

DIGITAL DATA MANAGEMENT AND LIBRARY SERVICE DELIVERY IN THE FIFTH INDUSTRIAL REVOLUTION: A STUDY OF NIGERIAN ACADEMIC LIBRARIES

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Abstract

This paper examines the role of digital data management in enhancing library service delivery within the context of the Fifth Industrial Revolution (5IR). Drawing on extant literature and selected Nigerian and global case examples, the study analyses how emerging technologies such as artificial intelligence, blockchain, cloud computing, and big data analytics are reshaping library operations. The paper focuses on key components of digital data management, including data governance, digital cataloguing, institutional repositories, metadata creation, access control, and disaster recovery. Findings indicate that while global institutions operate within structured governance and technological frameworks, many Nigerian academic libraries continue to face challenges relating to inadequate funding, weak digital policies, infrastructural deficits, and limited technical capacity. The study recommends targeted professional training in digital librarianship, increased investment in cloud-based infrastructure, the formulation of comprehensive data governance and disaster recovery policies, and strengthened inter-institutional collaboration through library consortia. It concludes that effective digital data management is critical for repositioning academic libraries as resilient, user-centred knowledge hubs in the 5IR era.

Keywords: **Digital Data Management, Library Services, Fifth Industrial Revolution (5IR) Academic Libraries, Information Technology**

Introduction

Technology and society have changed significantly as a result of advent of Industrial Revolutions. From the first Industrial revolution to 5th industrial revolution has transformed the way we live and carry out our regular tasks (Petcu et al., 2020). With the integration of advanced technologies such as Internet of Thing and Artificial Intelligent, which has led to an increase in mass production, electronic commerce, and automation. Golić, (2019), affirmed this that the goal of the fifth industrial revolution, is to improve manufacturing productivity and resource efficiency through modifying how humans and machines interact. This period simply marks the transition where information resource and library service move from the traditional way of rendering their services to the user to a technologically driven which can be access anytime, anywhere with the aid of information and communication technology devices (Ekwueme *et al*,2024). Therefore, in order to be relevant and responsive in the quickly changing 5th industrial revolution environment, libraries needs to adopt digital data management practice and transition from traditional print resources to digital data management to improve their services.

Dictionary for Library and Information Science (2007) posited digital data as information stored in a machine-readable format which facilitates easy accessibility, archiving, retrieval, and electronic dissemination. These digital resources improve the user experience by enabling remote access, multi-user use at the same time, and effective information retrieval (Igbo et al., 2022). In order to guarantee the longevity and accessibility of digital resources, library must make possible effort to manage this

resources digitally. This process includes activities like data curation, digital preservation, metadata development and the establishment of infrastructures and policies that support effective digital resource management in Nigerian academic libraries (Afolabi, 2022). This enhance delivery of information services, promoting scholarly research. The deployment of digital data management in Nigerian academic libraries has faced several difficulties, despite its recognised significance. These include a shortage of skilled personnel, insufficient funding, and inadequate infrastructure (Mohammed, Garba & Abdullahi, 2019). Addressing these challenges is essential for the successful integration of digital data management practices in Nigerian academic libraries.

Overview of the 5th Industrial Revolution (5IR)

According to Enakrire et al. (2024) 5IR is the most recent stage of technological development that is changing economies, societies, and industries. This revolution builds on the achievements of the fourth Industrial Revolution (4IR), which included technologies such as robotics, artificial intelligence (AI), and the Internet of Things (IoT) (Oladokun et al., 2024). The goal of this industrial transition is to promote a positive interaction between humans and robots in order to increase productivity and societal well-being (Ajani et al., 2023). The recent development of 5IR necessitates that these experts not only adopt new technologies but also develop their skill sets in order to support productive human-machine cooperation, which signifies a profound paradigm shift in the way knowledge is retrieved, organized, and shared Awoyemi (2023). According to Nwobu (2024), this shift

has made knowledge more accessible to library users, allowing people to access information from any location with internet connectivity.

