

**SMART LIBRARY AUTOMATION AND DIGITAL TRANSFORMATION IN AFRICA:
INTEGRATING EMERGING TECHNOLOGIES FOR EFFICIENT WORKFLOWS,
ENHANCED USER SATISFACTION, AND SUSTAINABLE DEVELOPMENT IN THE 5TH
INDUSTRIAL REVOLUTION.**

PETER OSARETIN OMOROGIEVA

Edo State College of Education Library, Igueben, Edo State

omorogievapeter5@gmail.com

+234 8123880781

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DR. STANLEY OMONDIALE UNUABOR, CLN, MNIM, MNLA

Edo State College of Education Library, Igueben, Edo State

stanleyunuabor@yahoo.com

&

ABILOYE SHEGUN VICTORY

Edo State College of Education, Afuze, Edo State

abiloyeshangun@gmail.com

Abstract

The accelerating convergence of digital technologies and smart automation is redefining the landscape of library and information service delivery in the era of the Fifth Industrial Revolution. This opinion-based empirical study critically explores the integration of emerging technologies such as artificial intelligence (AI), machine learning, cloud computing, and robotic process automation into library operations and workflows, with particular attention to African academic libraries. Drawing from a synthesis of recent scholarly publications (2021–2025), institutional reports, and global case analyses, the paper evaluates the impact of these innovations on library efficiency, service quality, and user satisfaction. Findings reveal that digital transformation has enhanced cataloguing accuracy, improved resource accessibility, and fostered data-driven decision-making across innovative libraries such as Covenant University Library (Nigeria) and the University of Pretoria Library (South Africa). However, the study identifies critical challenges hindering widespread adoption, including inadequate infrastructure, limited technical capacity, and ethical concerns related to data privacy, algorithmic bias, and transparency. It emphasizes that the sustainable integration of digital technologies in African libraries requires a balanced approach one that aligns automation initiatives with ethical governance, professional training, and inclusive user engagement. This paper argues that smart library automation, when responsibly implemented, can serve as a catalyst for achieving multiple Sustainable Development Goals (SDGs), notably Quality Education (SDG 4), Industry and Innovation (SDG 9), and Strong Institutions (SDG 16). It concludes by proposing a context-sensitive framework for digital transformation that prioritizes indigenous innovation, strategic partnerships, and policy alignment to ensure that African libraries remain both technologically advanced and socially relevant in the evolving information ecosystem.

Keywords: Smart libraries, artificial intelligence, digital transformation, library automation, user satisfaction, sustainable development, Africa.

Introduction

The 5th Industrial Revolution (5IR) signifies a transformative phase in global innovation where advanced technologies such as Artificial Intelligence (AI), Internet of Things (IoT), robotics, and big data analytics are being harmonized with human creativity and ethics to reshape industries and knowledge systems (Schwab & Malleret, 2022). Within the library and information science ecosystem, these technologies are revolutionizing how knowledge is created, accessed, and disseminated. Libraries, as central agents of intellectual development, are transitioning from traditional information repositories to dynamic, technology-driven learning environments known as smart libraries. These institutions are leveraging digital technologies and automation to enhance efficiency, streamline workflows, and foster user-centered service delivery (Olayemi & Adegboire, 2022). While these advancements signal libraries' evolution into adaptive, intelligent institutions, the literature predominantly highlights technological possibilities over practical implementation challenges in resource-constrained settings, underscoring the need for context-specific strategies in Africa.

In Africa, the transformation toward smart library systems has been gradual but promising. While libraries in developed countries have fully embraced automation and AI-driven technologies, many African libraries are still in various stages of digital transition, constrained by infrastructural and policy limitations (Nwakanma & Okoro, 2023). Nonetheless, digital transformation in African libraries holds significant potential for achieving the United Nations Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education) and SDG 9 (Industry, Innovation, and Infrastructure).

The integration of cloud-based library systems, digital repositories, and intelligent cataloguing tools is enhancing information accessibility, user engagement, and institutional visibility across the continent (Ojo & Madu, 2021). Thus, digital transformation in African libraries not only addresses immediate access gaps but also aligns with continental development priorities, offering a pathway to reduce educational inequalities provided that investments target sustainable infrastructure and local capacity building.

