READINESS AND CHALLENGES OF IMPLEMENTING INTERNET OF THINGS (IoT) IN NIGERIAN LIBRARY OPERATIONS

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Abstract

Adopting the Internet of Things (IoT) in library operations transforms information management and service delivery worldwide. However, Nigerian libraries face significant challenges, including inadequate infrastructure, insufficient funding, a lack of skilled personnel, and cybersecurity concerns. This paper evaluated the readiness of Nigerian libraries for IoT adoption by identifying key enablers and obstacles influencing implementation. Using a literature-based approach, the research reviews existing studies on library IoT applications, focusing on infrastructure readiness, policy frameworks, security concerns, and workforce competency. Key challenges include limited technological resources, inadequate training for library professionals, and insufficient institutional support. However, with targeted investment in digital infrastructure, capacity-building programs, strong policy frameworks, and strategic partnerships, Nigerian libraries can successfully integrate IoT to improve service delivery. The paper recommends a phased implementation approach for IoT, stakeholder collaboration, and sustainable funding mechanisms to enhance library operations and promote access to innovative information services, thereby positioning Nigerian libraries as key players in the digital information ecosystem.

Keywords: *Internet of Things (IoT), Library Operations, Smart Libraries*.

Introduction

The integration of the Internet of Things (IoT) into library operations is not merely a technological enhancement; it signals a profound transformation in how libraries function, interact with users, and deliver services. IoT technologies such as smart shelves, sensor-controlled environments, and real-time data analytics are revolutionising how resources are managed

and accessed. These innovations enable libraries to respond more effectively to user needs, streamline internal workflows, and enhance the overall user experience. By embedding intelligence and automation into daily operations, libraries are moving toward more adaptive, responsive, and inclusive service models.

However, the true potential of IoT in libraries extends beyond automation. It represents an opportunity to rethink access, equity, and engagement in the digital age. With the right tools, libraries can become more accessible to users with disabilities, more efficient in managing digital and physical assets, and more proactive in anticipating the evolving needs of their communities. This requires a significant shift in professional competencies. Library staff must be equipped with both technical skills and strategic awareness to navigate emerging technologies while ensuring data security and user privacy. Digital transformation must be accompanied by investment in human capital to make adoption meaningful and sustainable.

Despite the immense potential, libraries in developing countries, such as Nigeria, face substantial challenges in embracing the Internet of Things (IoT). Infrastructural deficits, limited funding, and a shortage of trained personnel pose serious barriers to implementation. Many libraries operate in environments that lack stable electricity, robust internet connectivity, or the technical frameworks required to support innovative systems. Concerns around privacy, data protection, and the absence of unified policy guidelines further complicate the integration process. Nevertheless, small-scale implementations and institutional pilot projects have demonstrated that progress is possible even within resource-constrained contexts. These efforts highlight the importance of local innovation, strategic planning, and scalable solutions that align with the unique realities of the Nigerian library ecosystem.

This study positions itself at the intersection of these opportunities and challenges. It examines the preparedness of Nigerian libraries to adopt IoT by assessing their infrastructure, staff capabilities, and policy frameworks. By doing so, it aims to provide practical insights that can guide decision-makers and stakeholders in developing a roadmap for the sustainable implementation of the Internet of Things (IoT). The broader goal is to support the transformation of Nigerian libraries into smart knowledge centres that not only keep pace with global technological trends but also respond to the specific needs of their communities. Through targeted investment and strategic capacity-building, libraries can become powerful drivers of innovation, inclusion, and sustainable development.

Concept of IoT in Libraries

The integration of Internet of Things (IoT) technologies is fundamentally reshaping library operations by enhancing efficiency, automating services, and improving user engagement. Prasad and Jahnavi (2019) noted that the Internet of Things (IoT) plays a crucial role in transforming traditional library settings into innovative, responsive environments by utilising interconnected devices and cloud-based systems. By embedding sensors and smart shelves into daily workflows, libraries can now monitor book movement in real-time, streamline inventory control, and facilitate seamless access to resources. Adewojo & Dunmade (2024) further explained that these intelligent systems optimise cataloguing, automate check-in and check-out processes, and support personalised service delivery, resulting in faster information retrieval and a significantly improved user experience. These innovations are not only

modernising operational functions but are also aligning libraries with contemporary expectations of digital interactivity and on-demand access.

