

AI-Powered Digital Archiving of Benin Artefacts in Edo Libraries: A Conceptual Framework for Cultural Heritage Preservation

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ABSTRACT

The Kingdom of Benin, located in present-day Edo State, Nigeria, possesses one of Africa's most extensive bodies of material and documentary heritage, much of which was dispersed following the 1897 British punitive expedition and remains scattered across museums, archives, and private collections worldwide. While recent international initiatives such as Digital Benin and the Edo Museum of West African Art (EMOWAA/MOWAA) have advanced the digital documentation of looted objects held abroad, comparatively little attention has been paid to the archival and documentary materials relating to Benin heritage held within Edo State's own library system. This paper presents a conceptual, literature-based examination of how artificial intelligence (AI) technologies, including computer vision, optical and handwritten text recognition, natural language processing, and automated metadata generation, can be applied to the digital archiving of Benin-related materials in academic and public libraries in Edo State. Drawing on a narrative review of cultural-heritage informatics literature and Nigerian library and information science scholarship, the paper proposes a five-layer framework spanning digitization, AI processing, metadata and ontology development, access and discovery, and preservation governance. The review finds that although AI adoption in Nigerian academic libraries remains constrained by inadequate infrastructure, limited funding, skills gaps, and ethical concerns, a phased and partnership-driven approach, anchored in Edo indigenous knowledge systems, offers a realistic pathway toward safeguarding and expanding access to Benin's documentary heritage. The paper concludes with recommendations for library administrators, heritage institutions, and policymakers in Edo State.

Keywords: artificial intelligence; digital archiving; Benin artefacts; Edo State libraries; cultural heritage preservation; digital libraries; Nigeria

Introduction

The precolonial Kingdom of Benin, centred on what is today Benin City in Edo State, Nigeria, produced one of the richest artistic and documentary traditions in West Africa, expressed through cast bronzes and brasses, carved ivories, coral-bead regalia, wooden and terracotta objects, and an extensive oral and administrative record maintained around the royal court. Much of this material heritage was violently dispersed in January 1897, when a British punitive expedition sacked Benin City, looted the royal palace, and sent thousands of objects, collectively known today as the Benin Bronzes, into circulation among museums and private collectors in Europe and North America (Museums Association, 2020). More than a century later, a global reckoning with this colonial legacy has produced a wave of restitution commitments, from Germany's transfer of ownership of over a thousand objects to Nigeria, to individual returns by institutions such as the Rautenstrauch-Joest-Museum and several university and civic museums, alongside the ongoing construction of the Edo Museum of West African Art (EMOWAA), now operating as the Museum of West African Art (MOWAA), on the historic palace grounds in Benin City (Museums Association, 2020).

Digital technology has played a central role in this restitution process. The most prominent example, Digital Benin, launched in November 2022 by the Museum am Rothenbaum (MARKK) in Hamburg, is an online catalogue that connects information on more than 5,000 Benin objects held across roughly 130 institutions in 21 countries, reuniting high-resolution images, provenance records, and oral histories in a single knowledge platform (Sharma, 2024; TexLibris, 2025). A distinguishing feature of the platform is its adoption of an Edo-derived classification framework, referred to as "Eyo Oto," in place of conventional Western museum taxonomies, reflecting a deliberate effort to let indigenous knowledge systems, rather than colonial-era cataloguing conventions, structure how the heritage is understood (TexLibris, 2025). Complementary technical initiatives have reinforced this documentation effort: the Factum Foundation conducted photogrammetry training for staff of EMOWAA and Nigeria's National Commission for Museums and Monuments (NCMM) in 2022 (Factum Foundation, 2023), while the Fraunhofer Development Center for X-ray Technology, working with the Staatliche Museen zu Berlin, has used high-energy computed tomography to generate detailed digital and 3D data sets of Benin objects (Staatliche Museen zu Berlin, 2023).

These initiatives have, however, concentrated overwhelmingly on museum-held physical objects located outside Nigeria. Far less attention has been directed toward the documentary, archival, and print heritage relating to Benin history and culture that resides within Nigeria itself, particularly in the library system of Edo State: state and institutional libraries, colleges of education, polytechnics, and university libraries that hold local history collections, administrative records, theses, oral history transcripts, photographs, and other materials documenting the Kingdom of Benin and its artefacts. Nigerian library and information science research shows that artificial intelligence is increasingly being explored as a tool for automating cataloguing, generating metadata, and supporting digital preservation in academic libraries, yet adoption nationally remains uneven and constrained by infrastructural, financial, and human-capacity limitations (Moustapha & Yusuf, 2023; Owate & David-West, 2024). This paper brings these two strands, the global momentum around digitizing Benin heritage and the emerging but constrained use of AI in Nigerian academic libraries, into a single conceptual framework focused specifically on the library sector in Edo State.

