Article

Measuring IoT Preparedness in University Libraries: A Study from Central Gujarat

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Abstract: The Internet of Things (IoT) is reshaping academic library operations through automation, real-time monitoring, and improved resource management. This study investigates IoT readiness across 50 universities in Central Gujarat using a multi-dimensional framework evaluating awareness, infrastructure, skilled personnel, administrative support, and perceived challenges. Results show strong awareness (96%) and moderate implementation (70%), with RFID systems and biometric access as the most common tools. Key barriers include high costs (94%), limited ICT expertise (72%), and LMS integration challenges (40%). Chi-square analysis confirmed significant differences in IoT tool adoption (χ^2 = 30.28, p < 0.001). Findings highlight positive perceptions of IoT's impact on security, workload reduction, and user satisfaction, but also reveal workforce skill gaps. The paper proposes a tiered roadmap for short-, medium-, and long-term IoT adoption, emphasising infrastructure upgrades, capacity building, and continuous performance monitoring to ensure sustainable implementation. This study also provides directions for comparative studies across regions in India to strengthen generalizability.

Keywords— Internet of Things (IoT); Academic Libraries; RFID; Smart Library Systems; ICT Skills; Digital Transformation; Gujarat Universities.

INTRODUCTION

The rapid growth of the Internet of Things (IoT) has transformed education and information services, reshaping libraries from static repositories into dynamic, interactive spaces. (Ray, 2021) By enabling interconnected devices to exchange data, IoT supports automation, remote monitoring, and personalised services that enhance efficiency in library operations. In academic settings, these technologies offer significant benefits, including optimised inventory management, enhanced security systems, and improved user engagement. (Yadav, 2019) However, effective integration of IoT requires more than technological investment. It depends on an institution's preparedness across multiple dimensions, including infrastructure, staff competence, financial resources, and administrative support (Ali et al., 2021). Although IoT adoption in libraries has attracted global attention, limited empirical research exists in the Indian context. No prior empirical study has examined IoT preparedness in Central Gujarat University libraries using a multi-dimensional framework. This study addresses that gap by systematically assessing readiness and proposing strategies for sustainable implementation.

LITERATURE REVIEW

Concept and Application

IoT refers to a network of devices that autonomously collect and share data, enabling real-time process automation. In libraries, IoT facilitates inventory tracking, environmental monitoring, and automated circulation through RFID, sensors, and QR codes (Jasim et al., 2021; Patel & Sharma, 2022).

Technological Infrastructure

Effective IoT integration requires robust

infrastructure including scalable servers, high-speed wireless connectivity, and compatible Library Management Systems (Ali et al., 2021). Cloud platforms have been identified as critical enablers of scalable IoT deployments (Rahman & Gupta, 2022). Successful cases, such as RFID-based asset management at the University of Hong Kong and smart climate control at MIT Libraries, demonstrate operational benefits (Smith & Chen, 2022; Wong et al., 2021).

Human Resource Capacity

Human resource capacity is a decisive factor in the adoption of IoT in libraries. A 2025 study on university libraries found that staff training and phased professional development ensure smoother implementation and reduce ethical risks (Shah et al., 2025) . Similarly, Lo's 2024 survey on AI literacy highlighted that while librarians are aware of emerging tools, many lack the technical depth to integrate them effectively, pointing to the need for structured, ongoing training (Lo, 2024). A 2025 systematic review further stressed that staff skills and awareness are often the most under-resourced aspects, yet they determine whether IoT projects remain pilots or scale into sustainable services (Boateng et al., 2025) . Together, these studies underline that without deliberate investment in staff capacity, IoT adoption in libraries cannot succeed.

Financial Considerations

Recent scholarship emphasises that financial feasibility is critical for IoT adoption in libraries. Xu et al. (2024) proposed a low-cost, software-defined smart library architecture, showing how design choices can reduce implementation costs without sacrificing scalability (Xu et al., 2024) . At the same time, Kissa et al. (2024) highlighted the use of time-driven activity-based costing (TDABC) to evaluate library services, allowing managers to pinpoint where IoT investments genuinely save costs versus where they merely shift expenses (Kissa et al., 2024).

