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APPLYING RFID-BASED TECHNOLOGIES FOR ENHANCED SECURITY OF INFORMATION RESOURCES IN ACADEMIC LIBRARIES IN NIGERIA

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Abstract

Nigerian academic libraries continue to grapple with outdated cataloguing systems, manual circulation processes, and limited automation, hampering users' ability to access information efficiently. This paper examines the potential of Radio Frequency Identification (RFID) technology to address these challenges by streamlining core library operations, including cataloguing, classification, circulation, inventory management, and security. Drawing on empirical and technical literature, the paper outlines how RFID enables faster, contactless circulation through self-check-in/check-out systems, supports more accurate inventory tracking without requiring line-of-sight scanning, and enhances security through automated theft detection. Global precedents, notably Singapore's National Library Board and the Seattle Public Library, demonstrate RFID's capacity to reduce processing time, ease staff workload, and improve user satisfaction at scale. Within Nigeria, adoption remains at an early and uneven stage, constrained by four interrelated barriers: the high cost of RFID infrastructure, inadequate ICT infrastructure and unreliable power supply, a persistent

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digital skills gap among library staff, and resistance to technological change. Evidence from Nigerian university library surveys confirms that cost and fear of job displacement are among the most commonly cited obstacles to implementation. The paper argues that overcoming these barriers requires coordinated action: phased funding partnerships between universities, government, and development partners; structured and continuous staff training; investment in alternative power sources such as solar energy; and deliberate change-management strategies to build staff buy-in. The paper contributes a function based framework synthesizing global and Nigerian RFID practice, and offers practical, stakeholder specific recommendations to support sustainable RFID adoption in resource constrained academic library settings.

Keywords: Radio Frequency Identification (RFID), Academic libraries, Library automation, Nigeria, Library security, ICT infrastructure, Digital literacy, Library management systems

Introduction

Academic libraries in Nigeria serve as essential hubs for knowledge acquisition, supporting teaching, learning, and research in tertiary institutions. These libraries manage large volumes of diverse information resources, from print materials to digital content, while catering to a growing population of students and researchers. Despite their importance, many Nigerian academic libraries still struggle with outdated cataloguing systems, limited automation, and inefficient circulation processes, which hamper users' ability to locate and retrieve materials promptly. A comprehensive assessment of two Nigerian academic libraries traced this shortfall to a combination of institutional, financial, and infrastructural factors that have collectively slowed automation efforts (Adewole-Odeshi, 2018). As universities expand and the demand for seamless academic support increases, there is a pressing need to modernize library systems to enhance service delivery.

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Over the past decade, there has been a noticeable surge in demand for quick and efficient access to information within academic settings. With students and researchers becoming increasingly reliant on real-time access to data, the traditional manual systems in most Nigerian academic libraries are proving insufficient, and users often face long queues for borrowing books, delayed catalogue updates, and difficulties in tracking the availability of resources. These challenges highlight the urgency for libraries to embrace more robust and user-friendly systems that streamline information retrieval and improve the overall user experience. Globally, academic libraries are leveraging innovative technologies to remain relevant and responsive to user expectations, and the integration of digital tools such as cloud-based Integrated Library Systems (ILS), Online Public Access Catalogues (OPAC), and, more recently, Radio Frequency Identification (RFID), has transformed how libraries manage resources. These technologies not only improve operational efficiency but also enable libraries to track inventory, reduce theft, and provide personalized user services; work on RFID application in library security has similarly framed the technology as a means of tightening asset tracking while simultaneously speeding up user access to materials (Mulla & Chandrashekara, 2006). This trend sets a compelling precedent for Nigerian academic libraries to explore and implement RFID-based systems for improved access to, and retrieval of, information resources.

Radio Frequency Identification (RFID) is a wireless technology that uses electromagnetic fields to automatically identify and track tags attached to objects. In library science, RFID provides a more efficient way to manage and circulate library materials. Unlike traditional barcodes, which require line-of-sight scanning, RFID tags can

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be read remotely, allowing for faster and simultaneous scanning of multiple items. An applied study on IoT-based library automation using RFID reported that the technology cut the time and labor required for routine library operations by 70–80% once fully implemented (Başciftçi & Bokiye, 2021), highlighting just how substantial the operational gains from automation can be. RFID enhances the automation of library operations such as check-in/check-out, inventory management, and security, and there are three main types of RFID systems: passive, active, and semi-passive.

