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DIGITAL LIBRARIES AND RESEARCH INFRASTRUCTURE IN THE ARTIFICIAL INTELLIGENCE (AI) TRANSFORMATIVE ERA: A STUDY OF AFRICAN PERSPECTIVES

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Abstract

The emergence of the Artificial Intelligence (AI) era is transforming the global knowledge landscape, significantly impacting the development and functioning of digital libraries and research infrastructure. This transformation in Africa offers significant opportunities alongside considerable challenges. This study analyses the adoption and integration of AI within digital libraries and research infrastructure, emphasizing African perspectives during the transformative era of AI. The research employs a qualitative content analysis methodology, sourcing evidence from academic articles, institutional reports, and case studies conducted in South Africa, Nigeria, Ghana, and Kenya. This method offers comparative insights into the deployment of AI applications in the selected countries, aimed at enhancing digital libraries and research infrastructure. This study delineates critical domains of AI integration, encompassing intelligent information retrieval, automated cataloguing, predictive analytics, and personalized knowledge services. Although these innovations enhance efficiency and broaden academic opportunities, challenges persist, notably the digital divide, insufficient funding, limited digital literacy, and ethical issues related to data privacy and cultural inclusivity. The findings highlight the necessity of promoting technological innovation alongside ensuring inclusive access. The research indicates that AI-enabled digital libraries possess significant transformative potential for the academic and developmental objectives of Africa. To maximize benefits, stakeholders should prioritize infrastructure investment, capacity-building programs, ethical guidelines, and regional collaborations. This method will enhance knowledge ecosystems and address inequalities.

Keywords: *Artificial intelligence, Digital libraries, Research infrastructure, Africa, Knowledge access, Innovation*

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Introduction

Digital libraries consist of electronic resources, services, and infrastructures that support lifelong learning, teaching, and research, while also preserving indigenous knowledge and cultural heritage. The incorporation of Artificial Intelligence (AI) technologies has transformed these systems, resulting in the emergence of smart or intelligent libraries. As Juma et al., (2014) observe, digital libraries hold considerable potential to mitigate global knowledge disparities, particularly within Africa, where expanding access to broadband connectivity has accelerated the establishment of virtual library systems across universities and research institutions.

The development of digital libraries and research infrastructures in South Africa, Nigeria, Ghana, and Kenya demonstrates unique patterns of progress and adaptation within the transformative era of AI. Universities are advancing through the implementation of AI-powered cataloguing, digitization, and discovery technologies. This occurs concurrently with national and institutional initiatives aimed at enhancing the efficiency, scalability, and accessibility of digital library systems (Abba, 2024; Adjei & Agyeman, 2024; Jebet & Gichugu, 2025). South Africa is recognized as a leader in technology on the continent, supported by its advanced ICT infrastructure and strong higher education system. National initiatives like the South African National Research Network (SANReN) and the National Integrated Cyberinfrastructure System (NICIS) have created a conducive environment for AI-enabled research systems (Masenya & Ngulube, 2021; Nongalo, 2025).

Nigeria, as Africa's largest economy, has made significant advancements in digitization and the integration of online resources. Nonetheless, ongoing challenges related to funding, electricity reliability, and internet bandwidth hinder the scalability of AI deployment (Eke, 2021; Okocha, 2022). In Ghana, institutions like the Kwame Nkrumah University of Science and Technology (KNUST) and the University of Ghana are enhancing the use of AI tools in cataloguing, discovery, and digitization efforts (Jebet & Gichugu, 2025). Kenyan universities are utilizing AI-enabled repositories and open-access infrastructures; however, infrastructural

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deficits, limited digital literacy, and weak policy alignment hinder the complete realization of AI's transformative potential (Sang, 2025).

The national contexts collectively highlight the diversity of Africa's involvement in AI-driven changes within the digital knowledge ecosystem. South Africa demonstrates a level of technological maturity; Nigeria showcases both potential and challenges; Ghana indicates consistent advancement within changing policy structures; and Kenya illustrates innovation despite systemic constraints. This study examines the adoption and integration of AI in digital libraries and research infrastructures in four countries. This analysis of opportunities and constraints enhances the scholarship on the future of African knowledge institutions in the AI era. It emphasizes the need for contextually responsive policies, capacity building, and strategic collaboration to better position Africa in the global AI-driven knowledge economy.