Case Studies

Recent case studies highlight how IoT is reshaping library services. Mammadov et al. (2025) presented a user-centric smart library system that used environmental sensors and machine learning to optimize study conditions, showing improved user comfort and energy efficiency (Mammadov & Kucukkulahli, 2025). In India, Rajendra Prasad Central Agricultural University (2025) implemented an RFID-enabled smart library with automated check-in/checkout and a mobile app (MyLib@FT), demonstrating how IoT can streamline workflows and enhance accessibility (Rajendra Prasad Central Agricultural University, 2025) . Similarly, Banaras Hindu University (2025) piloted RFID-based smart ID cards at its central library, extending IoT use beyond

circulation to access control and campus-wide integration (Banaras Hindu University, 2025).

Research Objectives:

1. To evaluate the level of awareness and understanding of IoT among university library professionals.
2. To determine the current stage of IoT adoption and identify the tools and technologies already in use in university libraries.
3. To assess the availability and preparedness of skilled personnel for effective IoT management in university libraries.
4. To analyse library professionals' perceptions of IoT in terms of its usefulness, workload reduction, security, staffing needs, time savings, and alignment with library principles.
5. To analyse how university libraries prioritise different IoT tools, identifying which technologies are widely adopted and which remain underutilised.
6. To examine the relative importance of key factors influencing IoT adoption in university libraries and identify prioritisation patterns that can guide effective alignment of managerial, financial, and technological drivers.
7. To analyse organisational barriers such as high technology costs, lack of management support, and staff resistance that affect IoT adoption in university libraries.

Scope

This study investigates the readiness of university libraries in Central Gujarat to integrate Internet of Things (IoT) technologies. The evaluation focuses on four critical dimensions: awareness of IoT concepts, availability of infrastructure, staff capabilities, and institutional support mechanisms. The purpose is to equip administrators and policymakers with actionable insights on current IoT adoption levels and the key factors driving or hindering successful implementation.

The universities included in the study are categorised and presented in Table 1.

(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**

METHODOLOGY

This investigation employed a quantitative, cross-sectional survey design to assess the readiness of university libraries in Central Gujarat for adopting Internet of Things (IoT) technologies. The study population comprised library professionals and institutional decision-makers involved in technology planning, infrastructure development, and library operations.

Instrumentation and Data Collection

A structured questionnaire was developed as the primary research instrument and validated through expert review to ensure content relevance and clarity. The instrument was disseminated electronically via Google Forms to respondents across 50 universities, representing private, state, deemed, and central institutions. The questionnaire comprised multiple sections designed to capture key dimensions of IoT readiness: awareness levels, current implementation status, infrastructure adequacy, availability of skilled personnel, perceived benefits, barriers to adoption, and future integration plans.

Data Treatment and Analysis

The responses were systematically coded and analysed using Microsoft Excel and SPSS. Descriptive statistics, including frequency distributions and percentages, were employed to summarise the key variables. Inferential statistical analysis was conducted using Chi-square tests to examine the association between categories of IoT tool adoption and institutional characteristics. Furthermore, a factor-ranking technique was applied to prioritise the motivators and constraints influencing IoT adoption within the university library context.

Outcome of Analysis

This multi-level analytical framework facilitated the identification of underlying patterns, significant relationships, and readiness indicators, thereby providing actionable evidence for academic administrators and policymakers seeking to enable sustainable and strategically aligned IoT implementation in library environments.