Passive RFID tags are the most common in libraries; they have no internal power source and rely on the energy transmitted by the reader to function. Active RFID tags contain an internal battery and can transmit data over longer distances, while semi-passive tags have a battery that powers the chip but not the signal transmission. In addition, RFID systems can be categorized by range: short-range systems, typically used in libraries for shelf-level identification and circulation tasks, and long-range systems, suitable for tracking items across larger spaces. The choice of RFID type depends on the specific needs and physical infrastructure of the library.

Compared with traditional barcoding systems, RFID offers significant advantages in speed, accuracy, and convenience. Barcodes require individual scanning, making circulation and inventory processes time-consuming, whereas RFID enables bulk item scanning, significantly reducing processing time. An overview of RFID applications in libraries traced this shift directly to the technology's growing use in book identification, self-checkout, sorting, and theft detection, framing it as a gradual replacement for barcode systems even as it introduces new infrastructural and cost considerations of its own

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(Galhotra & Galhotra, 2010). This superior functionality positions RFID as a more comprehensive technology for modern library management. The integration of RFID into academic library systems is, in turn, revolutionizing core operations such as cataloguing, classification, inventory management, self-check-in/check-out, and security: by using electromagnetic fields to automatically identify and track tagged items, the technology allows libraries to automate item identification and streamline data entry, a capability documented in an early Spanish-language study of RFID's role in library management and maintenance (Gómez-Gómez, Ena-Rodríguez, & Priore, 2007). In cataloguing specifically, RFID tags embedded in books can store essential bibliographic and item-specific data, such as titles, call numbers, and accession details, reducing repetitive manual data entry, a benefit likewise highlighted in the same review of RFID applications referenced above (Galhotra & Galhotra, 2010). This does not only enhance efficiency but also reduces errors.

Integrating RFID readers with the cataloguing module of the Integrated Library Management System (ILMS) helps ensure that bibliographic data entered by catalogers can be transferred to RFID tags, supporting more seamless tracking, a workflow described in a Nigerian assessment of RFID use across several university libraries (Manuwa, Abdulsalam, & Dawha, 2023). In classification, RFID has the potential to embed classification numbers, such as Dewey Decimal or Library of Congress codes, into tags, supporting more automated sorting and shelf-reading, where handheld devices can help detect mis-shelved or unclassified items and maintain the logical arrangement of materials; this shelf-reading application is likewise noted in the RFID applications review discussed earlier (Galhotra & Galhotra, 2010). Despite these advantages, the technology faces challenges, particularly the

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high initial cost of RFID tags, readers, and software infrastructure. One of the most visible and user-friendly applications of RFID technology in libraries is the self-check-in and check-out system, which enables users to borrow and return materials independently, reducing queues and enhancing user satisfaction, an application documented in an account of RFID adoption at Singapore's National Library Board (Devadoss, 2008). During self-check-out, a user authenticates using a library card or ID and places one or several books on a kiosk, where the RFID reader scans the tags simultaneously.

The system then retrieves item data from the ILMS, links it to the user's account, prints a receipt, and deactivates the book's security tag, allowing the user to exit through the RFID gate without triggering an alarm, a sequence described in an applied engineering study of a Nigerian university's circulatory security system (Olaniyi, Nuhu, Salau, Musa, & Oparaocha, 2016). This process is designed to be quick, contactless, and efficient, supporting multiple-item checkout without individual barcode scanning. Conversely, self-check-in involves placing returned items on an RFID-enabled station or drop box, where the system scans the items, updates the return status, reactivates security, and routes the item for shelving or reservation; the same Nigerian assessment of RFID adoption found that this streamlined return process can meaningfully reduce staff workload and errors during manual check-in, improving overall operational efficiency (Manuwa et al., 2023). Inventory management is likewise a vital library function, focused on the systematic tracking and verification of resources such as books, journals, and audiovisual materials, and RFID technology has transformed this process by enabling faster, more accurate, and less labor-intensive management of large collections. Taken together, these capabilities suggest that

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inventory control, once one of the most staff-intensive functions in a library, can increasingly be handled by a much smaller team without any corresponding loss in accuracy.