The evolution of IoT in library contexts has also brought a significant shift toward more accessible and user-driven services. Integrated into this transformation are smart shelving units, self-checkout systems, and automated notification platforms that allow users to navigate services with minimal staff intervention (Bal Ram et al., 2023). IoT applications now extend to areas such as environmental monitoring for sensitive archival materials and virtual navigation for enhanced user orientation (Asim & Arif, 2023). However, adoption is not without challenges. Concerns about security vulnerabilities, privacy risks, and the lack of uniform implementation standards continue to hinder the widespread adoption of this technology. Panigrahi et al. (2022) argued that for libraries to leverage the potential of IoT fully, professionals must actively engage with ongoing developments, particularly those related to cybersecurity and shifting user expectations. Emphasising this point, Bal Ram et al. (2023) highlighted the need for a balanced approach that embraces innovation while safeguarding user data, ensuring that IoT enhances service delivery without compromising the core values of library ethics and privacy.

IoT Applications in Library Operations

IoT applications have significantly transformed library operations, introducing a new level of efficiency, responsiveness, and user-centred service design. By integrating technologies such as smart shelves and sensor-based tracking systems, libraries can now monitor inventory in real-time, automate check-in and check-out processes, and simplify circulation tasks (Prasad & Jahnavi, 2019; Bal Ram et al., 2023). These innovations not only reduce manual workload but also enhance accessibility and ensure the timely movement of materials. Environmental sensors, as noted by Bal Ram et al. (2023), are increasingly being used to preserve rare and fragile collections by maintaining optimal storage conditions. Libraries have also implemented self-service kiosks and automated reminder systems, which allow users to manage their borrowing activities more independently and conveniently (Asim & Arif, 2023). Prasad and Jahnavi (2019) highlighted how real-time data analytics and personalised recommendation systems further empower librarians to make informed decisions and deliver more targeted services.

As the Internet of Things (IoT) continues to evolve, its role in enhancing library security and personalisation is becoming increasingly prominent. Intelligent surveillance systems, biometric access controls, and RFID-enabled tracking are now employed to ensure the safety of both users and collections, while minimising unauthorised access (Asim & Arif, 2023). Libraries are also enhancing user engagement through self-guided virtual tours and AI-driven content suggestions tailored to individual preferences. However, Bal Ram et al. (2023) emphasised that this wave of technological advancement must be balanced with rigorous data protection and cybersecurity practices to maintain user trust. By thoughtfully leveraging IoT tools, libraries have the opportunity to build more dynamic, interactive, and inclusive learning environments. As Prasad and Jahnavi (2019) argued, the Internet of Things (IoT) is not just a tool for efficiency; it is a catalyst for reimagining the library as an intelligent, adaptive space within a globally connected knowledge ecosystem.

Applications of IoT in Nigeria's Library Operations

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Key Trends in IoT Adoption in Libraries

The Internet of Things (IoT) is fundamentally transforming library operations by redefining how resources are managed, services delivered, and users interact with both digital and physical environments. The adoption of IoT technologies in libraries typically occurs in progressive stages, beginning with basic automation and progressing toward more sophisticated, user-driven ecosystems. At the initial level, tools such as Radio Frequency Identification (RFID), smart shelves, and automated circulation systems are introduced to improve inventory tracking, enhance cataloguing accuracy, and minimise manual workload. As Prasad and Jahnavi (2019) explained, these systems create a foundation for efficient resource management and provide real-time visibility into library assets. Kaladhar and Rao (2018) similarly noted that these automation technologies help streamline core operations, enabling libraries to manage their collections more effectively while preparing for future technological integration.