Statement of the Problem

Documentary materials connected to Benin history and artefacts held in Edo State libraries face many of the same risks of loss and deterioration that affect archival collections generally: humidity and fire damage, insect infestation, poor storage infrastructure, and the slow physical decay of paper-based and photographic records. Unlike the internationally coordinated effort to document dispersed Benin objects abroad, there is no comparable, dedicated programme for systematically digitizing and preserving the library-held documentary record of Benin heritage inside Nigeria. At the same time, broader studies of AI adoption in Nigerian academic libraries consistently report low levels of implementation, attributed to inadequate funding, weak digital infrastructure, limited staff training, and unresolved ethical and data-

privacy questions (Moustapha & Yusuf, 2023; Owate & David-West, 2024). Without a framework that connects the technical possibilities of AI-assisted archiving to the specific institutional realities of Edo State's libraries, there is a risk that this dimension of Benin's heritage record will continue to be overlooked even as international attention to the Benin Bronzes intensifies.

Objectives of the Study

This paper pursues the following objectives:

1. To examine the nature and preservation needs of documentary and archival materials relating to Benin artefacts held in Edo State libraries.
2. To review artificial intelligence technologies relevant to digital archiving, including computer vision, text recognition, natural language processing, and automated metadata generation.
3. To propose a conceptual framework for AI-powered digital archiving suited to the institutional context of Edo State libraries.

4. To identify the principal challenges likely to affect the adoption of such a framework.

5. To recommend institutional and policy measures to support implementation.

Significance of the Study

This paper is intended to be of value to the Edo State Library Board, librarians in the state's colleges of education, polytechnics, and universities, EMOWAA/MOWAA and NCMM as heritage-sector partners, and policymakers responsible for cultural heritage and digital infrastructure in Edo State. By translating global AI-in-heritage practice into a locally grounded framework, the paper aims to support more coordinated, sustainable, and culturally appropriate digital preservation of Benin-related documentary heritage.

Literature Review

Benin Kingdom Heritage and the Imperative of Documentation

The looting of Benin City in 1897 remains one of the most extensively documented cases of colonial cultural expropriation in Africa. Objects removed during the punitive expedition, ceremonial plaques, commemorative heads, ivories, and regalia belonging to the Edo people, were sold into private and institutional collections across Europe and North America, severing the connection between the Edo community and its material heritage for more than a century (Sharma, 2024). Since the early 2020s, this situation has begun to shift: Germany transferred ownership of over a thousand Benin objects to Nigeria, and museums including those in Glasgow and several U.S. institutions have initiated returns, while the Benin Dialogue Group, comprising Nigerian government, royal court, and international museum representatives, has coordinated broader restitution discussions (Museums Association, 2020; Sharma, 2024). The planned physical home for returned and newly excavated objects is EMOWAA/MOWAA, designed by Adjaye Associates on a site adjoining the Oba's palace in Benin City, conceived explicitly to depart from Western museum conventions and to incorporate archaeological remains uncovered during construction (Museums Association, 2020).

Digital Documentation Precedents

The most significant digital precedent for this paper's framework is Digital Benin, an online knowledge platform that aggregates object records, provenance data, high-resolution imagery, and oral-history interviews with Benin artisans and elders, drawing on the expertise of Nigerian and international scholars (Sharma, 2024; TexLibris, 2025). Rather than relying on conventional Western object categories, the platform introduces a controlled vocabulary grounded in Edo knowledge systems, illustrating how digital infrastructure can be designed to reflect, rather than override, indigenous frameworks of meaning (TexLibris, 2025). Parallel technical initiatives illustrate the range of capture technologies available: the Factum Foundation's 2022 training programme equipped EMOWAA and NCMM staff with photogrammetry skills for high-fidelity object documentation (Factum Foundation, 2023), while the Fraunhofer IIS/Staatliche Museen zu Berlin partnership has applied industrial computed tomography to generate detailed three-dimensional data sets of Benin bronzes (Staatliche Museen zu Berlin, 2023). Collectively, these initiatives demonstrate mature capture

methodologies that could, in principle, be adapted to library and archival materials, though to date their application has been concentrated on museum objects rather than documentary collections.