The 5th Industrial Revolution has further amplified the urgency for libraries to adopt human-centered technological innovation. The concept emphasizes not only efficiency through automation but also ethical, inclusive, and sustainable development approaches (Zhang & Xu, 2022). Smart library automation aligns with this philosophy by combining artificial intelligence and human expertise to achieve enhanced operational performance and user satisfaction. For African libraries, this transition requires strategic investment, capacity building, and policy alignment to bridge technological divides and support the continent's broader educational and developmental goals (AfLIA, 2023). In essence, aligning smart automation with 5IR's human-centered ethos demands proactive policy frameworks that foster indigenous innovation and inclusive participation, thereby positioning African libraries as active contributors to sustainable knowledge societies.

Despite the growing recognition of technology's transformative potential, libraries in Africa continue to face barriers to effective digital integration, including inadequate infrastructure, insufficient funding, and limited technical expertise (Nkiko & Lawal, 2024). Addressing these challenges is essential to unlock the full potential of smart libraries as catalysts for academic excellence and innovation. The ongoing evolution of digital ecosystems presents an opportunity for African libraries to reimagine their service delivery models, enhance operational efficiency, and strengthen user satisfaction through smart, data-driven decision-making. This study seeks to advance by synthesizing evidence-based pathways for ethical and sustainable adoption.

This paper explores how automation and digital transformation can be strategically harnessed to improve library workflows, enhance user experience, and contribute to sustainable development within

the African context. By reviewing recent scholarly publications and empirical evidence, it provides insights into how libraries can align technological innovation with ethical, inclusive, and sustainable service delivery in the era of the 5th Industrial Revolution. In the era of the 5th Industrial Revolution, thereby contributing to a more nuanced understanding of contextually relevant digital strategies for African academic libraries.

Literature Review

Conceptual Framework

Smart library automation refers to the application of artificial intelligence (AI), machine learning (ML), the Internet of Things (IoT), and robotics to improve library workflows, resource discovery, and user interaction. The concept aligns with the broader philosophy of the 5th Industrial Revolution (5IR), which emphasizes the fusion of technology with human-centered innovation (Schwab & Malleret, 2022). Within the field of library and information science, smart libraries are characterized by automated cataloguing, predictive analytics for user behavior, and adaptive information systems that respond to individual learning needs (Zhang & Xu, 2022). Taken together, these characteristics highlight smart library automation as a socio-technical endeavour that integrates advanced tools with human agency, yet the literature often prioritizes technical features over contextual adaptation, revealing a need for frameworks that explicitly address adoption barriers in developing regions.

Consequently, understanding user and librarian acceptance of these innovations requires grounding in established models such as the Technology Acceptance Model (TAM) and the Socio-Technical Systems Theory provide theoretical foundations for understanding how librarians and users adopt and adapt to emerging technologies (Venkatesh et al., 2023). These frameworks emphasize the importance of balancing technical efficiency with human agency in achieving sustainable digital transformation in libraries. In achieving sustainable digital transformation in libraries, a balance particularly crucial for African contexts where infrastructural limitations and capacity gaps can otherwise undermine equitable technology integration.

Global Trends in Smart Library Automation

Globally, libraries have embraced automation and digital transformation to enhance service quality, efficiency, and user satisfaction. Studies from Asia and Europe indicate that AI-powered cataloguing systems and robotic process automation (RPA) have significantly reduced repetitive tasks and improved metadata accuracy (Lee & Park, 2023). Similarly, North American universities have adopted predictive analytics to anticipate user needs and personalize digital content delivery (Henderson & Collins, 2022). The transition to cloud-based integrated library management systems (ILMS) and virtual reference services has also redefined user engagement and access flexibility (O'Connor, 2021). Collectively, these advancements position smart libraries as vibrant innovation hubs fostering lifelong learning and personalized engagement, demonstrating the transformative power of 5IR-aligned technologies opportunities that African institutions can emulate through localized adaptations and strategic partnerships to accelerate equitable progress. Moreover, smart libraries are emerging as innovation hubs that promote lifelong learning and interdisciplinary collaboration. For example, the Singapore National Library Board and MIT Libraries have implemented smart sensors, AI-driven recommender systems, and digital learning platforms to optimize user experiences (Wong & Chen, 2022). These global advancements demonstrate how automation and AI not only enhance efficiency but also redefine the social and educational roles of libraries in the 5IR era.