As libraries advance through the adoption lifecycle, the focus transitions from operational efficiency to intelligent data utilisation. This intermediate stage introduces real-time analytics and machine learning to monitor user behaviour, forecast resource demand, and optimise the physical layout and usage of library spaces. According to Asim and Arif (2023), these data-driven systems allow libraries to deliver increasingly personalised services, such as automated alerts for upcoming due dates, tailored reading suggestions, and location-based notifications. At this stage, IoT applications also include digital navigation systems and accessibility enhancements, such as voice recognition tools, screen readers, and Braille-compatible devices (Adewojo & Dunmade, 2024). Integrated into daily library services, these innovations ensure inclusivity, allowing users, especially those with disabilities, to interact with collections in more meaningful and autonomous ways (Prasad & Jahnavi, 2019).

In more advanced implementations, libraries shift toward a fully integrated, user-centric Internet of Things (IoT) environment. At this stage, bright spaces respond dynamically to user needs by adjusting lighting, temperature, or noise levels to enhance comfort and usability. Prasad and Jahnavi (2019) noted that these responsive environments are supported by

intelligent systems that enable seamless access to digital and physical content. However, despite global momentum, many libraries in developing countries have yet to reach this stage. In Nigeria, IoT integration remains in its early phase, constrained mainly by limited financial resources, underdeveloped infrastructure, and low awareness among library decision-makers (Igbinovia & Okuonghae, 2021). Furthermore, adoption is often impeded by concerns over data security and privacy, as well as the lack of institutional policies to standardise implementation (Asim & Arif, 2023). As Liang and Chen (2018) argued, the absence of regulatory clarity often deters investment and long-term planning for IoT adoption.

Nonetheless, the transformative potential of IoT continues to attract the attention of Nigerian libraries and policymakers alike. When supported by clear strategies and institutional commitment, the Internet of Things (IoT) can significantly enhance library performance, improve service quality, and increase access to information. Handayani (2020) asserted that such integration is most effective when it aligns with broader digital transformation agendas and capacity-building initiatives. Notable examples, such as the implementation of RFID technology at Nile University of Nigeria, demonstrate that meaningful progress is achievable when technical readiness and administrative support are in place (Asim & Arif, 2023; Liang & Chen, 2018). To unlock IoT's full potential, Nigerian libraries must prioritise the development of regulatory frameworks, invest in ICT infrastructure, and ensure ongoing professional development for staff. These efforts will help shift adoption from fragmented experimentation to structured, sustainable innovation that aligns with both national development goals and global best practices.

Emerging Trends, Adoption Stages, and Readiness for IoT in Nigerian Libraries

The adoption of Internet of Things (IoT) technologies is steadily redefining how libraries operate, offering opportunities for more intelligent workflows, real-time service delivery, and enhanced user engagement. Globally, IoT adoption in libraries follows three overlapping stages: initial automation, data-driven optimisation, and fully intelligent, user-centred ecosystems. At the early stage, libraries typically employ tools such as RFID tags, innovative shelving systems, and automated circulation technologies to streamline collection management and reduce manual processes (Prasad & Jahnavi, 2019; Kaladhar & Rao, 2018). As libraries advance, they begin to integrate real-time analytics and machine learning to monitor user patterns, anticipate demand, and tailor service delivery (Asim & Arif, 2023). The most advanced implementations involve sensor-equipped spaces and assistive technologies, such as Braille printers and voice recognition systems, designed to foster inclusion and meet the specific needs of users with disabilities (Hamam, 2023).

Within the Nigerian context, however, the readiness of libraries to transition through these stages remains highly uneven and generally underdeveloped. While select institutions, such as Nile University, have adopted technologies like RFID, most libraries in Nigeria remain at the basic automation phase (Asim & Arif, 2023; Liang & Chen, 2018). Readiness, in this case, extends beyond overcoming barriers; it encompasses the institutional capacity, infrastructural base, and strategic orientation needed to implement and sustain IoT systems effectively. Idiegbeyan-Ose et al. (2016) observed that many Nigerian libraries continue to struggle with foundational gaps, including inadequate internet connectivity, outdated digital infrastructure, and the absence of essential ICT tools. This digital divide, particularly pronounced between urban and rural libraries, further limits equitable readiness across the sector, creating disparities in access and adoption potential.