The fifth industrial revolution is an example of how humans and machines can work together to improve the effectiveness of information services provided to library patrons. This technical developments in library service delivery have caused libraries to move from manual to computer-based operations as we move from the first to the fifth industrial revolution, which has resulted in online service delivery

The 5th Industrial Revolution Technologies in Libraries

According to Prajapati et al. (2019) the 5IR covers the use of digital and mechanical machinery with other communication devices for information transfer across networks. Adigun et al.,(2024), listed out some technologies for libraries in the fifth industrial revolution which transforms beyond traditional bounds, giving libraries a dynamic and diverse ability to interact with users in new and unexplored ways. These technologies include;

Cloud Computing: Cloud computing, which provides scalable and affordable solutions for storage, collaboration, and resource sharing, has completely changed how libraries manage and provide digital services (Sharma et al, 2023). A more user-centric approach and increased resource accessibility are made possible by cloud-based library systems, which provide easy access to digital resources.

Blockchain: Blockchain technology is being used by libraries to improve transaction security and transparency, especially when it comes to managing digital assets and intellectual property (Tella, Amuda, and Ajani 2022). The integrity of library collections can be ensured by using blockchain's immutable record to confirm the authenticity of digital information resources. Additionally, it has the ability to safeguard copyright management and digital lending procedures, enhancing accountability and confidence.

Augmented Reality (AR) and Virtual Reality (VR): Virtual tours, interactive learning, and creative storytelling are all made possible by AR and VR technologies, which are revolutionising the way libraries interact with their users (Zhang et al. 2020). In order to bridge the gap between digital and physical library spaces and produce engaging instructional content, libraries are utilising AR and VR to increase user engagement (Prouzeau et al. 2020).

Internet of Things (IoT): In order to maximise space utilisation, improve user experiences, and advance sustainability, IoT sensors track a number of library operations factors, such as occupancy rates, environmental conditions, and resource usage (Azizi et al. 2020). A more comfortable and energy-efficient library environment is facilitated by sensors that modify climate control and lighting settings based on occupancy. Libraries are becoming smart, responsive places that are aware of their users' requirements due to IoT devices

Data Analytics and Big Data: Libraries are now using big data and data analytics to gain an insight into how users behave, how they utilise resources, and how collections development are created. These data-driven insights are essential for designing library strategies and making sure that resources are distributed as efficiently as possible to satisfy users' changing needs.

Artificial Intelligence (AI) and Machine Learning: These technologies have revolutionised cataloguing, information retrieval, and user interactions. Chatbots, recommendation algorithms, and AI-powered virtual assistants are improving user experiences and offering individualised and effective library services (Chaturvedi and Verma 2023).. As libraries transition to the Fifth Industrial Revolution, artificial intelligence (AI) and machine learning have taken center stage.

Robotic Automation: Robotic automation is being used by libraries to expedite routine tasks such as reshelving and book retrieval. RFID-enabled robots effectively find and arrange materials, freeing up library employees to work on more intricate and user-focused tasks (Tella and Ajani 2022). Robotic automation improves operational effectiveness and supports libraries' overall resource management plan.

Key Components of Data Management in Libraries

The growing quantity, variety, and complexity of digital information resources has made data management a crucial duty for modern libraries. Libraries no longer function

solely as custodians of physical collections; they now manage research data, institutional records, metadata, and digital objects across their life cycles. Effective data management enables libraries to support scholarly communication, enhance service delivery, and ensure the long-term sustainability of information resources (Moruf, 2025). Libraries increasingly generate, collect, and curate diverse forms of data, ranging from bibliographic records to research data and user-generated information. In my view, libraries that fail to adopt structured data management practices risk diminishing their relevance in an increasingly data driven research environment.

One of the core components of data management in libraries is data creation, organisation, and description. This involves the systematic capture of data and the application of standardised metadata schemas and cataloguing rules to ensure consistency and discoverability. Metadata frameworks facilitate interoperability across platforms and institutions, thereby supporting data sharing and reuse. Metadata, defined by Bhattacharya et al. (2023) as structured data about data, functions as the descriptive and administrative backbone of digital library services. Proper organisation and description also enhance retrieval efficiency and align library practices with open science and research transparency initiatives (Yuan et al., 2025). The researcher conceptualise that , investing in robust metadata practices is not just a technical requirement but a strategic tool that enhances the library's visibility and its contribution to research outcomes.

