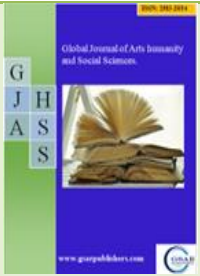


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THE INTEGRATION OF ARTIFICIAL INTELLIGENCE (AI) AND ROBOTIC IN CATALOGUING AND CIRCULATION OPERATIONS IN SELECTED LIBRARIES IN NIGERIA

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Abstract

This study investigated the integration of Artificial Intelligence (AI) and robotics in cataloguing and circulation processes within digital libraries in Nigeria. It sought to determine the current level of adoption, evaluate the impact of these technologies on routine administrative efficiency, and identify structural barriers impeding their implementation. A descriptive survey research design was adopted. The target population consisted of librarians and system administrators across selected university libraries in Nigeria. Data collection was executed using a structured electronic questionnaire titled AI and Robotics Integration Questionnaire (AIRIQ). Out of 134 administered questionnaires, 134 valid responses were retrieved and analyzed using descriptive statistics, including frequencies, mean scores, and standard deviations. The findings revealed that while there is a remarkably high conceptual awareness of generative AI, chatbots, and RFID-based automated circulation systems among information professionals, actual deployment remains nascent. The integration of AI algorithms for descriptive cataloguing and robotic applications for automated book retrieval significantly enhances user satisfaction, shortens service delivery time, and eliminates human errors in shelf management. Full-scale integration is faced by foundational challenges, which include infrastructural deficit, persistent power instability, and poor internet connectivity. It is concluded that without a deliberate overhaul of digital infrastructure, Nigerian academic libraries risk technological obsolescence. Based on these findings, the study recommends that university management allocate specific budget votes to build robust ICT infrastructure, ensuring a steady power supply and high-speed internet bandwidth. Library boards must implement mandatory capacity-building and continuous professional development training programs to bridge the emerging AI skill gaps among librarians. National policy frameworks should be established by the Librarians' Registration Council of Nigeria (LRCN) to regulate the ethical deployment of data-driven AI systems and protect user privacy.

Keywords: Artificial Intelligence, Robotics, Digital Libraries, Automated Cataloguing, Circulation Services, Nigeria.

Introduction

The global landscape of library and information science is undergoing a profound paradigm shift, propelled by the rapid evolution of digital technologies. Traditionally viewed as repositories for physical texts, libraries have transitioned into dynamic digital environments where knowledge management is driven by automation, cloud computing, and intelligent systems. At the vanguard of this modern metadata transformation is the

convergence of Artificial Intelligence (AI) and robotics (Kayode et al 2026)

In digital libraries, core administrative workflows—predominantly cataloguing (the organization and metadata creation of information resources) and circulation (the tracking, issuing, and retrieving of materials)—form the operational backbone of user service delivery. While traditional automation systems streamlined basic data entry, contemporary AI tools (such as Natural Language



Processing, machine learning, and expert systems) combined with mechanical robotics are revolutionizing these labor-intensive processes. Globally, this integration has been shown to minimize human error, optimize cataloguing speed, and enable 24/7 self-service circulation ecosystems (Nduka, 2024).

In developing nations like Nigeria, the pressure on academic and digital libraries to meet the expanding information needs of 21st-century researchers has never been greater. For decades, Nigerian libraries have faced persistent challenges, including backlogs in manual cataloguing, human inefficiencies in shelf-reading, and long queues at circulation desks (Igbo, 2024)

The introduction of AI and robotics offers a transformative pathway out of these administrative bottlenecks. Research indicates that AI algorithms can autonomously scrutinize, categorize, and index extensive volumes of digital resources by generating machine-readable cataloguing (MARC) records and assigning accurate metadata annotations (Adamu & Dogara, 2025). Furthermore, components of artificial intelligence, including autonomous robotic systems, are increasingly utilized globally to oversee physical-digital hybrid spaces—handling tasks ranging from book shelving and precision shelf-reading to automated material tracking at circulation boundaries.