Another key dimension of readiness lies in human capital development. Yusuf et al. (2019)

expressed concern that many Nigerian librarians lack the technical proficiency needed to implement and maintain IoT systems. Without practical exposure and sustained digital training, librarians may struggle to configure devices, interpret analytics, or secure sensitive user data. Though some academic libraries have demonstrated openness to digital experimentation, widespread technical readiness among staff remains a work in progress. As the adoption of IoT becomes more data-intensive and security-sensitive, the need for targeted capacity-building initiatives focused on IoT literacy, system maintenance, and ethical data governance becomes increasingly urgent.

Institutional and policy-level readiness also plays a defining role in IoT integration. Kunle et al. (2017) highlighted that a lack of clear implementation frameworks, fragmented ICT policies, and minimal government support continue to hamper proactive adoption efforts. Igbinovia (2021) noted that in Nigeria, IoT adoption is not only constrained by access to technology but also by organisational inertia, environmental constraints, and rising cybersecurity threats. For this reason, readiness must be understood holistically, encompassing infrastructure, skills, governance structures, and leadership vision. Moving forward, a sustainable path for Nigerian libraries involves strategic investments in infrastructure, more straightforward regulatory guidelines, and continuous professional development, as argued by both Idiegbeyan-Ose et al. (2016) and Kunle et al. (2017). While Nigerian libraries may currently be in a preparatory phase, with deliberate planning and focused resource allocation, they have the potential to emerge as intelligent, responsive institutions aligned with global digital transformation trends.

Challenges of IoT Adoption in Nigerian Libraries

1. **Financial Constraints and Technological Infrastructure Challenges:** Financial and infrastructural limitations continue to restrict IoT adoption in Nigerian libraries. Igbinovia (2021) observed that most libraries struggle to afford critical technologies, such as RFID, smart sensors, and automation tools. As Olorundare et al. (2017) noted, inadequate funding has a direct impact on the scope and scale of digital transformation. Internet instability and erratic power supply have also been reported as major setbacks, disrupting system functionality (Liang & Chen, 2018). Without dependable infrastructure, libraries cannot ensure the consistent performance of IoT applications. Staff training and technical maintenance have also been constrained due to insufficient investment. It has been emphasised that scalable implementation depends on closing these foundational gaps. Bridging them is essential for aligning Nigerian libraries with global innovation trends (Okoroma, 2018).
2. **Lack of Skilled Personnel:** Another significant barrier to IoT adoption in Nigerian libraries is the shortage of skilled personnel. Asim and Arif (2023) noted that many librarians lack the technical expertise required to implement and manage IoT systems effectively. Integrated into this challenge is the absence of structured training programs, which leaves staff unprepared for evolving technological demands. Without hands-on knowledge, the ability to fully utilise IoT tools in daily operations is greatly diminished (Awodoyin & Okiki, 2023). The effectiveness of adoption is further weakened when staff are unable to troubleshoot or adapt to system upgrades. Passive observation suggests that this skills gap hinders innovation at the institutional level. Addressing it through capacity-building is essential for meaningful IoT integration (Shahzad et al., 2024).

3. **Cybersecurity and Data Privacy Concerns:** Cybersecurity and data privacy concerns pose significant risks to the adoption of IoT in libraries. Liang and Chen (2018) highlighted that IoT devices often produce large volumes of sensitive data, including personal details and transactional records. Without proper safeguards, this information becomes vulnerable to unauthorised access and potential breaches. It has been observed that many libraries lack the security infrastructure needed to mitigate such threats (Massis, 2016). Weak encryption protocols and inadequate access controls further expose systems to cyberattacks. The absence of a comprehensive security framework undermines user trust and operational integrity. Ensuring data protection is thus crucial for the safe and responsible deployment of the Internet of Things (IoT) (Eltayeb, 2017).