Artificial Intelligence Technologies for Archiving

Beyond image capture, artificial intelligence offers a growing set of tools for organizing and interpreting heritage collections at scale. Convolutional neural networks (CNNs) have been shown to classify cultural artefacts with substantial accuracy on large and diverse image data sets, supporting automated identification and cataloguing tasks that would otherwise require extensive manual curatorial effort (Winterbottom et al., 2022). Computer vision techniques more broadly are being used across the heritage sector to automatically generate descriptive metadata, tagging visual elements such as materials, motifs, and object types at scale, which addresses a long-standing bottleneck in manual cataloguing (API4AI, 2025). Natural language processing and handwritten text recognition extend this capability to textual and documentary material, enabling transcription of handwritten records, deduplication of catalogue entries, and metadata generation for previously uncatalogued archival collections (CLIR, 2024). Emerging applications such as visual question answering further suggest how AI could eventually support interactive public engagement with digitized heritage collections, allowing users to query image collections in natural language (Bongini et al., 2020). Taken together, this literature indicates that the technical building blocks required for an AI-assisted library archiving programme, image classification, text recognition, and automated metadata generation, are reasonably mature, even though their application to library-held African heritage documentation specifically remains limited.

Artificial Intelligence in Nigerian Academic Libraries

Within Nigeria, empirical studies of AI adoption in academic libraries describe a sector at an early and uneven stage of implementation. A study of academic libraries in Kwara State found growing use of tools such as chatbots, automated cataloguing, and personalized recommendation systems, but identified infrastructural deficits, digital illiteracy, and ethical concerns including algorithmic bias and data privacy as significant barriers to wider adoption (Moustapha & Yusuf, 2023). A related study examining thirteen university libraries across South-South and South-East Nigeria found that while AI-generated content offers opportunities for more sustainable library operations, librarians continue to face ethical and bias-related challenges, alongside legal and infrastructural obstacles, in preserving and curating such content (Owate & David-West, 2024). These findings are consistent with the broader pattern reported across Nigerian library and information science research: awareness of AI's potential is comparatively high, but actual adoption lags due to funding constraints, unreliable power and internet infrastructure, and a shortage of staff trained in AI-related digital skills.

Theoretical Framework

This paper situates its proposed framework within the Technology Acceptance Model (TAM), which holds that an individual's intention to adopt a new technology is shaped primarily by their perceived usefulness of the technology and their perceived ease of using it (Davis, 1989). TAM has been applied directly in Nigerian library and information science research to explain librarians' adoption behaviour toward AI tools (Moustapha & Yusuf, 2023), and it offers a useful lens for this paper's framework: for an AI-powered archiving system to be adopted by Edo State's libraries, it must be perceived by library staff and administrators as both genuinely useful for safeguarding Benin heritage and realistically usable within the sector's current infrastructural and skills constraints.

Methodology

This paper adopts a conceptual, literature-based methodology appropriate to early-stage framework development in an under-researched area. A narrative review was conducted of publications from 2018 to 2026 spanning three intersecting bodies of literature: (a) international scholarship and heritage-sector reporting on the digitization and restitution of Benin heritage, (b) computer science and digital humanities literature on artificial intelligence applications in cultural heritage documentation, and (c) Nigerian library and information science research on AI adoption in academic libraries. Sources were identified through targeted searches of academic databases, institutional and museum-sector publications, and heritage journalism, and were selected for direct relevance to AI-enabled archiving practice or to the Benin/Edo heritage context. The resulting synthesis was used inductively to develop the five-layer conceptual framework presented in the following section, alongside an analysis of the challenges and recommendations grounded in the reviewed literature. As a conceptual paper, this study does not report primary empirical data collected from Edo State libraries; it is intended as a foundation for subsequent empirical validation, for example through surveys or case studies of specific library institutions.

Proposed Framework: AI-Powered Digital Archiving for Edo Libraries

Drawing on the reviewed literature, this paper proposes a five-layer conceptual framework for AI-powered digital archiving of Benin-related materials held in Edo State libraries.

Layer One: Digitization and Capture

The foundation layer involves systematic, high-resolution capture of library-held materials relating to Benin history and artefacts, including manuscripts, photographs, theses, oral history recordings, and administrative records. This layer can draw directly on capture methodologies already piloted in the Benin heritage sector, including photogrammetry techniques of the kind used in the Factum Foundation's training programme for EMOWAA and NCMM staff, adapted for two-dimensional documents and photographic collections (Factum Foundation, 2023).