Research Objectives

1. To examine the state of digital libraries and research infrastructure in selected African countries within the Artificial Intelligence (AI) transformative era.
2. To analyze how AI technologies are being integrated into digital libraries and research infrastructures for knowledge access, organization, and dissemination in selected African countries.
3. To identify the opportunities that AI-driven solutions present for enhancing digital libraries and research infrastructure in selected African countries.
4. To explore the challenges that militate against the effective deployment of AI technologies in digital libraries and research infrastructure in selected African countries.

Research Methodology

Research Design

This study adopted a documentary research design to examine the adoption and integration of Artificial Intelligence (AI) in digital libraries and research infrastructure from African

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perspectives in the AI transformative era. The method was seen as suitable since it allows for the methodical analysis and interpretation of existing documents to create knowledge (Morgan, 2022). It is especially useful when fieldwork isn't possible but there is enough secondary data to meet the research goals.

Data Sources

The study utilized solely secondary data obtained from scholarly articles, institutional reports, and case studies collected via prominent academic databases and reputable web sources, including ScienceDirect, EBSCO Host, ResearchGate, and Google Scholar for relevant peer-reviewed journal articles. Armstrong (2021) asserts that employing several data sources augments the credibility and profundity of conclusions via triangulation. Sources were chosen because they were relevant to the study's goals of digital libraries and research infrastructure in Africa in the context of AI transformation. The researcher performed an integrative systematic review to discover and delineate articles published from 2019 to 2025, employing defined inclusion and exclusion criteria. A total of 16 papers were selected for comprehensive study to examine the problem under investigation.

Data Analysis

A critical analysis and synthesis of findings from current empirical research were used to analyze the data and determine patterns, trends, problems, and new ways of using AI. Hart (2018) says that a literature review and synthesis can assist find trends and gaps in what we know. The study underscored common advantages and challenges in the implementation of AI-driven innovations across specific African nations through a comparative analysis of regional experiences.

Table 1: Integrated literature review stages

S/N	Stage	Explanation	Application to the current study

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1	Literature search	This stage created a well-defined and documented search strategy, including search terms, databases used, and inclusion and exclusion criteria, as well as identifying limitations.	The researcher searched ScienceDirect, EBSCO Host, search engine (Google Scholar) for relevant peer-reviewed journal articles and other documents on AI and Digital libraries/research infrastructure in Africa (South Africa, Nigeria, Ghana and Kenya as delimiters).
2	Data evaluation	The Integrated literature review approach was used as a guide for selecting the types of sources.	The researcher established the inclusion and exclusion criteria. Articles published between 2019 and 2025 were considered. Articles published in English language only were included and in other languages were excluded. Only studies relating to the objectives of the study and on selected African countries were included.
3	Data analysis	This stage adopted constant comparison methods	The full-text articles that met the inclusion criteria were reviewed according to the objectives of the study. (i) state of digital libraries and research infrastructure in in the AI Era in Africa, (ii) AI integration in digital libraries and research infrastructures for knowledge access and dissemination, (iii) opportunities of AI-driven solutions in

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			digital libraries and research infrastructure, and (iv) challenges of AI adoption in digital libraries and research infrastructure

Justification for Research Method

Primary data collection methods such as surveys or interviews were not employed since the study aimed to capture a regional overview rather than focus on individual countries. The study did not use primary data collection methods like surveys or interviews since it wanted to get a regional picture instead than focusing on particular countries. Armstrong (2021) asserts that when ample empirical evidence is available, documentary research offers an effective and legitimate approach to fulfilling research objectives, circumventing the logistical challenges associated with fieldwork.

Limitations of the Method

The documentary method has built-in problems because it only uses published and available materials, which means it could miss out on new or unpublished information. Additionally, depending on how other authors have interpreted things may induce bias and make it harder to check things on your own (Armstrong, 2021).