Another critical component is data storage and preservation. Libraries must provide secure and scalable infrastructure capable of accommodating both current and future data needs. Institutional repositories serve as trusted platforms for storing, managing, and preserving research outputs and associated datasets (Dube, 2025). I believe that preservation should be proactive rather than reactive; libraries should anticipate technological obsolescence and plan long-term strategies for digital continuity to maintain user trust and institutional memory. Data access, sharing, and quality assurance further constitute essential elements of library data management. Libraries must ensure that data is accessible to authorised users while maintaining accuracy, reliability, and completeness. Many libraries now support researchers with data management planning and FAIR-compliant data curation (Moruf, 2025; Lopez et al., 2023). In my opinion, libraries have a critical role as mediators between open access ideals and ethical obligations, ensuring that accessibility does not compromise data quality or privacy.

Another critical component is the development of digital repositories and archives, which ensure the long-term preservation and institutional memory of both scholarly and administrative records. Prasad et al. (2025) argued that digital repositories have moved beyond passive storage systems into dynamic platforms that support data mining, machine-readable metadata, and real-time access. Closely aligned with governance is digital cataloguing and classification, which serve as mechanisms for organizing knowledge and facilitating access through standardized bibliographic records. Koha's support for

MARC21 and UNIMARC has enhanced cataloguing efficiency across various contexts, as observed by Amirah et al. (2023), who reported its successful adoption in Malaysian academic libraries.

Nonetheless, cataloguing workflows remain limited in scope due to what Ojedokun et al. (2024) termed “partial automation, where cataloguing and circulation modules are used in isolation without full integration into the broader library system. This fragmentation is compounded by inconsistent application of authority control measures, which, as data governance and professional capacity building underpin all other components of data management in libraries. Das and Mishra (2022) viewed data governance in libraries to entails not only the articulation of access rights and accountability structures but also the alignment of digital content with organizational missions. Governance frameworks define policies, roles, and responsibilities for data ownership, security, and ethical use. Continuous professional development equips librarians with the skills needed for effective data lifecycle management (Badenhorst & Raju, 2025). While some institutions have adopted third-party backup services, these are often constrained by budget limitations, poor network infrastructure, or lack of trained IT personnel, further exacerbating their vulnerability

Concept of Digital Data Management

Glossary of Digital Library Terms (2024), affirmed digital data management in library is the means of carrying out a set of coordinated activities designed to collect, organise, store, secure, and preserve information resources in a digital form. In academic libraries, digital data management is referred to as the systematic techniques used to acquire, organise, store, preserve, and disseminate digital library materials in order to enhance research, teaching, and learning. This digital resources, including e-books, electronic journals, institutional repositories, and digitised local content. Reliability, accessibility, and longterm preservation of these resources are guaranteed by efficient digital data management.

The implementation of digital data management practices in Nigerian academic libraries has been influenced by the need to enhance service delivery and meet the evolving information needs of users. Cloud computing has emerged as a viable solution for managing digital records, offering benefits such as remote accessibility, data backup, and efficient storage solutions. Okuonghae et al. (2023) highlight that cloud computing facilitates the preservation of library records and supports effective information management systems in academic libraries. However, challenges such as irregular power supply, high costs of data, and vulnerability to cyber-attacks pose significant obstacles to its adoption.

Furthermore, the integration of big data analytics into library operations has the potential to revolutionise digital data management by enabling libraries to analyse user behavior, optimise services, and make informed decisions. Addressing these challenges requires

concerted efforts in training library personnel, investing in necessary infrastructure, and developing policies that support the ethical handling of digital data.

Benefits of Digital Data Management to Library Services.

In recent scholarly discourse, the benefits of digital data management to library services have been rigorously explored, with growing emphasis on how data systems reshape access, efficiency, analytics, preservation, and collaboration within modern libraries. One of the most widely acknowledged advantages is the enhancement of user access to resources anytime, anywhere. This flexibility, enabled through cloud infrastructure and web-based library management systems, has effectively eliminated the physical and temporal limitations of traditional libraries. Bhattacharya et al. (2023) contend that digital data environments expand user agency by decentralizing access," while Ghosh and Saha (2022) emphasize that open-source systems such as Koha extend access through personalized user dashboards, OPAC search, and mobile integration.

