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Decentralized Blockchain Systems for Managing Digital Archives in Academic Libraries: Navigating Challenges and Opportunities in the Era of the Fifth Industrial Revolution (5IR)

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Abstract

This study aims to examine the perception and awareness regarding the relevance of adopting blockchain technology for managing digital archives in the context of fifth industrial revolution (5IR). Ten system librarians who were chosen from five distinct academic libraries in Nigeria's Southwest geopolitical zone serve as the study's sample. An open-ended survey was used to gather data for the study, which took a strictly qualitative approach. Based on the findings, system librarians are aware of blockchain technology adoption and its benefits for digital archive management in academic libraries. The adoption of blockchain technology is perceived positively since it can help digital archives collect, preserve, and disseminate authoritative information in a distributed setting. It can also help digital archives create a single, verifiable record that is accessible to all and deserves respect. As such, the adoption of blockchain technology faces a number of hurdles, including challenging installation, scalability, maintenance costs, integration, data protection, governance, user adoption, energy consumption, long-term viability, and legal and ethical issues.

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Introduction

In an era of rapid technological advancement, the adoption of blockchain technology is gaining prominence across diverse sectors including business, education, the economy, and social systems (Warkentin & Orgeron, 2020; Kayode & Oguntayo, 2025). The emergence of the Fifth Industrial Revolution (5IR) has introduced transformative technologies into the educational landscape, with academic libraries—recognized as central hubs of information—being key beneficiaries. Blockchain offers promising solutions for securing library records, enhancing metadata systems, and enabling seamless resource sharing in digital environments. This study seeks to examine how blockchain is being utilized in the management of academic library records and digital archives within the context of 5IR.

Given these developments, it is essential to assess how academic libraries are evolving in response to technological change. Traditionally regarded as custodians of knowledge, libraries must now embrace digital innovations while preserving their core values (Tella, Ukwoma, & Kayode, 2020; Kayode et al., 2024; Adigun et al., 2024). Technologies such as machine learning, robotics, the Internet of Things (IoT), and blockchain are reshaping library operations and service

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delivery, offering solutions to longstanding challenges and enhancing institutional performance (Shah et al., 2024; Aderonumu, 2021). Blockchain, as a distributed ledger system, has been recognized by the World Economic Forum (2024) as one of the top ten emerging technologies.

Academic libraries play a critical role in the acquisition, preservation, and dissemination of information. Blockchain can strengthen these functions by verifying document ownership and facilitating secure, decentralized transactions. Libraries provide access to a wide range of materials—including digital, print, audio, and special collections—that support lifelong learning and scholarly growth. While institutions in developed countries are beginning to adopt blockchain, those in developing regions face challenges such as limited awareness and slow implementation (Tella et al., 2022).

In this study, "perception" refers to how librarians interpret and evaluate the use of blockchain in library services. It encompasses their understanding of its functionality, recognition of its benefits, awareness of potential challenges, and openness to innovation. Some librarians view blockchain as a tool for enhancing service delivery, while others express concern about its impact on traditional library practices (Oguntayo et al., 2024; Tella et al., 2022). "Awareness," on the other hand, denotes the extent to which librarians are informed about blockchain and its relevance to library operations. Jakati (2022) emphasized that understanding blockchain involves grasping both its applications and implications. Librarians who are technologically literate are better positioned to leverage emerging tools and develop innovative service models (Singh & Qazi, 2020).

Ultimately, blockchain has the potential to support the development of decentralized metadata systems, reducing reliance on centralized control. However, many librarians still lack a comprehensive understanding of their capabilities and significance. This study is therefore necessary to explore how librarians in Nigeria perceive and understand blockchain adoption in academic libraries, and to identify the benefits and challenges they associate with its use in managing digital archives and information services.

Objectives of the Study

Specific objectives that the study aimed to achieve were as follows:

- Examine the librarian's perceptions regarding the relevance of adopting blockchain technology for managing digital archives in academic libraries;
- Ascertain the level of librarian's awareness regarding the relevance of adopting blockchain technology for managing digital archives in academic libraries and
- Identify the anticipated challenges regarding the relevance of adopting blockchain technology for managing digital archives in academic libraries.