Statement of the Problem

The practical integration of AI and robotics within digital library infrastructures in Nigeria remains fragmented and emergent. Nigerian digital libraries continue to rely heavily on legacy library management software that demands significant manual intervention for resource processing and physical distribution tracking. This manual dependence results in slower retrieval times, high operational redundancy, and reduced user satisfaction. While literature acknowledges that librarians are increasingly aware of basic AI applications like chatbots and recommendation systems, actual technological adoption for core backend workflows—specifically automated cataloguing and robotics-driven circulation—remains critically low due to foundational barriers. These barriers include Infrastructural Deficits, Persistent power instability and substandard internet connectivity. Skills Gaps Lack of specialized technical competencies among information professionals to manage and evaluate robotic and machine learning systems, Policy and Financial Constraints. Shortages of institutional frameworks, data security standards, and capital funding required to scale high-tech installations. Without empirical investigation into how these advanced systems can be harmonized within the local constraints of the Nigerian educational sector, digital libraries risks widening the global digital divide. Therefore, this study investigates the integration, prospects, operational awareness, and socio-technical challenges of deploying AI and robotics within cataloguing and circulation operations in Nigerian digital libraries.

Objectives of the study

1. To examine the digital infrastructure available in Nigerian University libraries to support AI-driven cataloguing and circulation systems.

2. To ascertain the advantages of AI-integrated cataloguing and circulation workflows in digital libraries in Nigeria.
3. To evaluate the specific skills librarians, require to effectively manage AI and robotic tools in cataloguing and circulation operations.
4. To identify the primary barriers hindering the development of AI and robotics in Nigerian digital libraries.

Research Questions

1. What is the digital infrastructure available in Nigerian University libraries to support AI-driven cataloguing and robotic circulation systems?
2. What are the advantages of AI-integrated cataloguing and circulation workflows in digital librarians in Nigeria?
3. What are the specific digital skills librarians required to effectively manage AI and robotic tools in cataloguing and circulation operations?
4. What are the primary barriers hindering the deployment of AI and robotics in Nigerian digital libraries?

Literature Review

Conceptual Framework

The conceptual framework for integrating Artificial Intelligence (AI) and robotics into the cataloguing and circulation operations of digital libraries revolves around the Technology Acceptance Model (TAM) and the Diffusion of Innovations (DOI) Theory, adapted to the modern institutional repository environment. In this framework, the library workflow undergoes a structural transformation where traditional, manual data entry and handling processes are replaced or enhanced by automation. The conceptual framework connects three major blocks: Technological Inputs (Independent Variables): AI components (such as Natural Language Processing, Machine Learning algorithms, and expert systems) and Robotics components (including Automated Guided Vehicles (AGVs), BookBots, and RFID-enabled robotic shelf scanners).

Library Operations (Intervening Variables): The technical service ecosystem—specifically descriptive cataloguing, metadata generation, automated classification—and the physical/digital user-services layer—specifically book sorting, automated check-in/check-out, circulation tracking, and shelf

Lung & Wang, 2023)

To provide a granular understanding of this thematic area, empirical studies are reviewed under four foundational research questions designed to guide this inquiry. Recent studies indicate that while awareness of AI-driven tools is growing among Nigerian librarians, actual systemic adoption remains in its infancy. Librarians frequently report a high level of conceptual awareness regarding basic applications like chatbots and automated recommendation systems, but possess significantly lower practical familiarity with complex infrastructure such as automated cataloguing algorithms or robotic shelf management systems (Okuonghae & Tunmibi, 2025). A substantial portion of the

academic workforce expresses a willingness to adopt these modern systems, yet actual implementation rates across federal and state universities remain heavily constrained (Onwubiko, 2025). Many librarians experience conflicting attitudes—balancing professional enthusiasm for the technological evolution against an institutional resistance to change and tech-anxiety regarding structural shifts in traditional library workflows.

The traditional cataloguing and indexation process is notoriously labor-intensive. Empirical evidence demonstrates that AI technologies—particularly expert systems and pattern recognition—radically transform this sector by facilitating automated descriptive cataloguing and metadata creation (Tella & et al, 2026). AI systems operate via dual approaches: a human-computer interface where the human cataloguer supervises algorithmic output, and fully automated pipelines integrated with digital publishing systems. These advanced algorithms autonomously ingest massive digital text deposits, assign standardized subject headings, analyze big data trends, and generate accurate metadata tags with speeds and error-reduction rates that human metadata specialists cannot achieve manually (Oyetola et al, 2025). This integration enables academic libraries to handle massive backlogs of institutional repositories swiftly and accurately.