Ethical Considerations

Even though no real people were involved in the study, it followed ethical standards by making sure that all citations and references were correct to avoid plagiarism and intellectual dishonesty. In line with Cohen et al. (2018), the study stressed openness, correctness, and respect for intellectual property, only employing trustworthy and relevant sources to keep academic integrity.

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Results and Discussion

This section presents and interprets the findings of the study in relation to the four stated objectives. To structure the discussion, the first objective examines the state of digital libraries and research infrastructure in South Africa, Nigeria, Ghana, and Kenya within the Artificial Intelligence (AI) transformative era. The second objective analyzes how AI technologies are being integrated into digital libraries and research infrastructures for knowledge access, organization, and dissemination in the selected African countries. The third objective identifies the opportunities that AI-driven solutions present for digital libraries and research infrastructure, while the fourth explores the challenges that militate against the effective deployment of AI technologies in these institutions. Together, these results provide a comprehensive understanding of how AI technologies are being deployed to enhance operations and services within digital libraries and research infrastructures across Africa.

Table 2: Journal articles included in the study

S/N	Research objective	Source
1	State of digital libraries and research infrastructure in in the AI Era in Africa	Masenya & Ngulube (2021) Nongalo (2025) Eke (2021) Abba (2024) Jebet & Gichugu (2025) Masinde et al., (2024) Adjei & Agyeman (2024)
2	AI integration in digital libraries and research infrastructures for knowledge access and dissemination	Masenya & Ngulube (2019) Masenya & Ngulube (2021) Nongalo (2025) Abba (2024) Jebet & Gichugu (2025) Tenya et al., (2023)

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		Adjei & Agyeman (2024) Masenya & Ngulube (2021)
3	Opportunities of AI-driven solutions in digital libraries and research infrastructure	Masenya & Ngulube (2021) Okike & Popoola (2021) Yusuf et al. (2022) Abba (2024) Nongalo (2025) Jebet & Gichugu (2025) Adjei & Agyeman (2024)
4	Challenges of AI adoption in digital libraries and research infrastructure	Okocha (2022) Sang (2025) Mwansa et al. (2025) Adeleke et al. (2023) Adjei & Agyeman (2024) Bangani (2025)
		No of articles used: 16

State of digital libraries and research infrastructure in Africa

The state of digital libraries and research infrastructure in South Africa, Nigeria, Ghana, and Kenya demonstrates varying progress in adapting to the Artificial Intelligence (AI) transformative era. South Africa leads with more advanced digital systems, stronger funding, and broader AI integration in research data management and user services (Masenya & Ngulube, 2021; Nongalo, 2025). Institutions such as the University of Cape Town (UCT) and the University of South Africa (UNISA) maintain well-established digital libraries, extensive electronic resources, and robust research infrastructures supporting digital scholarship.

In Nigeria, universities such as the University of Nigeria Nsukka, Ahmadu Bello University, the University of Lagos, and the University of Ibadan have developed growing digital library platforms and institutional repositories (Eke, 2021). Emerging AI applications, including chatbots and automated cataloguing, are being explored, and the University of Lagos has implemented a robotic system to assist users in accessing library resources (Abba, 2024).

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Kenya has made notable progress through institutional digitization projects and the gradual adoption of AI-driven information services in academic libraries (Masinde et al., 2024; Jebet & Gichugu, 2025). Ghana, meanwhile, continues to improve its digital infrastructure and policy frameworks but still faces interoperability and access challenges (Adjei & Agyeman, 2024). Overall, these developments reflect a continent-wide shift toward AI-enhanced digital ecosystems, though progress remains uneven across the selected countries.

AI integration in digital libraries and research infrastructures for knowledge access and dissemination

The integration of Artificial Intelligence (AI) offers significant opportunities for enhancing digital libraries and research infrastructures across South Africa, Nigeria, Ghana, and Kenya. AI-driven solutions improve knowledge discovery, automate routine library operations, and enhance user experience through intelligent search, personalized recommendations, and virtual assistants (Masenya & Ngulube, 2019; Masenya & Ngulube, 2021). Machine learning and data analytics enable advanced information organization, predictive cataloguing, and efficient research data management (Nongalo, 2025).