Equally important is the capacity of digital data management to facilitate real-time data analytics, which provides insights into user behavior, borrowing patterns, and service effectiveness. Olowoporoku et al. (2024) explain, the availability of system-generated reports within Koha enables evidence-based decision-making in collection development and staff allocation. Das and Islam (2021) note that libraries equipped with analytics capabilities can "shift from reactive to anticipatory service models," anticipating user needs

through predictive analytics and usage trends. This analytical functionality, however, remains underutilized in many African academic libraries, where infrastructure limitations and skill gaps limit the exploitation of embedded data features.

Alongside analytics, long-term digital preservation is another transformative benefit. Prasad et al. (2025) highlight how digital repositories embedded within broader data governance frameworks support archival continuity and risk mitigation. Their findings demonstrate that well-managed digital preservation systems enhance scalability, facilitate redundancy, and reduce the risk of content loss. However, Chiware and Mathe (2025) caution that in many Sub-Saharan institutions, digital preservation remains “fragmented and project-based,” often lacking formal policies or sustainable funding mechanisms. These observations reinforce earlier work by Alhassan et al. (2023), who emphasize that even where digital repositories exist, the absence of ingest protocols and metadata quality control frequently undermines their long-term usability.

Beyond preservation, digital data management plays a central role in enabling collaboration and resource sharing across institutions. Collective cataloguing, union databases, and interlibrary loan integration are made possible through unified data platforms and interoperable systems. The study by Bwalya and Akakandelwa (2021) illustrates how Koha’s multi-branch functionality has facilitated collaboration among Zambian institutions, while Zainab et al. (2019) found that the ability to synchronize collections and services across campuses greatly enhances resource optimization and

service coverage. Collaborative networks such as academic consortia rely on harmonized metadata standards and shared governance structures, underscoring the importance of data standardization as a prerequisite for inter-institutional synergy.

While these benefits are well-documented, literature reveals that their realization remains uneven, particularly across different geographic and economic contexts. Most notably, the success of digital data systems is heavily contingent on staff capacity, system customization, and strategic alignment with institutional goals. Even where platforms are adopted successfully, the full breadth of digital functionalities often remains underutilized due to inadequate investment in analytics, low digital literacy among staff, or absence of robust digital policies.

Case Examples from Nigeria and Global Context

A growing body of case-based research illustrates how Nigerian universities, despite resource constraints, have embarked on digitization and integrated library system (ILS) adoption, while globally, institutions like the British Library, MIT Libraries, and the World Bank have advanced digital management through high-level frameworks, analytics, and open-access platforms. In Nigeria, early digitization projects, such as the University of Nigeria Nsukka's effort to create an e-thesis repository, highlighted core challenges notably infrastructural instability, inconsistent legal frameworks, and human resource deficits.

In a similar vein, Ilesanmi's analysis of the Kenneth Dike Library of university of Ibadan revealed that copyright uncertainties and funding shortfalls restricted the scope of digitized journal collections (Ilesanmi, 2013). This pattern reflects a structural gap in sustainable funding and governance, which is further affirmed by Usman Alhaji's survey across thirty academic libraries, reporting that none successfully digitized theses or examinations, primarily due to poor electricity supply and lack of expertise (Usman Alhaji, 2013). Furthermore, more recent Nigerian IT-focused studies underscore the crucial role that ILS platforms like Koha play in bridging these gaps. Ojedokun et al. (2024), through a nine-year longitudinal study at Bowen University, demonstrate that Koha significantly enhanced technical service delivery and staff ICT competencies; however, they also emphasize that staff resistance and absence of a formal digital policy often undermined systemic adoption.

Agbo Oche (2023) across Nigerian polytechnics echoes these systemic issues such as erratic power supply, network unreliability, and lack of sustainable funding were identified as principal obstacles to full implementation. Conversely, global exemplars, such as Britain's national library, offer instructive counterpoints. Michael Day et al. (2016) document the British Library's Flashback project, which employs disk imaging and policy-driven migration protocols within an OAIS-compliant preservation infrastructure. Collectively, these case insights articulate a compelling pattern: the transformation of library services through digital data management is contingent upon multi-dimensional

readiness comprising policy governance, metadata integrity, analytics capacity, staff expertise, and infrastructural resilience.