DATA ANALYSIS AND RESULTS

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

- **Awareness and understanding of IoT among university libraries**

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

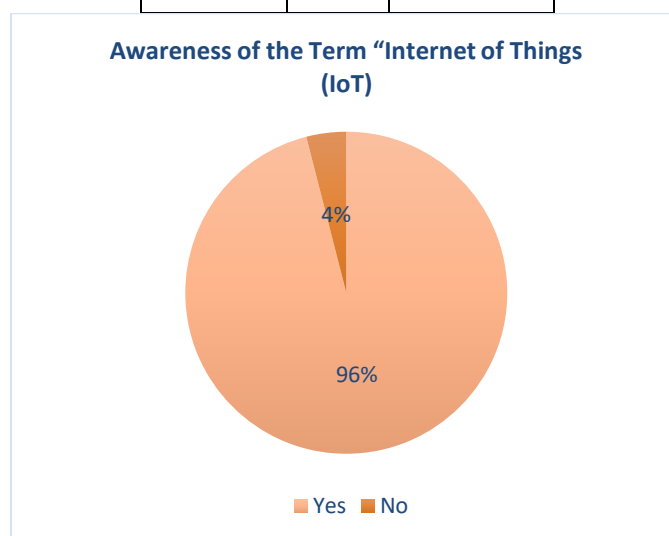| Response	Count	Percentage
Yes	48	96.00%
No	2	4.00%
Total	50	100%

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

Among the 50 participants, 96% reported being aware of the term *Internet of Things (IoT)*, while only 4% indicated unfamiliarity. This substantial level of awareness demonstrates a strong foundational understanding of IoT among

respondents. It suggests that university libraries operate in a context conducive to IoT adoption and provides a solid basis for advancing further research in this area.

IoT adoption and identify the tools

(Table 3 Has Your Library Adopted Any IoT Tools)

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

Library Adoption of IoT Tools
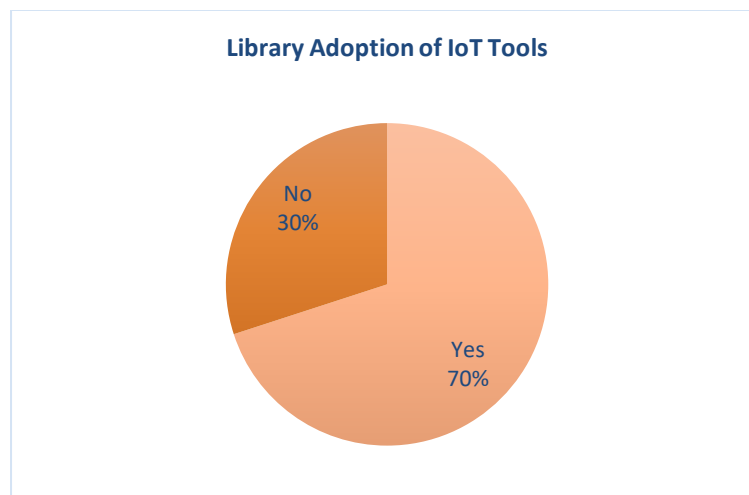
(Figure 2 Adoption Status of IoT Tools)

Seventy per cent of respondents indicated that IoT tools have been implemented in their university libraries, indicating a meaningful advancement toward institutional digital transformation. Conversely, 30% reported no implementation, revealing gaps in readiness and highlighting the need for targeted capacity-building measures and strategic planning to enable comprehensive IoT integration across the higher education sector.

Availability and preparedness of skilled personnel

(Table 4 Availability of Skilled Staff for IoT)

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


Availability of Skilled Staff
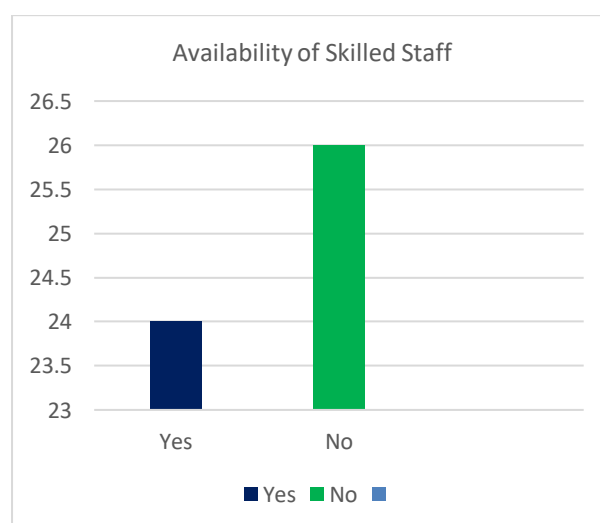
(Figure 3 Availability of Skilled Personnel for IoT Management)

Among the 50 respondents, 48% reported having skilled staff to manage IoT systems, while 52% acknowledged a shortage of such personnel. This almost equal split underscores a critical gap in human resource readiness and highlights the need for focused training and capacity-building initiatives to enable successful IoT integration in university libraries.

