adoption of IoT technologies among university libraries in Central Gujarat. Of the 50 institutions surveyed, private universities constituted the majority (60%), followed by state, deemed, and central universities. A significant 96% of respondents reported awareness of IoT, suggesting a robust foundational understanding and receptiveness to technological integration.

Approximately 70% of libraries have already implemented IoT tools, particularly RFID systems and biometric access controls, indicating substantial movement toward digital transformation. Despite this progress, 52% of institutions reported a lack of skilled personnel to manage these systems, underscoring the pressing need for capacity building and professional training.

Perceptions regarding the impact of IoT were overwhelmingly positive. Respondents acknowledged improvements in stack operations, workload reduction, enhanced security, time efficiency for users, and alignment with core library values such as Ranganathan's five laws. Concerns about job displacement were minimal, suggesting optimism about technology augmenting rather than replacing human roles.

In terms of planned adoption, RFID stock control devices (74%), book dropboxes (68%), and biometric access systems (66%) were most prioritized. Advanced technologies like smart chairs (24%) and other experimental tools saw limited consideration, reflecting a cautious approach toward non-essential innovations.

Ranking analyses revealed that perceived RFID benefits and user demand are primary motivators for adoption. However, factors like availability of funds, top management support, and trend awareness ranked lower, signaling gaps in institutional readiness and strategic alignment.

Key barriers included high technological costs (94%), limited ICT expertise (72%), resistance from staff (50%), and integration issues with existing Library Management Systems (40%). Additionally, concerns around standardization, vendor availability, and data privacy emerged as secondary challenges.

Overall, the findings highlight a promising yet uneven landscape of IoT integration. While libraries show readiness in intent and partial implementation, sustained progress hinges on strategic investments in infrastructure, staff development, leadership support, and policy reforms to facilitate holistic and future-ready adoption.

8. CONCLUSION

This study examined the preparedness of university libraries in Central Gujarat for the integration of Internet of Things (IoT) technologies through a comprehensive, multi-dimensional readiness framework. The findings reveal a high level of awareness and a moderate degree of IoT adoption, particularly in

essential areas such as RFID-based automation and biometric access control. However, challenges including limited ICT expertise, high technological costs, and infrastructure constraints continue to hinder widespread and effective implementation.

Despite these barriers, library professionals expressed strong support for IoT integration, recognising its potential to streamline operations, improve user services, and uphold the fundamental principles of librarianship. The study underscores the need for targeted investments in infrastructure, skills development, and policy frameworks, along with proactive leadership to ensure sustainable adoption. By addressing technological obsolescence and measuring tangible impact metrics, university libraries can better position themselves to evolve into smart, user-centric learning environments. The insights from this research offer practical guidance for policymakers and institutions seeking to modernise academic libraries through scalable, secure, and strategic IoT integration.

9. Limitations and Future Research

This study presents several limitations that must be acknowledged. Firstly, the research is geographically restricted to the Central Gujarat region, limiting the applicability of its findings to other institutional or regional contexts. Secondly, the data is derived solely from self-reported responses of library professionals, which may be subject to biases such as social desirability or partial knowledge of IoT operations.

The study also excludes the perspectives of IT personnel, who are key stakeholders in the deployment, configuration, and maintenance of IoT systems in libraries. Their inclusion could have provided valuable technical insights and a more grounded view of implementation challenges.

Additionally, the focus on established IoT tools may have excluded emerging or experimental technologies that could significantly influence future library services. A critical limitation is the absence of quantifiable impact metrics, such as changes in circulation statistics, resource utilisation efficiency, or energy savings after IoT implementation. This lack of empirical performance data hinders the ability to evaluate the true return on investment and operational effectiveness of IoT deployments.

Another significant concern is technology obsolescence. Given the rapid evolution of IoT platforms and hardware, the tools adopted today may become outdated or unsupported shortly. This underlines the necessity for ongoing technology assessment, timely updates, and investment in scalable and upgradeable systems to ensure sustained performance and security.

10.**Future Research Directions:**

Future research should focus on conducting longitudinal studies to evaluate the sustained impact of IoT integration on library efficiency, service quality, and user engagement. Expanding the geographical and institutional scope will provide broader insights and enhance the generalizability of findings. Incorporating the perspectives of IT staff, end-users, and administrators will allow for a more holistic understanding of implementation challenges and opportunities. Additionally, developing and monitoring quantifiable impact metrics such as circulation statistics, energy savings, and user satisfaction will help assess the effectiveness of IoT adoption. Researchers should also explore the integration of AI with IoT for intelligent automation and predictive services, while addressing ethical considerations related to data privacy and governance. Finally, strategies to manage technology obsolescence, such as investing in scalable, modular systems and establishing regular upgrade protocols, must be examined to ensure long-term sustainability and relevance of Iot-enabled library systems.