Each item is fitted with an RFID tag containing data such as title, call number, and accession number, allowing handheld readers to scan shelved items without physically handling them. The same Spanish-language study of RFID in library management explained that RFID readers can capture data from tags within range and compare it against catalogue records, helping identify missing, mis-shelved, or extra items in a way that streamlines the inventory process and allows a smaller number of staff to scan large collections efficiently (Gómez-Gómez et al., 2007). Unlike barcode systems, RFID can read multiple items simultaneously and does not require line-of-sight, making shelf checks quicker and more reliable. Security remains a crucial aspect of library management, particularly in protecting valuable resources from theft and unauthorized removal, and RFID technology has proven effective in enhancing both service delivery and security by enabling automated surveillance and theft detection without the need for physical checks, as the earlier-cited work on RFID for physical information security in libraries similarly observed (Mulla & Chandrashekara, 2006). Each item is embedded with an RFID tag containing a unique identifier and a security bit linked to its record in the ILMS.

When a user borrows an item, the RFID system deactivates the security bit, allowing the user to exit through RFID-enabled gates without triggering an alarm; however, if an item is removed without proper checkout, the tag remains active and an alert is triggered, a mechanism consistent with the circulatory security design described earlier for a Nigerian

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university library (Olaniyi et al., 2016). This gives libraries a robust and largely user-friendly solution to security and anti-theft concerns. RFID additionally supports real-time tracking of items throughout the library, improving search speed, location accuracy, and resource availability, and ultimately enhancing user satisfaction and operational efficiency. In many developed countries, the adoption of RFID technology has revolutionized library operations by streamlining services and empowering users through self-service capabilities, and libraries across Europe, North America, and parts of Asia have successfully implemented RFID systems that allow users to independently borrow, return, and renew items, and manage their accounts, without staff assistance.

A notable example is Singapore's National Library Board (NLB), which introduced RFID in 1998 and became the first public library system in the world to deploy RFID-based self-checkout at scale. An account of this rollout describes how NLB's adoption of RFID supported automated check-out/check-in, sorting, and inventory management across acquisitions, cataloguing, and circulation, contributing to substantial reductions in queuing and processing time and easing staff workload (Devadoss, 2008). Similarly, the Seattle Public Library in the United States contracted for an RFID-based automated materials-handling and sorting system in the early 2000s to support self-service checkout, automated returns, and more efficient inventory tracking (Boss, 2003). Such implementations illustrate how RFID-powered sorting and self-service systems can allow libraries to reassign staff from routine circulation work to programming, digital literacy, and other outreach services. Other developed countries, such as the United Kingdom and Finland, have similarly demonstrated how RFID technology can transform library services by

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offering fast, reliable, and personalized access to information. These global implementations provide a valuable blueprint for academic libraries in developing countries, showing that RFID can significantly improve user experience, service delivery, and staff productivity when strategically implemented and consistently updated.

RFID Adoption in Nigerian Academic Libraries

Although the adoption of RFID in Nigerian libraries remains at an early stage owing to infrastructural and funding limitations, several institutions have begun implementing or exploring the technology to enhance circulation, inventory management, self-service, and security. A survey of selected Nigerian university libraries found that respondents generally held a positive perception of RFID's effectiveness for managing library resources, although implementation remains limited and uneven across institutions; the same study also identified RFID's higher cost relative to other methods, the vulnerability of tags to compromise, and staff fears about job loss as among the main barriers to wider use (Manuwa et al., 2023). Some Nigerian universities are reported in the professional literature to have begun adopting RFID for automated circulation and security; an applied engineering account, for instance, describes an RFID-based circulatory security system developed and tested at the Federal University of Technology, Minna, which combined RFID tagging with encryption to secure patron data during circulation (Olaniyi et al., 2016). These efforts, while still emerging, reflect a growing interest among Nigerian academic libraries in aligning with global best practice in digital librarianship through RFID adoption.