Circulation works form the transactional core of library interaction. Robotics systems, paired with Radio Frequency Identification (RFID) technology, alleviate the physical bottlenecks associated with manual book handling, sorting, and user records management. In modern digital-physical hybrids, automated robotic mechanisms such as BookBots and robotic cranes are deployed to retrieve or sort materials with high precision. Furthermore, self-learning AI frameworks combined with automated circulation systems ensure that the process of borrowing, tracking, and returning books operates seamlessly around the clock (24/7) without requiring constant human monitoring (Oyekale, 2023). These automated systems keep flawless statistics on book utilization, track missing items, and minimize misplaced books on shelves through continuous automated scans.

Despite the undeniable operational benefits, the deployment of cutting-edge automated systems in Nigeria faces an uphill battle against deep-seated infrastructural and financial constraints. The major barriers obstructing successful implementation include inadequate funding because high capital layout is required to purchase and maintain AI frameworks and robotic machinery (Okuonghae & Tunmibi, 2025), lack of trained technological personnel and technical experts within the library environment who can handle NLP models or maintain robotic hardware, erratic power supplies and unreliable internet connectivity, which threaten the continuous up-time required for real-time automated digital libraries (Onwubiko, 2025).

The integration of Artificial Intelligence and robotics stands as a pivotal evolutionary leap for digital libraries in Nigeria. Emplacing these technologies into the administrative core of library operations transitions cataloguing from a slow, manual data entry workflow

into a dynamic, algorithmic generation of metadata. Similarly, circulation operations shift toward a highly synchronized, error-free automated ecosystem. While the conceptual readiness and baseline awareness among Nigerian librarians are steadily gaining momentum, institutional frameworks must aggressively address the underlying deficits in funding, power infrastructure, and technological literacy to successfully move from theoretical awareness to nationwide operational reality (Akinagbe, 2024).

Despite the expanding corpus of literature on library automation, a critical methodological and contextual gap remains unaddressed. Most existing Nigerian studies (e.g., Adamu & Dogara, 2025; Okuonghae & Tunmibi, 2025) focus strictly on general AI awareness or broad perceptions of librarians via questionnaire surveys. There is a profound lack of empirical, hands-on case studies or experimental research detailing the functional integration of physical robotics (like RFID-driven sorting units or shelf-scanning bots) within Nigerian digital spaces. Resent literature fails to offer a localized, contextualized AI governance policy or structural framework that addresses how Nigerian libraries can sustain power-intensive AI tools amidst erratic local power grids. This study addresses this exact gap by investigating the practical, operational interface of both AI software and robotic hardware engineered specifically to withstand the resource-constrained environment of Nigerian digital libraries.

Methodology

This section deals with the analysis of the data. In this study, the data were analyzed using descriptive statistics. Specifically, the demographic profile of the respondents such as gender, work experience, and educational qualifications were summarized using frequency and simple percentage. While mean and standard deviation were employed in analyzing the research questions. The questionnaire items being structured on a 4-point Likert scale, mean value of 2.50 and above is accepted indicating respondents' agreement with the questionnaire items. On the other hand, mean value less than 2.50 is rejected showing respondents' disagreement with the questionnaire items. Four research questions are analyzed in this study in line with the objectives of the study, and results are interpreted accordingly.

Result and Interpretation

Table 1: Analysis of demographic profile of respondents

Gender	Frequency	Percentage (%)
Male	76	56.7
Female	58	43.3
Total	134	100.0
Age Distribution		
Below 30 years	29	21.6
30 – 40 years	48	35.8
41 – 50 years	36	26.9

51 years and above	21	15.7
Total	134	100.0
Highest Qualification		
B.Sc./BLIS	44	32.8
M.Sc./MLS	57	42.5
Ph.D	33	24.7
Total	134	100.0
Work Experience		
less than 1 years	18	13.4
1 – 3 years	39	29.1
4 – 6 years	46	34.3
7 years and above	31	23.1
Total	134	100.0