4. **Policy and Regulatory Gaps:** A well-defined policy and regulatory framework is critical to successful IoT adoption in Nigerian libraries. Olorundare et al. (2017) reported that the absence of national guidelines creates ambiguity in implementation and slows progress. Without clear direction, institutions face uncertainty around standards, responsibilities, and compliance requirements. This policy vacuum limits strategic planning and deters investment in IoT infrastructure. Passive challenges have also been noted in aligning library practices with broader digital governance initiatives. Effective regulation would not only guide integration but also ensure consistency and accountability. Establishing such a framework is a foundational step toward sustainable IoT deployment (Chukwudebe et al., 2021).

5. **Limited Awareness and Resistance to Change:** Low awareness and resistance to change among key library stakeholders continue to be significant obstacles to IoT adoption. Nwankwo et al. (2020) observed that many librarians and administrators lack a clear understanding of the benefits of IoT, resulting in hesitation or outright reluctance to adopt the technology. This resistance is often rooted in familiarity with traditional library practices, which makes adapting to modern, tech-driven systems challenging. It has also been reported that the absence of structured awareness campaigns further contributes to scepticism. When stakeholders are not fully informed, innovation is perceived as disruptive rather than transformative. Bridging this gap requires intentional change management and targeted sensitisation efforts (Khan et al., 2021).

Conclusion

Integrating IoT technology into library operations presents a valuable opportunity to enhance efficiency, resource management, and user experience. While developed countries have made significant advances in this area, Nigerian libraries face numerous challenges, including inadequate infrastructure, limited funding, policy gaps, and a shortage of skilled personnel. However, IoT adoption is attainable with strategic government policies, investment in digital infrastructure, and focused staff training. Learning from global best practices and fostering collaboration among policymakers,

library administrators, and tech experts can pave the way for smart, future-ready libraries in Nigeria.

Recommendations

1. **Strengthening Digital Infrastructure and Ensuring Sustainable Funding:** To enable successful IoT adoption in Nigerian libraries, the government and regulatory bodies must establish a clear, enforceable policy framework that outlines implementation strategies, data security protocols, and privacy safeguards. Standardised regulations will ensure consistent IoT integration while mitigating cybersecurity risks. Policies should align with international data protection standards and promote ethical usage, providing a structured roadmap for digital transformation. Robust cybersecurity measures must also be mandated to protect user data and build trust. Prioritising regulatory oversight and digital security will create a reliable, efficient environment that supports innovative library development across Nigeria.

2. **Strengthening Policy Frameworks and Cybersecurity Measures:** For effective IoT adoption in Nigerian libraries, the government and regulatory bodies must establish clear, standardised policies that define implementation strategies, data security protocols, and privacy guidelines. These frameworks will ensure a consistent approach to integration, reduce cybersecurity risks, and support compliance with global best practices. Enforcing strong cybersecurity measures and aligning data protection laws with international standards will safeguard user data, promote ethical IoT usage, and create a secure foundation for digital transformation in library services.

3. **Capacity Building and Stakeholder Engagement:** To successfully integrate IoT in Nigerian libraries, targeted training programs must be implemented to equip library professionals with essential skills in cybersecurity, data management, and IoT technologies. Ongoing professional development will strengthen their capacity to manage innovative systems effectively. Simultaneously, awareness and advocacy initiatives should educate stakeholders, decision-makers, users, and institutional leaders on the benefits of IoT, fostering digital literacy and support for adoption. This combined focus on capacity building and stakeholder engagement is crucial to ensuring the effective implementation of policies and the long-term sustainability of IoT-driven innovations in Nigerian libraries.

4. **Building Strategic Partnerships and Implementing IoT in Phases**: Nigerian libraries should collaborate with technology experts, universities, and research institutions to harness expertise in IoT deployment and develop innovative, context-specific solutions. Learning from international best practices can guide the creation of scalable strategies tailored to local needs. A phased implementation with pilot projects in select institutions will enable testing, refinement, and gradual adaptation, ensuring sustainable and effective IoT integration across the library system.

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