Library professionals' perceptions of IoT

(Table 5 Library Professionals' Perception of IoT Impact)

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%
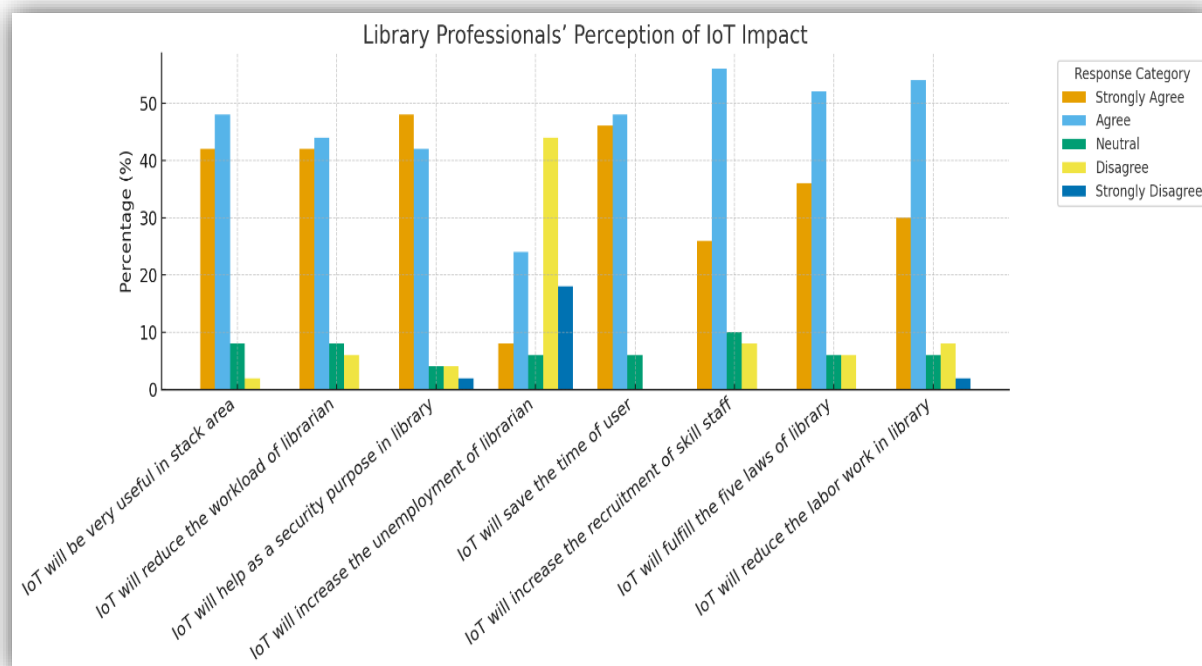
(Figure 4 Library Professionals' Perception of IoT Impact)