From table 1, the demographic profile shows that 76 respondents (56.7%) were male, while 58 (43.3%) were female, indicating a fairly balanced gender representation with a slight male dominance. The majority of respondents were 30–40 years old (35.8%), followed by those aged 41–50 years (26.9%), suggesting that most participants were within the active working-age group and likely familiar with emerging digital technologies in library operations. Regarding educational qualifications, 57 respondents (42.5%) held M.Sc./MLS degrees, indicating that most participants possessed advanced professional knowledge relevant to AI and robotics in libraries. In terms of work experience, 46 respondents (34.3%) had 4–6 years of experience, while 31 (23.1%) had over seven years, implying that the respondents had sufficient professional exposure to provide informed opinions on the integration of AI and robotics in cataloguing and circulation operations in Nigerian university libraries.

Research question one: What are the digital infrastructure available in Nigerian University libraries to support AI-driven cataloguing and robotic circulation systems?

Table 2: Means score of digital infrastructure available in Nigerian universities to support AI-driven cataloguing and robotic circulation systems.

S/N	Questionnaire Items	SA	A	D	SD	n	$\bar{x}$	Std. Deviation
1	High-speed internet connectivity and stable network infrastructure.	58	47	20	9	134	3.15	0.89
2	Artificial Intelligence-compatible Integrated Library Management Systems (ILMS), such as Koha.	50	46	28	10	134	3.01	0.93
3	Smart technologies such as barcode scanners and networked computer systems..	48	54	20	12	134	3.03	0.90

Source: Fieldwork, 2026

The findings in Table 2 reveal that Nigerian university libraries possess essential digital infrastructure to support AI-driven cataloguing and robotic circulation systems. Respondents agreed that high-speed internet connectivity and stable network infrastructure are available, as indicated by the highest mean score of 3.15 ($SD = 0.89$). Similarly, the availability of AI-compatible Integrated Library Management Systems (ILMS), such as Koha ($\bar{x} = 3.01$, $SD = 0.93$) and smart technologies, including barcode scanners and networked computer systems ($\bar{x} = 3.03$, $SD = 0.90$),

was also acknowledged. Since all mean scores exceeded the benchmark of 2.50, the findings indicate that the digital infrastructure required to support AI-driven cataloguing and robotic circulation systems is generally available in Nigerian university libraries.

Research question two: What are the advantages of AI-integrated cataloguing and circulation workflows in digital libraries in Nigeria?

Table 3: Means score of the advantages of AI-driven integrated cataloguing and circulation workflows in digital libraries in Nigeria.

S/N	Questionnaire Items	SA	A	D	SD	n	$\bar{x}$	Std. Deviation
1	Improve the speed and accuracy of cataloguing and circulation operations in digital libraries in Nigeria.	62	44	21	7	134	3.20	0.91
2	Enhance users' ability to search for, locate, and access library resources in digital libraries in Nigeria.	57	45	18	14	134	3.08	0.90
3	Reduce routine manual tasks and improve the overall efficiency of library service delivery in digital libraries in Nigeria.	60	40	24	10	134	3.12	0.92

Source: Fieldwork, 2026



The results in Table 3 indicate that respondents agreed that AI-integrated cataloguing and circulation workflows offer significant benefits to digital libraries in Nigeria. The highest-rated advantage was improving the speed and accuracy of cataloguing and circulation operations with a mean score of 3.20 (SD = 0.91). Respondents also agreed that AI reduces routine manual tasks and improves the overall efficiency of library service delivery ($\bar{x}$ = 3.12, SD = 0.92) and enhances users' ability to search for, locate,

and access library resources ($\bar{x}$ = 3.08, SD = 0.90). Since all mean scores are above the benchmark of 2.50, the findings demonstrate that AI integration significantly enhances the effectiveness and quality of digital library operations in Nigeria.

Research question three: What are the specific digital skills librarians required to effectively manage AI and robotic tools in cataloguing and circulation operations?