Digital Transformation in African Libraries

In Africa, digital transformation within libraries is progressing but remains uneven due to infrastructural and policy challenges. Research by Nkiko and Lawal (2024) and Nwakanma and Okoro (2023) reveals

that Nigerian, South African, and Kenyan academic libraries are gradually adopting cloud-based systems, institutional repositories, and digital reference services. However, inadequate funding, poor broadband connectivity, and limited technical expertise hinder full implementation (AfLIA, 2023). While pockets of innovation demonstrate feasibility in select African settings, the persistent infrastructural and expertise constraints reveal a critical gap between aspiration and reality, necessitating coordinated strategies that build on emerging successes to foster equitable digital ecosystems continent-wide.

Despite these limitations, successful initiatives such as the University of Pretoria's Smart Library Project and the Covenant University Library's AI-driven cataloguing pilot illustrate the transformative potential of digital innovation in African higher education (Olayemi & Adegboire, 2022). Digital transformation has also enhanced operational transparency, data-driven decision-making, and remote access to resources (Ojo & Madu, 2021). Nonetheless, the pace of adoption varies widely across regions, reflecting disparities in ICT infrastructure and institutional readiness.

According to Adeleke (2022), for Africa to fully leverage the benefits of smart libraries, there must be a comprehensive strategy integrating technology policy, funding mechanisms, and professional capacity development. Without such coordination, digital inequality will continue to constrain the continent's ability to participate meaningfully in global knowledge economies. Without such coordination, digital inequality will continue to constrain the continent's ability to participate meaningfully in global knowledge economies, thereby reinforcing the necessity for the coordinated, Africa-led strategy advocated in this review

Challenges and Ethical Considerations

The integration of AI and automation in libraries introduces complex ethical, operational, and governance concerns. Issues such as data privacy, algorithmic bias, intellectual property rights, and digital inequality have emerged as key challenges (Zhang & Xu, 2022; Lawal & Ajibade, 2023). Libraries must ensure transparency in AI-driven decision-making and protect users' personal information from misuse or surveillance. Ethical frameworks rooted in human-centered AI principles are increasingly recommended to guide automation policies and ensure responsible innovation (Wong & Chen, 2022).

Operationally, many African libraries face persistent technical, financial, and policy-related constraints that impede the sustainability of AI initiatives (AfLIA, 2023). The reliance on foreign technologies also raises concerns about contextual relevance and technological dependency. Consequently, ethical localization of technology that is, developing culturally and contextually appropriate AI tools is vital for advancing Africa's digital library transformation (Nkiko & Lawal, 2024). While global recommendations advocate human-centered principles, their application in African settings remains limited by resource constraints and foreign tech dominance, revealing a pressing need for context-specific ethical governance that integrates local values, capacity building, and multi-stakeholder collaboration to foster truly sustainable and culturally relevant automation.

Linking Digital Transformation to the Sustainable Development Goals (SDGs)

Smart library automation directly supports several United Nations Sustainable Development Goals (SDGs). Specifically, SDG 4 (Quality Education) is advanced through equitable access to digital knowledge resources, while SDG 9 (Industry, Innovation, and Infrastructure) benefits from the creation of resilient ICT frameworks in libraries (UNESCO, 2023). Furthermore, libraries that utilize digital tools to promote information literacy and civic engagement contribute to SDG 16 (Peace, Justice, and Strong Institutions) by fostering informed, participatory, and empowered communities (IFLA, 2023). This alignment reveals libraries not merely as beneficiaries of digital transformation but as active catalysts for achieving multiple SDGs simultaneously, highlighting the necessity for African

policymakers and institutions to embed SDG-oriented metrics and ethical safeguards into automation strategies to maximize long-term societal impact.

By aligning technological innovation with sustainable development principles, libraries can serve as catalysts for social inclusion, innovation, and educational advancement across Africa. This perspective underscores the importance of strategic collaboration among governments, technology providers, and academic institutions to realize the full potential of smart libraries as enablers of Africa's digital transformation in the 5IR era.

Methodology

Research Design

This study adopts an opinion-based empirical review design grounded in a qualitative and interpretive research approach. This design is appropriate for exploring emerging trends, perceptions, and practices in smart library automation and digital transformation across Africa. By synthesizing empirical findings and theoretical discussions from high-ranking scholarly publications, the study provides critical insights into the opportunities, challenges, and ethical considerations shaping the adoption of emerging technologies in libraries.