Layer Two: AI Processing

Captured materials are then processed using appropriate AI tools: convolutional neural network-based image classification for photographs and illustrated materials, following approaches shown to achieve strong classification accuracy on heritage image collections (Winterbottom et al., 2022); optical and handwritten text recognition for typed and handwritten documents; and natural language processing for indexing oral history transcripts and generating searchable metadata from uncatalogued textual collections (CLIR, 2024).

Layer Three: Metadata and Ontology

Rather than adopting a generic Western cataloguing schema, this layer would develop a controlled vocabulary reflecting Edo indigenous classification concepts, following the precedent set by Digital Benin's "Eyo Oto" framework (TexLibris, 2025). This ensures that automated metadata generated in Layer Two is organized in ways that are meaningful to, and controlled by, the descendant community rather than imposed from outside.

Layer Four: Access and Discovery

Digitized and catalogued materials would be made accessible through a searchable institutional repository, potentially integrated with AI-driven discovery tools such as intelligent search and reference chatbots, consistent with emerging practice already reported in Nigerian academic libraries (Moustapha & Yusuf, 2023). Interoperability with national and international heritage platforms, including the National Library of Nigeria and Digital Benin, would extend the reach and impact of locally digitized materials.

Layer Five: Preservation and Governance

The final layer addresses long-term sustainability: redundant digital storage and backup, provenance and rights tracking, and an explicit data governance policy addressing the ethical and privacy concerns that Nigerian library research consistently identifies as a barrier to AI adoption (Owate & David-West, 2024). This layer also encompasses staff capacity building, ensuring library personnel are trained not only to operate AI tools but to make informed judgments about their outputs.

Challenges and Constraints

Several challenges, well documented in the Nigerian library and information science literature, are likely to affect implementation of this framework. Infrastructural constraints, including unreliable electricity supply and limited internet connectivity, remain a persistent barrier to technology adoption in Nigerian academic libraries generally (Moustapha & Yusuf, 2023). Funding constraints similarly limit the acquisition of the scanning equipment, computing capacity, and software licences that AI-powered archiving requires. A shortage of staff trained in AI tools and digital preservation techniques compounds these material constraints, as does resistance to technological change among some library personnel (Moustapha & Yusuf, 2023). Ethical and data-privacy considerations, including questions of algorithmic bias and appropriate governance of digitized cultural content, represent a further significant concern (Owate & David-West, 2024). Finally, there is a risk specific to heritage digitization: if AI classification systems are trained on, or default to, Western cataloguing categories rather than Edo indigenous frameworks, digitization could inadvertently decontextualize the very heritage it is meant to preserve, underscoring the importance of the ontology layer described above.

Recommendations

1. Adopt a phased digitization strategy that prioritizes the most physically at-risk documentary materials in Edo State libraries before undertaking comprehensive digitization.
2. Establish formal partnerships between Edo State libraries and EMOWAA/MOWAA, NCMM, MARKK/Digital Benin, and the Factum Foundation to share technical expertise, equipment access, and training capacity.
3. Invest in structured capacity-building programmes for librarians covering AI-assisted cataloguing, digitization techniques, and metadata standards.
4. Develop an Edo-specific controlled vocabulary and metadata ontology, in consultation with royal court and community stakeholders, rather than adopting generic international schemas wholesale.
5. Establish a clear data governance policy addressing privacy, provenance, and ethical use of AI-generated metadata before large-scale implementation begins.
6. Pursue interoperability with national and international platforms, including the National Library of Nigeria and Digital Benin, to maximize the visibility and long-term impact of digitized collections.

Conclusion

International efforts to document and repatriate Benin heritage have demonstrated the technical feasibility of AI-assisted cultural heritage digitization, from Digital Benin's knowledge platform to photogrammetric and computed-tomography documentation of returned objects. Yet these efforts have concentrated on museum-held objects abroad, leaving the documentary and archival heritage held within Edo State's own library system comparatively underserved. This paper has proposed a five-layer conceptual framework, spanning digitization, AI processing, metadata and ontology development, access and discovery, and preservation governance, designed to bring the demonstrated technical possibilities of AI-powered archiving into the specific institutional context of Edo State libraries. Realizing this framework will require sustained attention to the infrastructural, financial, and skills constraints that continue to limit AI adoption across Nigerian academic libraries, as well as a deliberate commitment to grounding digital systems in Edo indigenous knowledge frameworks rather than imported

cataloguing conventions. Future research should test and refine this framework through empirical engagement with specific library institutions in Edo State.

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