11.Suggestions and Recommendations

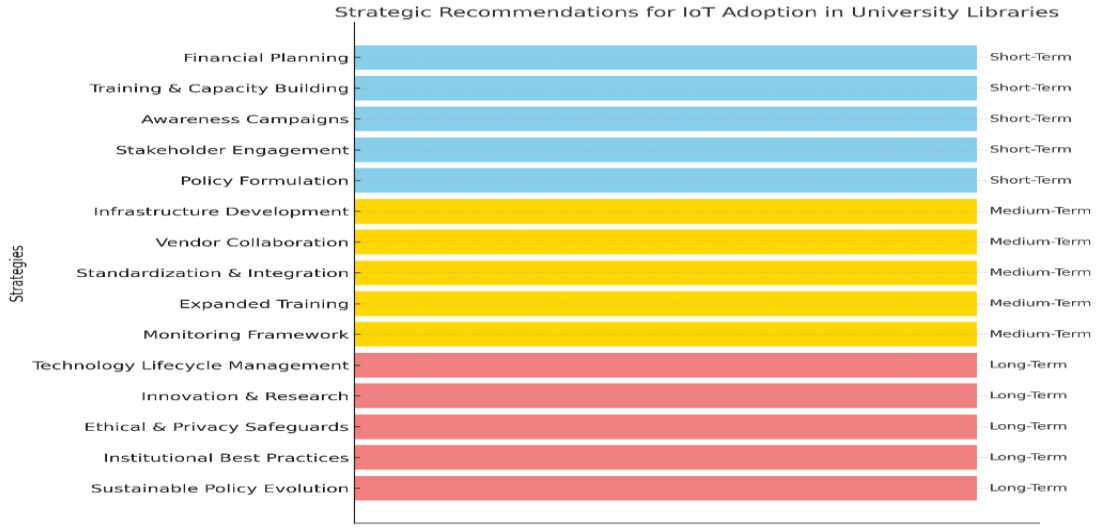
Suggestions and Recommendations are divided into three parts in the short term (0–1 year), in the medium term (1–3 years) and over the long term (3+ years).

In the short term (0–1 year), university libraries are encouraged to initiate foundational actions that facilitate the transition toward IoT integration. This includes allocating initial funding through institutional grants or budget realignments, as well as conducting orientation workshops and certification programs aimed at building basic IoT literacy among library professionals. Awareness campaigns should be organized to inform stakeholders of the benefits and implications of IoT adoption, thereby minimizing resistance and addressing employment concerns. Collaborative working groups comprising IT and library personnel can be formed to oversee pilot implementations. Concurrently, institutions should develop preliminary IoT policies to establish governance, ethical standards, and accountability mechanisms.

In the medium term (1–3 years), libraries should emphasize infrastructure strengthening and procedural formalization. Upgrading wireless networks, transitioning to cloud-based platforms, and deploying IoT-ready library management systems are critical steps. Formal partnerships with IoT solution providers may

be established to facilitate cost-effective procurement, technical support, and long-term service reliability. Institutions should also focus on interoperability by adopting standardized protocols. Advanced staff training through workshops and e-learning modules should be introduced to enhance technical competencies. Additionally, performance monitoring tools should be implemented to track circulation data, system usage, and energy consumption to evaluate the operational impact of IoT systems.

Over the long term (3+ years), strategic sustainability and innovation should be prioritized. Libraries must adopt technology lifecycle planning practices to address obsolescence and ensure the continuity of IoT services. Strategic investments in scalable and modular platforms will enable adaptability to emerging technologies. Institutions should explore research collaborations to integrate Artificial Intelligence (AI) with IoT for predictive analytics and intelligent automation. Ethical data management frameworks, including privacy safeguards and compliance mechanisms, should be strengthened. Furthermore, libraries are advised to engage in inter-institutional knowledge exchange to promote best practices and innovation. Periodic policy reviews will be essential to maintain alignment with technological advancements and evolving user needs.



(Figure 9 : Categorisation of IoT adoption strategies in university libraries by implementation timeline.)

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