Thus, the literature exposes a strategic imperative: to replicate global best practices within Nigerian and similar contexts, future research must focus on multi-level frameworks that integrate technology deployment with staff development, policy articulation, and infrastructural modernization. Transitioning from isolated case narratives to embedded, systemic models aligned with 5IR values emerges as a foundational research agenda for the coming decade.

Challenges Facing Libraries in Data Management

Despite the evident benefits of digital data management, libraries particularly in Nigeria and other developing contexts continue to face several challenges that hinder effective implementation. A primary challenge is the inadequacy of infrastructure, such as unreliable electricity supply, low internet bandwidth, and insufficient technological facilities, which impede consistent access to digital platforms (Agbo Oche, 2023; Usman Alhaji, 2013). Additionally, funding constraints remain a critical barrier, as most libraries operate under limited budgets that restrict the acquisition of modern technologies, subscription to databases, and investment in long-term preservation infrastructures (Chiwere & Mathe, 2025). Another notable challenge is the shortage of skilled personnel to manage, curate, and preserve digital

data effectively. Studies have shown that Nigerian librarians often lack advanced training in metadata standards, digital preservation, and big data analytics, resulting in underutilization of existing systems such as Koha (Ojedokun et al., 2024; Olowoporoku et al., 2024). Resistance to change and limited digital literacy among staff also exacerbate this challenge, slowing the adoption of innovative technologies.

Policy and governance gaps further weaken digital data management practices. Many libraries lack formalised policies on data curation, access control, and disaster recovery, leaving them vulnerable to data loss and security breaches (Das & Mishra, 2022; Olanrewaju & Oyelude, 2021). Cybersecurity risks, including hacking and ransomware attacks, present an additional concern, especially in contexts where robust authentication and encryption mechanisms are absent (Ossom-Williamson, 2023). Collectively, these challenges underscore the need for systemic reform in infrastructure, capacity development, funding, and governance frameworks to achieve sustainable digital transformation in libraries.

Recommendations

To address the challenges identified, several strategic recommendations are proposed.

1. First, libraries should prioritise capacity building and continuous professional development for librarians in areas such as metadata management, digital preservation, artificial intelligence, and big data analytics. Training workshops and collaborations with international library bodies can help bridge the knowledge gap (Bhattacharya et al., 2023).

2. Also, infrastructure investment and funding diversification are critical. Governments, educational institutions, and donor agencies should commit resources toward stable electricity, broadband connectivity, and acquisition of advanced technologies. Public-private partnerships may also provide innovative funding models to sustain digital library systems (Kulkarni et al., 2023).

3. Thirdly, libraries must develop and enforce comprehensive governance frameworks, including policies on data curation, access control, intellectual property, and disaster recovery. Integrating international standards such as Dublin Core and OAIS models will enhance interoperability and ensure long-term sustainability (Prasad et al., 2025; Day et al., 2016).

4. Furthermore, adopting emerging technologies such as blockchain for data security, AI for cataloguing and recommendation systems, and IoT for smart library services can enhance efficiency and user experience (Adigun et al., 2024; Tella et al., 2022). Importantly, these technologies must be adapted to local contexts, ensuring affordability and scalability.

5. Finally, fostering collaboration and resource sharing among academic libraries will reduce duplication of effort, promote knowledge exchange, and enhance collective resilience. National and regional consortia can play a significant role in pooling resources, negotiating licenses, and establishing shared repositories (Bwalya & Akakandelwa, 2021; Jamogha et al., 2022).

Conclusion

Digital data management represents a transformative force in the modernization of library services within the Fifth Industrial Revolution era. Its benefits ranging from enhanced

access and efficiency to improved preservation and collaboration position libraries as critical hubs of knowledge creation and dissemination. However, persistent challenges in infrastructure, funding, staff capacity, governance, and cybersecurity continue to limit the full realization of its potential, particularly in developing regions such as Nigeria. Addressing these challenges requires a holistic approach that combines technological adoption with strategic governance, policy alignment, and human capital development. Lessons from global best practices, including the British Library and the World Bank Open Knowledge Repository, highlight the importance of structured frameworks, sustainable financing, and advanced metadata management. For Nigerian academic libraries to thrive in the 5IR, systemic reforms that embed resilience, innovation, and collaboration into data management practices are imperative. Only through such deliberate actions can libraries remain indispensable in driving education, research, and societal transformation in the digital age.

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