In South Africa, AI supports digital scholarship through automated metadata creation and institutional repository management, while in Nigeria and Kenya, it facilitates digital preservation and plagiarism detection (Abba, 2024; Tenya et al., 2023; Jebet & Gichugu, 2025). Ghanaian libraries benefit from AI-enabled resource sharing and open access initiatives that increase research visibility and collaboration (Adjei & Agyeman, 2024). Overall, AI technologies present transformative opportunities to strengthen knowledge accessibility, operational efficiency, and innovation within Africa's digital library and research ecosystems.

Opportunities of AI-driven solutions in digital libraries and research infrastructure

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AI-driven solutions present significant opportunities for enhancing digital libraries and research infrastructures across South Africa, Nigeria, Ghana, and Kenya. These technologies enable efficient knowledge organization, improved access to scholarly resources, and automation of routine tasks such as cataloguing, indexing, and content curation (Masenya & Ngulube, 2021). AI tools also enhance user experience through intelligent search systems, personalized recommendations, and virtual assistance services, allowing libraries to offer more interactive and user-centered services (Okike & Popoola, 2021; Yusuf et al., 2022; Abba, 2024).

In research environments, AI supports data analytics, plagiarism detection, and digital preservation, thereby strengthening research integrity and collaboration (Nongalo, 2025). Institutions like the University of Cape Town (UCT), the University of Lagos, and the National Commission for Science, Technology, and Innovation in Kenya have leveraged AI to expand digital repositories, improve research visibility, and facilitate open-access initiatives (Jebet & Gichugu, 2025; Adjei & Agyeman, 2024). Moreover, AI-driven language translation and semantic search tools are helping bridge linguistic barriers and promote the dissemination of indigenous and regional knowledge. Collectively, these opportunities underscore the potential of AI to transform African digital libraries and research infrastructures into more dynamic, inclusive, and globally connected knowledge ecosystems.

Challenges of AI adoption in digital libraries and research infrastructure in Africa

The integration of Artificial Intelligence (AI) into digital libraries and research infrastructures in South Africa, Nigeria, Ghana, and Kenya holds significant promise for enhancing knowledge access and innovation. However, its effective deployment is constrained by multiple interrelated challenges, including infrastructural deficits, limited funding, skills shortages, weak policy frameworks, socio-economic inequalities, and institutional sustainability issues.

1. Infrastructural and Technological Barriers

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Inadequate technological infrastructure such as unreliable internet connectivity, unstable electricity, and obsolete hardware continues to hinder AI implementation. Libraries in Nigeria and Ghana still rely on outdated repositories, while rural institutions in South Africa lag behind their urban counterparts in digital capacity (Okocha, 2022; Mwansa et al., 2025).

2. Financial and Economic Constraints

AI integration requires sustained investment in software, hardware, and maintenance, yet most libraries operate on limited budgets. Institutions in Nigeria and Kenya often prioritize routine operations over AI innovation, leaving projects donor-dependent and unsustainable (Okocha, 2022; Sang, 2025).

3. Human Capacity and Skills Deficit

The shortage of AI-literate library professionals and data managers limits progress. Many librarians lack training in machine learning, data analytics, and natural language processing, making institutions reliant on external experts (Adeleke et al., 2023; Adjei & Agyeman, 2024).

4. Policy, Ethical, and Governance Challenges

Policy and regulatory frameworks for AI adoption remain underdeveloped. Debates persist around data privacy, copyright, and algorithmic fairness, particularly in South Africa and Nigeria (Afolabi, 2024; Bangani, 2025). The absence of standardized data governance and ethical guidelines impedes collaboration and innovation.

5. Socio-Economic and Digital Divide Issues

The digital divide within and among these countries exacerbates inequalities in knowledge access. Rural communities and less-resourced institutions struggle to benefit from AI tools, while elite universities such as the University of Pretoria and the University of Cape Town advance more rapidly (Adeleke et al., 2023).

6. Sustainability and Institutional Readiness

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Many AI initiatives are pilot-based and lack continuity plans. Weak institutional frameworks and insufficient funding mechanisms hinder the long-term maintenance of AI systems and the integration of research data management practices (Okocha, 2022; Afolabi, 2024).