The analysis of library professionals' perceptions indicates strong agreement on the positive impact of IoT in libraries. A majority believe IoT is highly useful in stack management (90%), reduces workload (86%), improves security (90%), and saves user time (94%). Respondents also agree that IoT will reduce manual labour (84%), support the recruitment of skilled staff (82%), and align with the Five Laws of Library Science (88%). Concerns about unemployment are relatively low, with 62% disagreeing that IoT would replace librarians. Overall, the findings show that professionals view IoT as a tool for efficiency, security, and user satisfaction, while fostering new opportunities for technology-skilled staff rather than causing job loss.
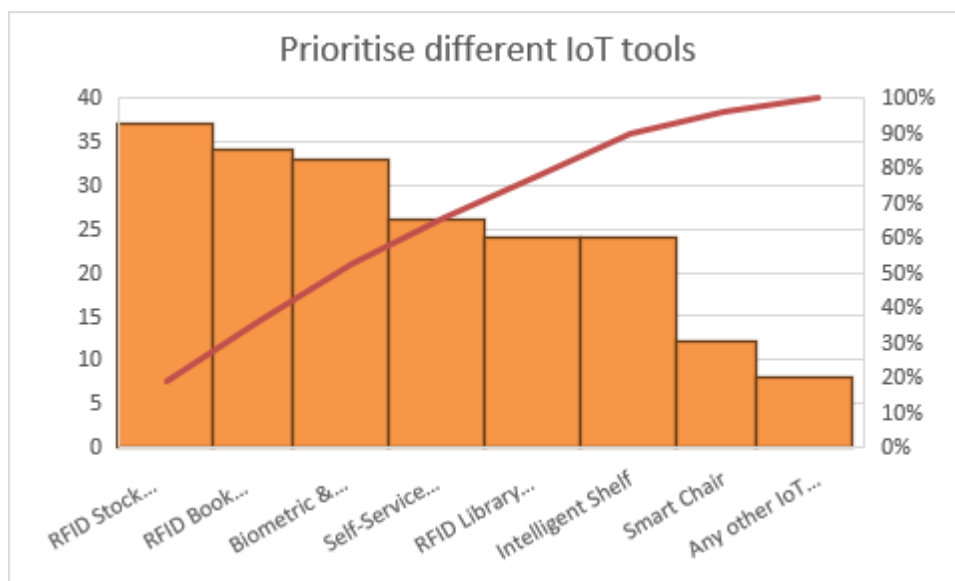
Prioritise different IoT tools

(Table 6 prioritise different IoT tools)

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 Result: Chi-square (χ^2 = 30.28, df = 7, p = 0.00008426) indicates a statistically significant difference (p < 0.05) in IoT tool adoption across universities.

A chi-square test was conducted to examine differences in the adoption of IoT tools across universities. The results were significant, $\chi^2(7)$ = 30.28, p < 0.001, indicating that adoption is not evenly distributed. Some tools, such as RFID Stock Control Devices and Book Dropboxes, are used far more widely than others, like Smart Chairs and other IoT services. This confirms that institutions prioritise core automation tools over experimental ones.

(Figure 5 Prioritise different IoT tools)

The analysis of IoT tool adoption in university libraries reveals a clear prioritisation of core automation technologies over experimental ones. RFID Stock Control Devices (74%), RFID Book Dropboxes (68%), and Biometric & Access Control systems (66%) are the most widely used, highlighting their role in streamlining circulation, inventory, and security. Tools like Self-Service Kiosks (52%), RFID Security Gates (48%), and Intelligent Shelves (48%) show moderate adoption, reflecting gradual progress toward user self-service and resource tracking. In contrast, Smart Chairs (24%) and other IoT services (16%) remain least prioritised, indicating that comfort-based or experimental innovations are not yet a focus. The chi-square test (χ^2 = 30.28, df = 7, p < 0.001) confirms significant differences in adoption, suggesting that libraries are strategically investing in technologies that provide immediate operational and security benefits, while postponing large-scale implementation of less essential tools.
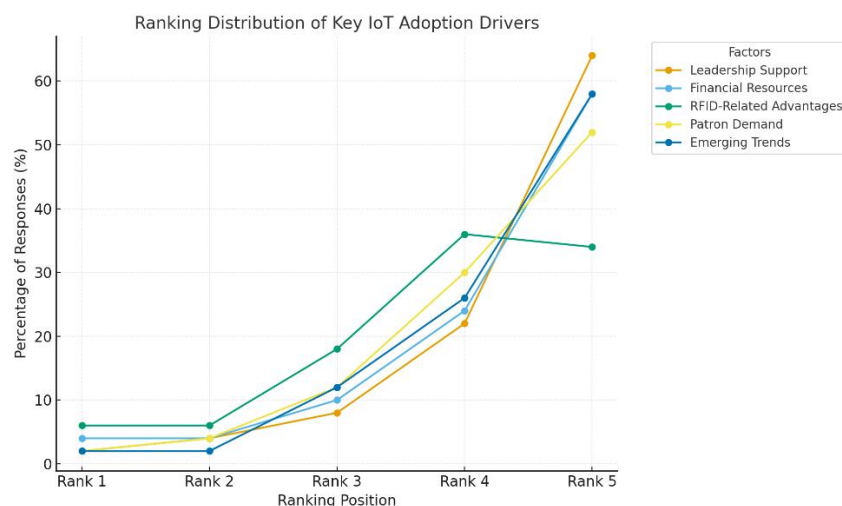
Relative Importance of Key Factors Influencing IoT Adoption in University Libraries