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Benefits of RFID for Nigerian Academic Libraries

RFID holds numerous benefits that are fundamental to the effective operation of academic libraries in Nigeria. It promotes faster circulation by enabling the simultaneous scanning of multiple items without requiring direct line-of-sight or precise alignment, unlike traditional barcodes. The Nigerian university library survey discussed earlier reported that RFID implementation was strongly associated with positive perceptions of resource management and seamless service delivery among the librarians surveyed (Manuwa et al., 2023). The Singapore case study referenced above further illustrates how self-checkout and self-return kiosks, once integrated with RFID, empower users to manage transactions independently and free library staff to focus on more complex tasks and user assistance (Devadoss, 2008). When RFID is integrated with automated material handling, as at the Seattle Public Library (Boss, 2003), it can also facilitate more rapid processing and sorting of returned materials, further reduce staff workload and speed up re-shelving. The increased speed of circulation processes made possible by RFID can translate directly into shorter waiting times for users, improving satisfaction with library services, and self-service options can offer users greater autonomy and, where paired with assistive interfaces, improved accessibility for users with mobility or visual impairments.

RFID further improves both operational efficiency and the overall user experience by generating usable circulation data. Data on circulation patterns and resource utilization, once analyzed, can inform decisions about collection development and resource allocation, a possibility raised in the Spanish-language RFID study cited earlier (Gómez-Gómez et al., 2007). Nigerian academic libraries could, in principle, draw on such circulation data to

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inform acquisition decisions, although the specific use of RFID data for individualized, automated book recommendations to patrons is not yet well documented in the library and information science literature and should be treated as a potential future application rather than an established practice. RFID also facilitates effective theft detection in Nigerian academic libraries: RFID-enabled security gates at library exits can detect unauthorized removal of items and trigger alarms, while the tags themselves are difficult to remove without damaging the item, further enhancing security, as both the earlier-cited circulatory security study and a separate account of RFID for curbing security challenges in Nigerian academic libraries describe (Olaniyi et al., 2016; Umar, 2018). This capacity to reduce book theft and loss helps protect and preserve library collections over time.

RFID tags also provide unique identifiers for each item, allowing quicker and more accurate tracking of location and circulation status. This can improve inventory management, reducing the time and effort traditionally spent on manual stock-taking, a point emphasized in the RFID applications review referenced earlier in this paper (Galhotra & Galhotra, 2010). Handheld RFID readers allow staff to quickly scan shelves and locate misplaced or mis-shelved books, helping ensure that resources remain accessible to patrons. Collectively, these gains suggest that RFID's value extends well beyond simple efficiency, touching on staff wellbeing and the overall quality of professional library service.

Barriers to RFID Adoption in Nigerian Academic Libraries

One of the major barriers to RFID implementation is its high initial and maintenance cost; many libraries in Nigeria are unable to implement RFID technology for this reason.

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The Nigerian university library survey discussed earlier found that librarians consistently identified the higher cost of RFID, relative to other circulation and security methods, as a major barrier to adoption (Manuwa et al., 2023). A fully functioning RFID system requires tags, readers, infrastructure, middleware, printers, and related components that can cost an organization a substantial sum, posing a significant financial burden for libraries with limited budgets. Infrastructural deficiency also poses a significant challenge to the implementation of RFID technologies in Nigerian academic libraries: an early but still relevant study of ICT adoption across Nigerian university libraries found that inadequate funding and the poor state of electrical infrastructure were among the major obstacles limiting effective ICT adoption more broadly, a finding consistent with the infrastructural barriers relevant to RFID uptake in developing-country contexts generally (Ani, Esin, & Edem, 2005). These cost- and infrastructure-related barriers are therefore not unique to RFID but reflect longer-standing structural constraints on technology adoption across the Nigerian library sector.

RFID technology involves complex components, namely tags, readers, antennas, middleware, and software integration, and it also requires network configuration, database management, and cybersecurity considerations. The skills and personnel needed to manage these components are lacking in many Nigerian academic libraries, a gap consistent with an exploratory study of digital literacy among African library and information science professionals, which found that respondents generally rated their digital literacy skills as moderate overall, with clear gaps in more advanced technical skills such as metadata development and library website or systems development relevant to

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sustaining RFID and other automated systems (Subaveerapandiyan, Sinha, & Ugwulebo, 2022). Library staff often lack either prior exposure to RFID or the specific skills required to operate and troubleshoot it, and the absence of dedicated technological expertise within many libraries compounds this problem. Many Nigerian librarians also lack adequate training owing to insufficient or non-existent RFID-related capacity-building programmes, and the same study of digital literacy among African LIS professionals suggested that this kind of skills gap can constrain the adoption of emerging technologies and limit libraries' ability to sustain innovative services once introduced (Subaveerapandiyan et al., 2022). Addressing this gap will likely require sustained institutional investment in training rather than one-off workshops, given how broad the range of technical competencies involved in operating RFID actually is.