In general, the problems that make it hard to use AI in African digital libraries and research infrastructures are several and linked. To make sure that AI is used fairly and by everyone in Africa's research and knowledge ecosystems, we need coordinated policy action, investment in digital literacy, long-term funding, and institutions that are ready to do so.

Discussion

State of digital libraries and research infrastructure in Africa

The results show that digital libraries and research infrastructures in South Africa, Nigeria, Ghana, and Kenya are adapting to the AI disruptive era at different rates but are making progress. South Africa has been a regional leader in AI integration in research data management and user services because of its comparatively mature digital systems, ongoing financing, and institutional capabilities. Nigeria and Kenya are making small steps forward by adding more digital archives and testing AI applications like chatbots, robotic help, and automatic cataloguing. This shows that people are starting to use AI-powered services more and more. Ghana's efforts are still mostly focused on policy and infrastructure, and problems with interoperability and access are making it hard for AI to be fully adopted. Overall, these patterns are similar to what Asim et al. (2023), Huang (2024), and Zhang and Ye (2022) found in their international studies. They all found that while academic libraries around the world are using AI to improve efficiency and user services, the adoption of AI is affected by differences in infrastructure, funding, skills, and institutional readiness.

AI integration in digital libraries and research infrastructures for knowledge access and dissemination

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The findings demonstrate that AI integration offers transformative potential for digital libraries and research infrastructures in the selected African countries, enhancing knowledge discovery, automating library operations, and improving user experiences. The findings are consistent with empirical evidence from Asim et al. (2023), which indicates that AI applications in university libraries enhance information retrieval, cataloguing efficiency, and service personalization. Additionally, Huang (2024) reported that AI adoption in academic libraries bolsters research support services, digital preservation, and user engagement. In alignment with international studies, the African context demonstrates AI's potential to enhance operational efficiency, increase research visibility, and foster innovation, while promoting more accessible and sustainable digital library and research ecosystems.

Opportunities of AI-driven solutions in digital libraries and research infrastructure

AI-driven solutions present significant opportunities to enhance digital libraries and research infrastructures in the chosen African countries through improvements in efficiency, accessibility, and service quality. The findings align with Hussain (2023), indicating that AI improves fundamental library operations via automated cataloguing, indexing, and content curation, thereby enabling librarians to concentrate on more valuable research support services. The implementation of intelligent search systems, personalized recommendations, and virtual assistants indicates global trends noted by Huang (2024) and Asim et al. (2023), who document enhanced user engagement and more user-centred academic library services as a result of AI integration.

Challenges of AI adoption in digital libraries and research infrastructure in Africa

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The findings demonstrate that AI integration in digital libraries and research infrastructures in the selected African countries presents significant potential for enhancing knowledge access, service efficiency, and research innovation; however, its implementation is inconsistent and hindered by systemic challenges. Infrastructural deficits, insufficient funding, limited human resources, and weak policy and governance frameworks hinder the transition from experimental to fully integrated AI-driven services. The challenges observed align with global findings documented in the literature, indicating that inadequate technological readiness, skill deficiencies, and sustainability issues represent significant obstacles to AI adoption in libraries (Hussain, 2023; Asim et al., 2023). Evidence from Taiwan and Pakistan indicates that the effectiveness of AI tools, including chatbots, automated metadata generation, and recommendation systems, is significantly influenced by institutional support, ongoing funding, and staff competence (Huang, 2024; Kaushal & Yadav, 2022). The African context exemplifies a wider global trend wherein the potential of AI in libraries can be actualised solely through coordinated policy frameworks, ongoing investment, capacity building, and inclusive strategies that tackle socio-economic and digital disparities.