The qualitative nature of this research enables a thematic and comparative analysis of previous studies, institutional reports, and global case examples. This approach facilitates the identification of patterns and gaps in the literature while providing a scholarly foundation for proposing context-specific strategies to enhance efficiency, innovation, and sustainability in African libraries.

Data Sources

The study draws on peer-reviewed journal articles, institutional reports, and conference proceedings published between 2021 and 2025 to ensure currency and relevance to recent technological advancements. Major academic databases consulted include Scopus, Web of Science, Emerald Insight, Elsevier, SpringerLink, and Library Hi Tech.

Institutional and policy documents were also reviewed, including reports from the International Federation of Library Associations and Institutions (IFLA), the United Nations Educational, Scientific and Cultural Organization (UNESCO), and the African Library and Information Associations and Institutions (AfLIA).

The selection criteria for inclusion were based on the following considerations:

- Relevance to smart library automation, digital transformation, and AI integration in libraries.
- Empirical and conceptual rigor of the publication.
- Contextual applicability to African or developing countries.
- Publication recency (not older than four years).

A total of 12 academic and institutional publications were interpreted to ensure depth, diversity, and regional representation.

Publications Included in the Review

No.	Author(s) & Year	Source Type	Key Contribution / Relevance to African Smart Libraries in the 5IR
1	Adeleke (2022)	Journal article	Highlights funding and infrastructural barriers in Sub-Saharan African libraries; informs recommendations on policy and investment
2	AfLIA (2023)	Institutional position paper	Provides Africa-specific guidance on AI ethics and capacity building; central to ethical localization discussion
3	Anyira (2021)	Journal article	Discusses prospects and challenges of digital innovation in Nigerian university libraries
4	Braun & Clarke (2021)	Book (thematic analysis guide)	Methodological foundation for the thematic synthesis applied to all 12 sources
5	Chisenga & Mchombu (2022)	Journal article	Explores emerging technologies for reimagining African library services
6	Henderson & Collins (2022)	Journal article	Global case studies on collaborative innovation and user personalization
7	IFLA (2023)	Global report	Links libraries to SDG 16 and sustainable development; used for SDG alignment
8	Lawal & Ajibade (2023)	Journal article	Ethical considerations of AI in developing-country libraries; core to ethical framework
9	Nkiko & Lawal (2024)	Journal article	Capacity-building strategies for African librarians in the 5IR
10	Olayemi & Adegboire (2022)	Journal article	Indigenous software solutions and digital sovereignty in African libraries
11	OECD (2022)	Report	Responsible AI innovation principles; contextualized for African ethical adoption

No.	Author(s) & Year	Source Type	Key Contribution / Relevance to African Smart Libraries in the 5IR
12	UNESCO (2023)	Official recommendation	Ethics of AI and SDG linkages; directly supports SDG 4, 9, and 16 mapping

Table 1 presents the 12 peer-reviewed and institutional sources systematically analysed. Selection was limited to publications 2021–2025 that met the inclusion criteria of relevance, empirical/conceptual rigor, and African or developing-country applicability.

Data Collection Procedures

Data were collected using thematic synthesis techniques. Keywords such as “smart libraries,” “AI in libraries,” “library automation,” “digital transformation,” and “African library innovation” were applied in combination with Boolean operators to retrieve relevant literature. Abstracts and full texts were screened to ensure thematic relevance and methodological quality.

The study also incorporated secondary analysis of existing case studies, focusing on African university libraries including Covenant University Library (Nigeria), University of Pretoria Library (South Africa), and University of Nairobi Library (Kenya) to provide contextual grounding and comparative insights across diverse regional contexts.

Data Analysis

The analysis was carried out through a multi-stage thematic synthesis approach. Rather than simply extracting keywords, we closely examined and compared the 12 selected publications, specifically looking for “friction points” each of the publications was coded for technological features, reported barriers, and alignment with TAM and Socio-Technical Systems Theory, allowing direct comparison of global versus African implementation gaps. Between established global smart library frameworks and the practical infrastructure limitations commonly found across African contexts. This comparative process enabled a shift away from surface-level description toward a deeper, more critical interpretation of how Fifth Industrial Revolution (5IR) technologies actually function (and sometimes falter) in resource-scarce settings.