Table 4: Means score of the specific digital skills librarians require to effectively manage AI and robotic tools in cataloguing and circulation operations

S/N	Questionnaire Items	SA	A	D	SD	n	$\bar{x}$	Std. Deviation
1	Librarians require skills in operating and managing AI-powered library management systems.	52	50	24	8	134	3.09	0.87
2	Librarians require technical skills to operate and troubleshoot robotic technologies and automated book-handling equipment.	49	53	26	6	134	3.08	0.92
3	Librarians require data management and digital literacy skills to effectively use AI and robotic tools.	61	42	20	11	134	3.14	0.94

Source: Fieldwork, 2026

The findings in Table 4 show that respondents agreed that librarians require specific digital skills to effectively manage AI and robotic tools in cataloguing and circulation operations. Data management and digital literacy skills received the highest mean score of 3.14 (SD = 0.94), indicating their importance for the effective use of AI and robotic technologies. Respondents also agreed that librarians require skills in operating and managing AI-powered library management systems ($\bar{x}$ = 3.09, SD = 0.87) and

technical skills to operate and troubleshoot robotic technologies and automated book-handling equipment ($\bar{x}$ = 3.08, SD = 0.92). Since all mean scores exceeded the benchmark of 2.50, the findings suggest that these digital competencies are essential for the successful integration and management of AI and robotics in library operations.

Research question four: What are the primary barriers hindering the deployment of AI robotics in Nigerian digital libraries?

Table 5: Means score of the primary barriers hindering the deployment of AI robotics in Nigerian digital libraries.

S/N	Questionnaire Items	SA	A	D	SD	n	$\bar{x}$	Std. Deviation
1	Inadequate funding limits the acquisition, implementation, and maintenance of AI and robotic technologies.	66	36	19	13	134	3.16	0.99
2	Insufficient ICT infrastructure, including unreliable internet connectivity and unstable electricity supply.	54	50	16	14	134	3.07	0.92
3	Limited technical expertise and inadequate training among	41	58	25	10	134	2.98	0.98

Source: Fieldwork, 2026

From table 5,

The findings in Table 5 indicate that respondents agreed that several barriers hinder the deployment of AI and robotics in Nigerian digital libraries. Inadequate funding was identified as the most significant barrier, recording the highest mean score of 3.16 (SD = 0.99), suggesting that financial constraints limit the acquisition, implementation, and maintenance of AI and robotic technologies. Respondents also agreed that insufficient ICT infrastructure, including unreliable internet connectivity and unstable electricity supply ($\bar{x}$ = 3.07, SD = 0.92), and limited technical expertise and inadequate training among library

personnel ($\bar{x}$ = 2.98, SD = 0.98) impede AI deployment. Since all mean scores exceeded the criterion mean of 2.50, the findings confirm that these factors are major obstacles to the successful deployment of AI and robotics in Nigerian digital libraries.

FINDINGS AND DISCUSSION

Research indicates that the adoption of AI and robotics in Nigerian university libraries is limited and often fragmented. While many libraries have migrated from manual card systems to Integrated Library Management Systems (ILMS), the deployment of advanced AI—such as machine learning for predictive cataloguing or robots for book retrieval—is rare. Current "AI-driven" tools are

largely limited to basic security scanning devices, RFID-based self-checkout systems, and basic chatbots for reference services (Jibga, 2025; Moustapha, 2024).

The integration of these technologies has the potential to streamline operations. AI-powered cataloguing can automate metadata generation, while robotics can assist in inventory management and shelf-reading, reducing human error and manual labor (Igbo, 2024).

AI also enhances User Experience. Automated circulation systems enable independent borrowing and returning, allowing users to interact with library services without physical dependence on staff for routine transactions (Agboke, 2021). Integration of AI and robotics improves efficiency. Machine learning can analyze usage patterns, helping librarians make data-driven decisions regarding collection development and resource allocation (Dada, 2026; Udo-Onkon, 2024). Challenges to Implementation Despite the potential benefits, there are several critical barriers that impede widespread integration, which include infrastructural Deficiencies, funding and Economic Constraints, espavially high costs of procurement, maintenance, and technical training for AI infrastructure. Additional, human Capital and Resistance. There is a notable lack of technical expertise among library staff, compounded by a fear of job displacement, which leads to resistance toward adopting new technologies (Moustapha, 2024; Udo-Onkon, 2024). Lack of Policy Frameworks: Most libraries lack a strategic, institutional roadmap for AI integration, resulting in ad-hoc and unsustainable implementation (Jibga, 2025).