RFID resources and services rely on electricity to function, yet unreliable power supply is a persistent problem for libraries, especially in developing countries such as Nigeria. A study on electricity access for ICT facilities in Nigerian university libraries identified inadequate and unreliable power supply as a major challenge affecting the use of automated systems, and recommended greater investment in alternative power sources such as solar energy (Adeyoyin, Alawiye, & Ewulo, 2019). This finding is also in line with the earlier-cited study of ICT adoption in Nigerian academic libraries, which found that intermittent power supply and inadequate funding are among the challenges affecting the development and sustained use of ICT-based technologies more broadly (Ani et al., 2005). Even where libraries provide backup generators to address unreliable power supply, the unavailability of funds for fueling these generators presents a further obstacle, frustrating

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the effective implementation and use of RFID technologies. Resistance to technological change also reflects a negative attitude among some library staff toward the adoption of new technology, and the Nigerian university library survey discussed throughout this paper found that fear of job displacement was among the perceived barriers to RFID adoption reported by the librarians surveyed (Manuwa et al., 2023). Some staff remain cautious in their understanding and use of technological tools and services, at times avoiding electronic systems out of concern about damaging or deleting important information while operating them.

Recommendations

1. University management, government agencies, and library associations should establish dedicated funding partnerships, including with international development partners, to offset the high capital cost of RFID infrastructure, adopting phased implementation rather than requiring full system deployment at once.
2. Structured, continuous RFID-specific training programmes should be institutionalized for librarians and technical staff to close the digital skills gap and reduce dependence on external technical support.
3. Libraries should prioritize investment in reliable alternative power sources, such as solar systems and inverters, alongside RFID hardware procurement, since unreliable power supply directly undermines system functionality.

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4. Library administrators should implement deliberate change-management initiatives, including sensitization, incentives, and staff involvement in planning, to reduce resistance to RFID adoption among personnel.

Contribution to Knowledge

1. The paper consolidates fragmented literature on RFID application across specific library operations (cataloguing, circulation, inventory, and security) into a single, function-based framework relevant to the Nigerian academic library.
2. It provides a comparative synthesis of global RFID practices (Singapore, USA) against emerging Nigerian implementations, offering a benchmark model for adoption in a developing country such as Nigeria.
3. It systematically identifies and categorizes specific barriers, namely cost, infrastructure, skills gap, power supply, and staff resistance, relevant to the Nigerian academic library environment, drawing on empirical Nigerian and comparable developing-country evidence.
4. It offers actionable, stakeholder-specific recommendations that bridge the gap between RFID's documented benefits and its practical, sustainable implementation in resource-constrained academic library settings.

Conclusion

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The integration of RFID technology into academic libraries represents a transformative step toward improving the quality, efficiency, and responsiveness of library services in Nigeria. As explored throughout this paper, RFID offers a wide range of benefits, including faster circulation processes, improved inventory management, enhanced security, and a more satisfying user experience. By automating routine library operations such as cataloguing, check-in/check-out, and inventory control, RFID does not only optimize workflow but also allows library staff to shift their focus to more strategic and user-centered services.

Evidence from global best practice in Singapore and the United States demonstrates that RFID is a proven and scalable solution for modern library management. Within Nigeria, emerging evidence, including the university library survey and the applied engineering work on circulatory security discussed throughout this paper, signals growing interest in, and gradual movement toward, RFID adoption in Nigerian academic libraries, even though implementation remains limited and uneven (Manuwa et al., 2023; Olaniyi et al., 2016). The journey toward fuller implementation is not, however, without its challenges: the high initial cost of deployment, infrastructural deficiencies, limited technical expertise, unreliable power supply, and resistance to change among library staff all constitute significant barriers. These issues must be addressed through strategic investment, policy support, consistent training, and change-management initiatives, and stakeholders, including government agencies, university management, library associations, and international development partners, must work collaboratively to provide funding, build

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capacity, and create an enabling environment for RFID adoption in Nigerian academic libraries.

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