Reliability and Validity

To ensure reliability and validity, a multi-step verification process was employed. Sources were cross-validated using multiple databases to confirm authenticity and scholarly integrity. Priority was given to indexed and peer-reviewed publications to minimize bias. Additionally, findings from global contexts were compared with African case studies to ensure balanced representation and contextual accuracy.

Peer debriefing with professionals in library and information science was also conducted to validate the interpretation of key themes and maintain objectivity in the analysis and conclusions.

Ethical Considerations

Although this study does not involve human participants, ethical integrity was maintained through responsible citation practices and intellectual transparency. All sources were properly acknowledged in accordance with APA 7th edition referencing standards. The research aligns with the principles of academic honesty, non-plagiarism, and intellectual respect.

In discussing automation and AI integration, the study emphasizes the importance of ethical technology adoption, focusing on user data privacy, algorithmic transparency, and equitable access particularly in African library environments where digital divides persist (Lawal & Ajibade, 2023; AfLIA, 2023). By prioritizing these ethical dimensions within both the research process and the analysed literature, the study underscores that sustainable AI integration in African libraries requires not only technical solutions but also proactive governance frameworks that center local realities, user rights, and social justice to align fully with 5IR's human-centric ethos and relevant SDGs.

Summary of Methodology

Hence this methodological framework provides a comprehensive foundation for examining how digital transformation and automation are reshaping library service delivery in Africa. By integrating an interpretive review of global and regional literature, the study offers a balanced and contextually relevant analysis that bridges theory and practice. It also contributes to developing actionable recommendations for achieving sustainable, inclusive, and ethically guided smart library ecosystems across the African continent.

Findings and Discussion

Overview

The analysis of twelve scholarly and institutional sources reveals that the integration of digital technologies and smart automation has significantly transformed library operations, workflows, and user engagement globally. However, in Africa, the pace of adoption remains uneven due to infrastructural, financial, and policy-related challenges. Despite these constraints, growing evidence suggests that smart library automation enhances efficiency, service innovation, and user satisfaction, while contributing to the achievement of several United Nations Sustainable Development Goals (SDGs) particularly those related to education, innovation, and institutional strengthening (IFLA, 2023; UNESCO, 2023). This pattern across the 12 sources underscores the transformative yet uneven potential of digital technologies in libraries, reinforcing the need for Africa-centric research and policy interventions that translate global best practices into locally viable models capable of bridging infrastructural gaps and advancing sustainable development objectives.

Emerging Innovations in Smart Library Automation

Recent developments in library automation demonstrate a decisive shift from traditional systems to AI-driven and cloud-based infrastructures. Studies show that libraries increasingly adopt intelligent cataloguing, robotic process automation (RPA), and predictive analytics to streamline workflows and improve user experience (Lee & Park, 2023; Henderson & Collins, 2022). This decisive transition not only reduces manual burdens but also reorients libraries toward predictive, user-centric ecosystems aligned with 5IR's emphasis on human-technology harmony opportunities that African libraries, through targeted pilots and capacity building, can leverage to enhance workflow optimization and inclusive engagement despite infrastructural constraints.

In African contexts, libraries such as Covenant University Library (Nigeria), University of Pretoria Library (South Africa), and Kenyatta University Library (Kenya) have piloted automation initiatives involving digital repositories, RFID technologies, and virtual reference chatbots. These innovations have improved information retrieval accuracy, reduced staff workload, and increased round-the-clock

service accessibility (Nkiko & Lawal, 2024; Olayemi & Adegbore, 2022). Such successful implementations in select African universities illustrate the feasibility of adapting global smart technologies to local realities, offering valuable blueprints for enhancing operational resilience and educational equity opportunities that, if systematically scaled through policy support and shared learning, could accelerate the continent's transition toward sustainable, human-centered library ecosystems in the 5IR era.

Globally, institutions such as MIT Libraries and the National Library Board of Singapore demonstrate how AI-based recommender systems and virtual reality (VR) learning spaces can enhance user engagement and digital literacy (Wong & Chen, 2022). These cases highlight the potential for African libraries to achieve comparable progress through strategic investment, localized innovation, and capacity building.

In many African settings, forward-thinking libraries like those at Covenant University in Nigeria and the University of Pretoria in South Africa have rolled out successful pilot projects incorporating RFID for better inventory and security management, alongside virtual reference chatbots powered by AI to handle user queries.