(Table 7 Relative Importance of Key Factors Influencing IoT Adoption in University Libraries)

Position	Leadership Support	Financial Resources	RFID-Related Advantages	Patron Demand	Emerging Trends
Rank 1	1 (2.00%)	2 (4.00%)	3 (6.00%)	1 (2.00%)	1 (2.00%)
Rank 2	2 (4.00%)	2 (4.00%)	3 (6.00%)	2 (4.00%)	1 (2.00%)
Rank 3	4 (8.00%)	5 (10.00%)	9 (18.00%)	6 (12.00%)	6 (12.00%)
Rank 4	11 (22.00%)	12 (24.00%)	18 (36.00%)	15 (30.00%)	13 (26.00%)
Rank 5	32 (64.00%)	29 (58.00%)	17 (34.00%)	26 (52.00%)	29 (58.00%)

(Table 8 Mean Rank Scores of Key Factors Influencing IoT Adoption)

| Factor	Mean Rank Score
Leadership Support	4.42
Financial Resources	4.28
RFID-Related Advantages	3.86
Patron Demand	4.26
Emerging Trends	4.36

(Figure 6 Relative Importance of Key Factors Influencing IoT Adoption in University Libraries)

The analysis of Tables 7 and 8 along with Figure 6 indicates that leadership support is the most critical factor influencing IoT adoption in university libraries, as reflected in its highest mean rank score. Emerging trends also hold strong importance, showing that libraries are conscious of staying aligned with global technological developments. Financial resources and patron demand, though necessary, appear to play more of a supporting role rather than being primary drivers of adoption. RFID-related advantages, while offering practical benefits, rank lowest, suggesting that individual technologies are less influential than broader strategic and institutional considerations. The overall pattern shows that respondents view these factors as moderately important, with leadership vision and attention to emerging trends carrying greater weight. This highlights that institutional readiness, guided by committed leadership and responsiveness to change, is more decisive for IoT adoption than financial capacity, user demand, or specific technologies.

Barriers Analysis for IoT Implementation in University Libraries

(Table 9 Major Barriers to IoT Implementation in University Libraries)

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%
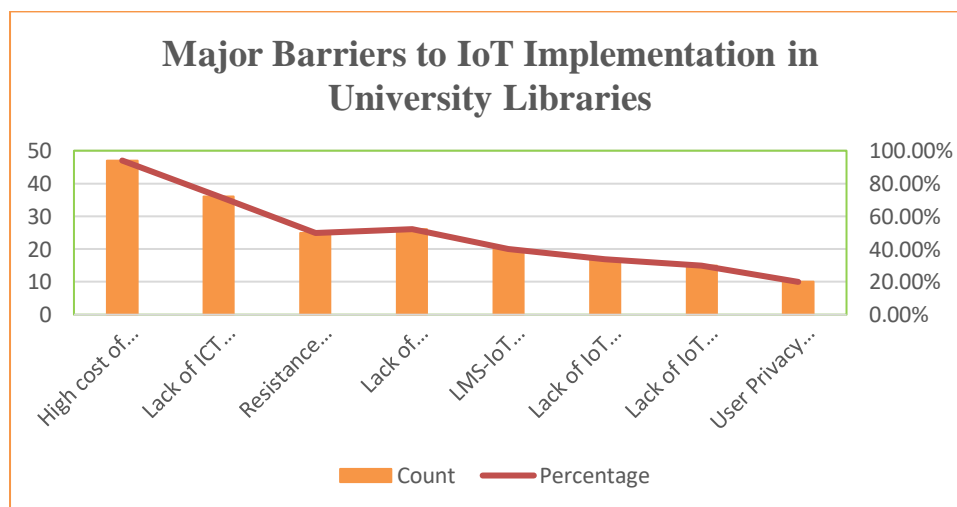
(Figure 7 Major Barriers to IoT Implementation in University Libraries)