Literature Review

According to Jha (2023), academic libraries are increasingly functioning as data providers by selecting, storing, and sharing digital assets. However, emerging technologies like blockchain present significant challenges to library and educational management. Blockchain helps reduce risks and protect users while enabling access to both digital and print content. As a result, modern academic libraries are adopting innovative tools to deliver information more efficiently. The impact of blockchain on library services is therefore considered substantial.

Jakati (2022) noted that blockchain is primarily used for secure digital transactions by storing records in a time-stamped and distributed format, making data difficult to duplicate or falsify. His article explains the mechanics of blockchain and its current and future applications in libraries. Similarly, Abid (2021**)** discussed blockchain and artificial intelligence in library contexts, emphasizing the limited number of existing studies. His work supports researchers and librarians in understanding key issues before implementing AI in library operations.

Suman and Patel (2021**)** traced blockchain's origins to Bitcoin, describing it as a relatively new and not yet fully understood technology. Their study explored its potential use in libraries and data centers to enhance data management. They also cautioned that while blockchain is powerful, it carries risks and must be applied thoughtfully by librarians.

Omame and Alex-Nmecha (2021) positioned blockchain within the framework of the Fourth Industrial Revolution, highlighting its use in libraries and data centers through cryptographic data sharing across networks. Although initially developed for digital currency, blockchain now influences fields such as data science and library services. Their study identified various applications in libraries, including record keeping, storage, categorization, and research data management, while also acknowledging that its benefits and limitations depend on institutional needs.

Shah et al. (2024) examined blockchain's potential impact on records management, predicting a transformative effect on information systems, though adoption in records management may lag. Hoy and Brigham (2017) also explored blockchain's future relevance for librarians and medical professionals. Lemieux (2017), a leading expert, demonstrated blockchain's utility in real estate, healthcare, and finance, offering a model for secure recordkeeping based on archival science. Her work underscores blockchain's potential to preserve authentic documents over time.

Despite these contributions, it is evident that limited research has addressed blockchain's role in managing digital archives within academic libraries, particularly in Africa. Most existing studies focus on records management and originate from developed countries. Empirical research remains scarce, with much of the literature being theoretical. Therefore, this study seeks to explore how librarians in Africa—especially Nigeria—perceive and understand blockchain technology for digital archive management, including the benefits and challenges they encounter in practice.

Methodology

A qualitative research approach was adopted to explore librarians' understanding and experiences regarding the adoption of blockchain technology for managing digital archives. This method was chosen for its strength in capturing rich, descriptive data and enabling researchers to draw meaningful conclusions from participants' narratives. Additionally, qualitative methods are cost-effective and practical, especially when self-administered (Creswell & Poth, 2018). The study employed an open-ended questionnaire to gather in-depth insights into librarians' awareness, perceptions, perceived benefits, and challenges associated with blockchain integration. Although various qualitative tools exist, open-ended questionnaires remain a common and effective instrument for eliciting detailed responses in exploratory research. Participants were system librarians from five academic libraries located in Southwest Nigeria. Each librarian held a degree in Library and Information Science (LIS), ensuring subject-matter relevance. Two librarians were purposively selected from each institution, resulting in a total of

ten participants. These individuals were responsible for data and information management within their libraries, making them well-suited to provide informed perspectives on the topic. The questionnaire included pre-formulated questions aligned with the four core objectives of the study. It also featured a brief definition of blockchain technology and clear instructions to aid comprehension. During the data collection phase, participants were invited to complete the survey promptly. All ten questionnaires were returned fully completed and subsequently analyzed. Informed consent was obtained from all participants, who were assured of their right to withdraw at any point should they feel uncomfortable or encounter any issues. Their voluntary participation and openness contributed significantly to the depth and reliability of the findings.

Results and Discussion

Librarian's awareness regarding the relevance of adopting blockchain technology for managing digital archives in academic libraries.

When asked whether they had started utilizing blockchain technology for digital archives in their libraries and whether they were aware of it. The majority of system librarians are aware of blockchain technology. According to the findings overall. It can be applied to the creation of immutable digital archives, guaranteeing that information once saved will never be changed or removed. This is crucial for preserving the integrity of academic records, historical documents, and cultural heritage materials. Also, ensure that digital resources remain accessible and intact over time, even as technology evolves.