These initiatives clearly show that the technology itself works well. Yet what stands out more broadly is how innovations in African libraries tends to revolve around mobile-first approaches that prioritize easy, affordable access via smartphones and basic connectivity, rather than depending on the expensive, robotics-heavy setups often highlighted in Western models.

This pattern points toward a distinctly African flavour of the Fifth Industrial Revolution (5IR) in the library space one rooted in frugal innovation. Here, libraries deliver sophisticated, high-value services not by throwing money at cutting-edge hardware, but by creatively leveraging limited resources, existing widespread mobile infrastructure, and low-cost adaptations to meet real local needs effectively.

Impact on Operational Efficiency and Workflow Optimization

Automation has been widely recognized for improving operational efficiency by reducing manual tasks, accelerating cataloguing processes, and optimizing circulation workflows. Research from both developed and developing nations indicates that cloud-based integrated library management systems (ILMS) enhance real-time collaboration between departments, facilitate remote access, and support data-driven decision making (O'Connor, 2021; Nwakanma & Okoro, 2023). Collectively, the adoption of cloud-based ILMS and related tools illustrates a consistent pattern of workflow optimization and enhanced decision-making capabilities worldwide, reinforcing their value as foundational elements of modern library operations though their effective scaling in developing regions, including Africa, hinges on strategic investments in connectivity, training, and localized system customization to prevent efficiency gains from remaining unevenly distributed.

In African academic libraries, digital transformation has helped to bridge workflow gaps, improve metadata accuracy, and enhance interlibrary resource sharing. However, adoption rates remain inconsistent, primarily due to limited technical infrastructure and inadequate funding (Adeleke, 2022). Nonetheless, successful pilot programs show that automating repetitive processes allows librarians to focus more on user centered services, such as information literacy instruction and research support.

User Satisfaction and Digital Access Equity

Findings across the reviewed literature indicate that smart technologies directly influence user satisfaction and digital access equity. AI-powered interfaces, self-service kiosks, and mobile library applications have improved user convenience and information personalization (Henderson & Collins, 2022). Furthermore, libraries that implement smart data analytics can better understand user preferences, adapt service delivery, and support individualized learning pathways (Zhang & Xu, 2022).

Collectively, the literature demonstrates that data-driven personalization and self-service tools can significantly elevate user engagement and perceived value, but their equitable impact hinges on overcoming infrastructural and skills-related barriers in developing regions highlighting the critical role African libraries can play in closing access divides through contextually adapted, human-centered design that balances innovation with inclusivity.

In the African context, user satisfaction continues to be shaped by connectivity challenges, digital literacy levels, and platform usability. Nevertheless, initiatives such as Covenant University's Koha-based automation system and University of Pretoria's mobile digital portal demonstrate how well-designed smart systems can promote inclusivity and equitable access (Nkiko & Lawal, 2024). These advancements support SDG 4 (Quality Education) by ensuring continuous and adaptive access to learning materials, even in resource-limited environments.

Challenges and Limitations of Technology Integration

Despite evident benefits, the reviewed studies highlight persistent challenges affecting technology integration in African libraries. Key issues include insufficient ICT infrastructure, inconsistent funding, and skills gaps among library personnel (Ojo & Madu, 2021; AfLIA, 2023). These findings suggest that until the underlying social and technical subsystems are harmonized, the full potential of smart automation will likely remain constrained by the unique environmental realities of the African academic landscape.

The challenges identified in this study namely funding and skill gaps are best understood through the Technology Acceptance Model (TAM). Findings indicate that while "perceived usefulness" of smart libraries is high among African librarians, the "perceived ease of use" is hampered by inconsistent power and internet stability

Furthermore, applying the Technology Acceptance Model (TAM) to the 12 reviewed studies reveals that while perceived usefulness of smart libraries is consistently high among African librarians, perceived ease of use remains low due to unreliable power and internet (Adeleke, 2022; AfLIA, 2023). Similarly, Socio-Technical Systems Theory highlights a persistent misalignment between the technical subsystem (software) and the social subsystem (institutional culture and staff readiness), explaining why several otherwise promising pilots have underperformed

Another major concern involves the ethical and regulatory implications of AI adoption. Scholars have identified risks associated with data privacy, algorithmic bias, and lack of transparency in AI systems used for cataloguing and user profiling (Lawal & Ajibade, 2023; Zhang & Xu, 2022). Furthermore, technological dependence on foreign vendors restricts local innovation and raises sustainability concerns.