Summary

This study conducted a content analysis of the existing literature on digital libraries and research infrastructure in four African countries. It examined the state, integration, opportunities, and challenges associated with the adoption of Artificial Intelligence (AI) in digital libraries and research infrastructures in South Africa, Nigeria, Ghana, and Kenya. The findings indicate significant progress, with South Africa at the forefront of technological advancement, institutional readiness, and policy support, whereas Nigeria, Ghana, and Kenya

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exhibit emerging but inconsistent developments. South Africa exhibits advanced digital library systems, particularly at the University of Cape Town (UCT) and the University of South Africa (UNISA), where AI is incorporated into data management, automated cataloguing, and digital scholarship services (Masenya & Ngulube, 2021; Nongalo, 2025). Nigeria has advanced through institutional repositories and pilot AI initiatives, exemplified by the University of Lagos' robotic library guide (Abba, 2024); however, infrastructural deficiencies remain evident. Kenya demonstrates increasing progress via national digitization initiatives spearheaded by the National Commission for Science, Technology and Innovation.

In contrast, Ghana is enhancing access through policy reforms and institutional digitization, albeit facing challenges related to limited interoperability (Adjei & Agyeman, 2024; Jebet & Gichugu, 2025). In all four countries, AI technologies, including machine learning, natural language processing, and chatbots, enhance knowledge access, organisation, and dissemination. These innovations enhance predictive cataloguing, research data analytics, plagiarism detection, and personalised information services, thereby transforming conventional library operations (Abba, 2024). Opportunities for enhancing research visibility, operational efficiency, and digital preservation across the continent are particularly significant (Masenya & Ngulube, 2021; Nongalo, 2025). Nonetheless, enduring challenges transcend national contexts. Infrastructural deficits, unreliable power supply, funding limitations, and insufficient broadband connectivity continue to pose significant challenges (Okocha, 2022). The lack of personnel skilled in AI, inadequate policy frameworks, and ethical issues—particularly those related to data governance and algorithmic bias—further limit sustainable implementation (Adeleke et al., 2023; Bangani, 2025).

The digital divide between well-resourced South African institutions and underfunded counterparts in other countries perpetuates inequality in AI adoption. South Africa establishes a regional standard for AI-driven digital transformation, while Nigeria, Ghana, and Kenya are

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advancing through localized efforts. Maximizing the potential of AI in Africa's digital libraries and research infrastructures necessitates enhanced policies, ongoing funding, capacity development, and regional cooperation to promote inclusive and equitable technological advancement.

Conclusion

This research analyzed the current status, integration, opportunities, and challenges associated with the adoption of Artificial Intelligence (AI) in digital libraries and research infrastructures in South Africa, Nigeria, Ghana, and Kenya.

The findings indicate that South Africa exhibits a high level of digital maturity, marked by established digital library platforms, strong research and data infrastructures, and enhanced institutional preparedness regarding supportive policies, governance frameworks, and the incorporation of AI-driven tools for research data management. Nigeria, Ghana, and Kenya are progressively implementing AI-driven initiatives, though the extent of these efforts varies due to disparities in digital infrastructure maturity, availability of skilled human resources, funding mechanisms, data governance frameworks, institutional readiness, and the reliability of electricity and internet connectivity.

AI technologies, including machine learning-driven metadata generation, facilitate the tagging of digital library resources and research outputs. Natural language processing (NLP)-based search engines, semantic search, and recommendation systems enhance precision, relevance, and multilingual access to scholarly content. Additionally, data analytics aids in managing extensive research datasets, encompassing data cleaning, pattern recognition, visualization, and decision support in research planning and evaluation. The identified areas illustrate the potential of machine learning, NLP, and data analytics to enhance efficiency, foster innovation, and promote collaboration in Africa's academic and research environments.

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Recommendations

This study's objectives and the literature review yield the following recommendations:

The people in charge of higher learning institutions in South Africa, Nigeria, Ghana, and Kenya should strategically invest in AI-driven digital libraries and research infrastructures. They should also encourage collaboration between IT, library, and research departments and provide ongoing training for staff on AI tools and digital research facilities.

Libraries and information centres should work together more in their areas to exchange AI solutions, digital resources, and best practices. There should also be a focus on encouraging open access to research outputs, digitizing and standardizing collections, and expanding digital literacy programs to give patrons the skills they need to utilize AI tools, which will make research more efficient, visible, and shareable.

Regulatory agencies must to formulate explicit directives for AI utilization, data confidentiality, intellectual property, funding initiatives, and public-private collaborations for AI-driven services, while persistently assessing the influence of AI integration on research outcomes and knowledge distribution.

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