Conclusion

The integration of Artificial Intelligence (AI) and robotics into the cataloguing and circulation operations of digital libraries in Nigeria represents a paradigm shift in the management of academic and institutional knowledge. This study demonstrates that leveraging AI-driven systems and smart automation significantly optimizes core technical services by accelerating metadata generation, refining automated classification, and streamlining routine data organization processes (Adamu & Dogara, 2025). Furthermore, in circulation operations, these technologies facilitate seamless self-service transactions, real-time book tracking, and 24/7 user engagement, fundamentally reshaping how patrons interact with digital library environments (Enakrire & Oladokun, 2024). By handling tedious, high-volume operational tasks, AI allows contemporary Nigerian librarians to transition toward higher-value roles, such as specialized research support and user-centric digital literacy initiatives.

Despite the undeniable transformative potential of AI and robotics, their widespread adoption across Nigerian digital libraries is still in its formative stages and encounters significant domestic obstacles. Academic libraries continue to battle severe structural constraints, including inadequate Information Communication Technology (ICT) infrastructure, erratic power supply, high implementation costs, and a pronounced digital literacy deficit among existing staff. Additionally, integrating sophisticated machine learning

models introduces complex administrative hurdles regarding user data privacy, copyright compliance, and algorithmic bias.

Ultimately, the successful integration of AI and robotics within the Nigerian digital library ecosystem depends heavily on institutional readiness, continuous human capital development, and systemic policy frameworks. To bridge the existing digital divide and remain globally competitive, Nigerian universities and government stakeholders must commit to sustaining robust funding models for infrastructural upgrades, developing localized AI evaluation standards, and rolling out continuous professional training programs for librarians. Only through deliberate, inclusive, and ethically grounded implementation can Nigerian libraries fully capitalize on AI and robotics to build sustainable, intelligent information repositories for the future.

Recommendations

1. **Robust Infrastructure and Energy Hybridization:** The foundational barrier to AI and robotic integration in Nigerian university libraries remains erratic power and poor internet infrastructure. Digital libraries must transition to hybrid green-energy solutions (such as solar-powered inverter systems) paired with dedicated, high-bandwidth fiber optic internet lines. This ensures that automated cataloguing servers and robotic sorting devices operate uninterrupted, preventing database corruption during unexpected outages.
2. **Systematic Deployment of RFID and Intelligent Sorting Robots:** To optimize circulation, Nigerian digital libraries must upgrade physical-to-digital touchpoints. Implement Radio Frequency Identification (RFID) tagging across physical collections alongside automated robotic crane systems or automated material handling (AMH) bots. This allows for seamless book tracking, shelf scanning, and error-free 24/7 self-check-in/check-out circulation services, which significantly reduces the manual workload of library staff.
3. **Upskilling and Mandatory AI-Literacy Programs for Librarians:** A recurring issue in the Nigerian library ecosystem is a moderate-to-low confidence level among library professionals regarding advanced technological tools. Academic institutions and library boards must institute ongoing training workshops focusing on Machine Learning (ML), Natural Language Processing (NLP) for metadata generation, and fundamental robotics management. Upskilling shifts the workforce from manual cataloguers to strategic data curators and human-AI collaborators.
4. **Establishment of National AI Governance and Policy Frameworks:** Integrating AI comes with systemic risks, including metadata bias, data privacy issues, and intellectual property concerns. The National Library of Nigeria (NLN) and the Librarians' Registration Council of Nigeria (LRCN) should collaboratively formulate comprehensive AI usage guidelines. These frameworks must enforce strict data security protocols to protect



users' data during circulation transactions while standardizing automated descriptive cataloguing patterns across Nigerian digital libraries.

5. Consortium-Based Funding and Multi-Sectoral Partnerships The initial cost of setting up AI algorithms and robotic infrastructure can be prohibitively high for individual Nigerian institutions. Libraries should form strategic consortia to pool financial resources and establish public-private partnerships (PPPs) with tech firms and bodies like the Tertiary Education Trust Fund (TETFund). This collective approach can lower procurement costs for library automation licenses and hardware components.

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