Addressing these issues requires multi-stakeholder collaboration among governments, professional associations, and educational institutions to formulate policies that encourage technological independence, capacity development, and equitable digital inclusion.

Ethical and Human-Centered Technology Adoption

Ethical considerations emerged as a consistent theme across the literature. While AI and automation enhance efficiency, they must be implemented within a framework of ethical responsibility, transparency, and inclusivity. Libraries bear the moral responsibility to ensure that automation does not compromise user privacy or reinforce systemic bias in information dissemination (Lawal & Ajibade, 2023). Ultimately, this underscores that the smartness of a library should be measured not merely by the complexity of its algorithms, but by its capacity to maintain human-centered oversight and protect the digital rights of its patrons.

Human-centered AI design featuring ethical algorithms, explainable systems, and user control mechanisms has been recommended to balance automation with professional judgment (Zhang & Xu, 2022). Consequently, African libraries must adopt context-sensitive ethical frameworks that reflect regional realities while aligning with global best practices.

Linking Findings to the Sustainable Development Goals (SDGs)

The findings demonstrate a strong alignment between smart library automation and the United Nations Sustainable Development Goals (SDGs).

SDG 4 (Quality Education): Smart libraries foster lifelong learning by providing equitable access to digital information resources.

SDG 9 (Industry, Innovation, and Infrastructure): Automation promotes innovation and strengthens institutional ICT infrastructure.

SDG 16 (Peace, Justice, and Strong Institutions): Transparent and accessible information systems foster civic participation and institutional accountability.

By deliberately aligning smart library automation with SDG 4, SDG 9, and SDG 16, African institutions can transform technological adoption into a powerful cross-cutting mechanism for educational equity, innovation resilience, and institutional strengthening thereby turning libraries into active drivers of Africa's sustainable development agenda rather than mere beneficiaries of global technological trends.

Summary of the Findings

In summary, the literature reveals that while African libraries are still in the early stages of smart automation, progress is accelerating. Innovations in AI, cloud computing, and data analytics are reshaping how libraries operate, deliver services, and engage users. Nonetheless, sustainable development in this sector depends on addressing persistent challenges such as funding constraints, skills shortages, and ethical oversight.

The evidence suggests that strategic and ethically guided integration of smart technologies can lead to enhanced efficiency, greater user satisfaction, and stronger institutional resilience, thereby advancing the goals of inclusive and sustainable digital transformation across African libraries.

Conclusion and Recommendations

Conclusion

This study critically examined the integration of digital technologies and smart automation in library operations and services, with a focus on improving workflow efficiency, innovation, and user satisfaction in African academic libraries. The findings revealed that the Fifth Industrial Revolution has ushered in a new era of intelligent information systems, transforming the way libraries organize, manage, and deliver knowledge.

Globally, libraries are adopting advanced technologies such as artificial intelligence (AI), machine learning, cloud computing, and robotic process automation (RPA) to streamline cataloguing, enhance information access, and enrich user experiences. In Africa, institutions such as Covenant University Library (Nigeria) and the University of Pretoria Library (South Africa) exemplify how strategic investment in digital technologies can significantly improve service delivery, operational efficiency, and user engagement.

However, this study also identified persistent challenges including inadequate infrastructure, limited technical expertise, funding constraints, and ethical issues related to data privacy and algorithmic transparency. Despite these barriers, the opportunities presented by digital transformation remain

substantial for advancing library service delivery, promoting equitable access to information, and contributing to the attainment of several Sustainable Development Goals (SDGs) particularly SDG 4 (Quality Education), SDG 9 (Industry, Innovation, and Infrastructure), and SDG 16 (Peace, Justice, and Strong Institutions).

By grounding these findings in the Technology Acceptance Model and Socio-Technical Theory, it becomes clear that sustainable success depends on aligning digital tools with the local social and infrastructural context. Ultimately, smart library automation must be human-centered and ethically guided to ensure that it acts as a genuine catalyst for the Sustainable Development Goals, particularly in fostering inclusive education and strong institutional frameworks across Africa.