The analysis indicates that the most significant barrier to IoT adoption in university libraries is the high cost of technology (94%), which underscores the financial limitations faced by institutions. A considerable proportion of respondents (72%) also emphasized the lack of ICT expertise among library professionals, reflecting a pressing skills gap. Organisational challenges are further evident, with insufficient management support (52%) and staff resistance (50%) emerging as key concerns. In addition, technical obstacles such as LMS–IoT integration difficulties (40%) and the absence of standardized protocols (34%) complicate implementation efforts. External factors, including the limited availability of IoT vendors in India (30%) and user privacy concerns (20%), add to these constraints. Collectively, the findings reinforce the research objective by demonstrating that organisational barriers—particularly financial, managerial, and cultural—remain the dominant impediments to successful IoT adoption in university libraries.

FINDINGS

The study found a high level of awareness of IoT among university library professionals in Central Gujarat, with 96 percent of respondents reporting familiarity. However, actual implementation is moderate, with 70 percent of libraries adopting IoT tools. Adoption is concentrated on core technologies such as RFID stock control devices (74%), RFID book dropboxes (68%), and biometric access systems (66%), while experimental tools like smart chairs (24%) remain less prioritised. A chi-square test ($\chi^2 = 30.28$, $p < 0.001$) confirmed significant variation in adoption patterns across institutions.

Human resource readiness emerged as a critical gap. Only 48 percent of respondents reported having skilled personnel to manage IoT systems, indicating the need for targeted training and capacity-building initiatives. Despite this limitation, perceptions of IoT were overwhelmingly positive. Most professionals agreed that IoT improves stack management (90%), enhances security (90%), reduces workload (86%), and saves user time (94%). Furthermore, 82 percent believed it would create opportunities for skilled staff, while 88 percent felt IoT aligns with Ranganathan's Five Laws of Library Science.

Analysis of adoption drivers highlighted leadership support as the most influential factor (mean rank 4.42), followed by responsiveness to emerging technological trends (4.36). Financial resources (4.28) and patron demand (4.26) played secondary roles, while RFID-related advantages ranked lowest (3.86). This suggests that institutional vision and leadership are more decisive in shaping IoT integration than specific technological features.

Major barriers to adoption included the high cost of technology (94%) and the lack of ICT expertise among professionals (72%). Organisational challenges such as inadequate management support (52%) and staff resistance (50%) also hindered progress. Technical limitations, including LMS–IoT integration issues (40%) and lack of standard protocols (34%), alongside external factors such as limited vendors (30%) and privacy concerns (20%), further constrained implementation.

Overall, the findings demonstrate that while IoT is positively perceived and increasingly adopted, sustainable growth depends on strong leadership, skill development, and strategic investment to overcome financial and organisational barriers.

Limitations and Future Directions

This study has provided a comprehensive understanding of IoT preparedness in the university libraries of Central Gujarat, yet certain aspects open promising avenues for further exploration. The regional focus, while valuable in generating localized insights, naturally limits the generalizability of findings. Extending the scope to other states and regions of India would enable comparative analysis and offer a broader perspective on IoT adoption patterns across diverse institutional settings.