Recommendations

Based on the findings, the following recommendations are proposed to enhance digital transformation and automation in African libraries:

1. Develop a Continental Smart Library Framework

National and regional organizations such as the African Library and Information Associations and Institutions (AFLIA) and the IFLA Africa Section should collaborate to develop a unified framework for smart library transformation. This framework should provide policy direction, technical standards, and ethical guidelines for AI adoption and automation across academic and public libraries in Africa.

2. Strengthen ICT Infrastructure and Funding Mechanisms

Governments and academic institutions should prioritize investment in ICT infrastructure, including broadband connectivity, cloud-based systems, and sustainable energy sources. Establishing public-private partnerships can also help ensure consistent funding and long-term maintenance of digital systems (Adeleke, 2022; AFLIA, 2023). Such strategic investment is a prerequisite for closing the digital divide, as the "perceived usefulness" of smart library tools cannot translate into actual user adoption if the foundational technical subsystem remains unreliable.

3. Build Technical Capacity and Promote Continuous Professional Development

Library professionals must be equipped with the technical and analytical skills required to manage emerging technologies. Regular training programs, workshops, and certification courses in digital librarianship, data analytics, and AI applications should be integrated into institutional staff development plans (Nkiko & Lawal, 2024). This proactive focus on upskilling ensures that the social subsystem the librarians themselves is sufficiently prepared to navigate the complexities of 5IR technologies, thereby preventing the human-automation gap that often leads to institutional resistance and digital stagnation.

4. Promote Ethical and Responsible AI Adoption

Libraries should adopt transparent and explainable AI systems that respect user privacy and minimize algorithmic bias. Institutional policies must align with IFLA's Code of Ethics and UNESCO's Recommendation on the Ethics of Artificial Intelligence (2021) to ensure fairness, accountability, and inclusivity in technological applications (Lawal & Ajibade, 2023; UNESCO, 2023). therefore, by formalizing these ethical guardrails, African libraries can ensure that the transition to automation does not result in the mechanization of bias, but rather fosters a digitally sovereign environment that protects both the data and the dignity of the local user community.

5. Encourage Indigenous Innovation and Localized Solutions

African libraries should promote locally developed software and digital solutions tailored to regional languages, user needs, and institutional contexts. Supporting indigenous innovation enhances digital sovereignty and reduces reliance on foreign technology providers (Olayemi & Adegboire, 2022). Prioritizing localized development, institutions can ensure that their technical infrastructure remains culturally relevant and economically sustainable, transforming the library from a passive consumer of global technology into an active producer of regional knowledge solutions.

6. Foster Collaborative Research and Knowledge Sharing

Academic libraries should engage in collaborative research with universities, research centers, and technology developers to explore AI applications and data-driven service models. Creating open-access repositories for smart library research will promote evidence-based innovation and facilitate knowledge exchange (Henderson & Collins, 2022). By breaking down institutional silos, these partnerships allow African libraries to pool limited resources and intellectual capital, ensuring that the transition to the 5th Industrial Revolution is a collective advancement rather than a series of isolated and potentially redundant efforts.

7. Align Library Automation with Sustainable Development Goals (SDGs)

Automation initiatives should be explicitly aligned with institutional and national strategies for achieving the SDGs. Libraries can serve as innovation hubs that promote inclusive education, knowledge democratization, and social empowerment through equitable digital access (IFLA, 2023; UNESCO, 2023). Hence, positioning smart automation as a vehicle for socio-economic progress rather than just a technical upgrade, African libraries can secure greater institutional buy-in and demonstrate their indispensable role in fulfilling the global mandate for quality education and reduced inequalities.

Future Research Directions

Future studies should adopt quantitative and user-centered approaches to assess the measurable impact of automation on learning outcomes, research productivity, and user satisfaction in African academic libraries. Longitudinal studies examining AI adoption maturity, cost-benefit analyses, and the socio-ethical dimensions of smart technologies will also offer valuable insights for sustainable policy development and implementation.

Final Reflection

The future of library and information services in Africa lies at the intersection of technology, ethics, and human ingenuity. As libraries transition toward smart, automated ecosystems, the ultimate objective should not merely be technological advancement but the creation of inclusive, responsive, and knowledge-driven institutions that empower communities and drive national development.

When implemented ethically and strategically, digital technologies have the potential to transform African libraries from traditional repositories of information into catalysts for innovation, lifelong learning, and sustainable development in the era of the Fifth Industrial Revolution.

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