The cross-sectional survey design offered a useful snapshot of current awareness, adoption levels, and perceived challenges. However, IoT adoption is a dynamic process influenced by technological advancements and institutional strategies. Longitudinal studies could therefore provide richer insights into how libraries sustain, scale, and adapt IoT implementations over time. The use of self-reported data in this study captured the professional perspectives of librarians and administrators, but future research may benefit from triangulating these perceptions with observational evidence or system-generated data to present a more holistic picture.

Examining policy and standards for IoT adoption, as well as engaging with national and international best practices, would provide actionable guidance for institutions. Cost optimization strategies, including comparative vendor analysis and collaborative procurement models, could also help libraries overcome financial barriers. Finally, incorporating the perspectives of students and faculty would offer user-centric insights into satisfaction, trust, and engagement with IoT-enabled services, thereby ensuring that technological adoption aligns with user needs as well as institutional goals.
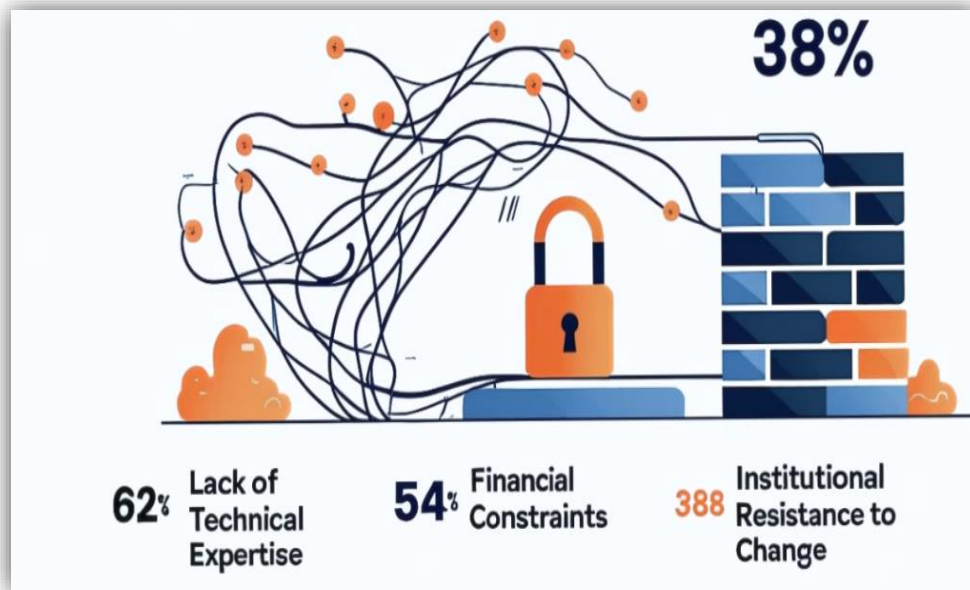
(Figure 8 Limitations to implementation for IoT)

CONCLUSION

This study demonstrates that university libraries in Central Gujarat are entering a transitional phase in the adoption of Internet of Things (IoT) technologies. Awareness among library professionals is almost universal, and implementation levels are moderate, with strong reliance on core tools such as RFID-based devices and biometric access systems. Positive perceptions of IoT's role in enhancing security, improving efficiency, and supporting the principles of librarianship further reinforce its relevance in the academic environment.

At the same time, the findings highlight critical challenges. High technology costs, limited ICT expertise, and organisational barriers such as insufficient management support and staff resistance continue to hinder progress. Human resource readiness, in particular, emerges as a decisive factor that can either enable or constrain successful adoption. The analysis also shows that institutional leadership and responsiveness to emerging trends play a more pivotal role in shaping adoption strategies than individual technological features or user demand.

Overall, IoT integration in university libraries holds significant promise for transforming services, optimising resource management, and enriching user experiences. However, sustainable progress will require strategic investment, continuous capacity building, and supportive leadership. By addressing financial and organisational barriers, universities can move toward building smart, technology-driven libraries that remain responsive to evolving academic and user needs.

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