One respondent emphatically mentioned:

> *My level of understanding regarding blockchain technology is rather high as a result of my exposure to it from reading and hearing about it, as well as seeing firsthand how academic libraries that have already implemented it are doing well right now. Academic libraries will reap endless benefits from adopting blockchain technology, which is an amazing technology in digital era.*

Concerning the above, another respondent has this to say:

> *Clearly, I am aware of blockchain technology; it is a fantastic tool that can be found in many academic libraries. That technology has not been incorporated into my library, though, is quite regrettable*

Based on the previously mentioned results, it appears that all of the system librarians involved in this study are aware of blockchain technology and how libraries and information centers are implementing it. Unquestionably, immutable record-keeping and basic transactional data are the best uses cases for blockchain technology. The library community's values of accountability, openness, transparency, and privacy may be able to be balanced by it. Although blockchain technology might not be the optimal answer, it can help academic libraries reconsider their processes regarding verifiable, immutable transactions and their subjects. It integrates supply chain management ideas with various library operations and activities.

Librarian's perception regarding the relevance of adopting blockchain technology for managing digital archives in academic libraries

Librarians were asked to indicate how they perceive blockchain technology adoption in their respective libraries. The results reveal that the perception of librarians on blockchain technology for managing digital archives in academic libraries is positive.

One respondent remarked that:

> *Immutable, tamper-proof records are considered a major advantage of blockchain technology by many in the library sector. For the preservation of digital collections, research data, and academic documents in particular, this is pertinent. Said another way, academic libraries entrusted with knowledge preservation view blockchain technology as a means of fostering trust in the legitimacy and dependability of digital materials.*

One respondent noted that:

> *Blockchain technology may be perceived by librarians as a means of improving access to digital resources via decentralized networks, thus expanding the reach of information and decreasing dependence on centralized authorities.*

One respondent stated that:

> *In the context of handling academic credentials and intellectual property, blockchain technology is seen as a means of preventing unwanted access and tampering with sensitive information.*

The study's findings suggest that all of the librarians involved had a favorable opinion of blockchain technology adoption and believe it has the potential to advance digital archives and academic libraries. It is clear from the body of existing research that blockchain technology adoption is difficult and has enormous potential. It offers promise for improved compliance monitoring and can help university libraries with research procedures to increase accountability and repeatability. Blockchain technology also has the ability to enhance ownership and first sale records management for library purchases, in addition to improving circulation, interlibrary borrowing, and e-lending records management. It makes sense that librarians in this study had a favorable opinion on it.

The librarians were asked to indicate whether there are challenges they envisage with the adoption and integration of blockchain to academic libraries for managing digital archives. The findings generally showed that while blockchain technology holds benefits for academic libraries, its adoption is accompanied by challenges.

One respondent explained that:

> *Librarians and archivists in an academic library may resist adopting blockchain technology due to a lack of understanding or fear of the technology's complexity. This resistance could slow down implementation and reduce the effectiveness of the new system. Significant training programs would be necessary to bring staff up to speed, which could also divert resources from other important library functions.*

One respondent emphasized that:

> *If an academic library wants to use blockchain technology to store user information related to digital archives, it may encounter issues with GDPR compliance. For instance, GDPR requires that personal data be erasable upon request, but blockchain's immutable nature means that once data is entered, it cannot be easily deleted. This could lead to legal challenges and the need for complex workarounds, such as encrypting the data and securely managing the keys*.

One respondent submitted that:

> *A consortium of academic libraries trying to create a shared blockchain technology for managing digital archives might face difficulties establishing a common governance model. Questions about who controls the blockchain technology, how updates are implemented, and how disputes are resolved could hinder collaboration and lead to fragmented implementations.*

Consequently, while blockchain technology offers promising benefits for managing digital archives in academic libraries, there are substantial challenges that must be addressed. These include and not limited to, scalability, cost, integration, data privacy, governance, user adoption, energy consumption, long-term viability, and legal and ethical issues. Careful planning and consideration are essential for overcoming these obstacles and successfully implementing blockchain solutions. The results here imply that there are challenges associated with user adoption of blockchain technology in academic libraries for managing digital and archives and this ranges from implementation and maintenance cost (Jha,2023).

Conclusion

This study examined the awareness and perception of blockchain technology adoption in managing digital archives and academic library records within the digital era. Findings revealed that librarians are increasingly aware of blockchain's growing relevance and its application in academic libraries and information centers. They recognize its potential to enhance data integrity, decentralize recordkeeping, and support the secure dissemination of authoritative information. The ability of blockchain to create verifiable, time-stamped records and demonstrate the scarcity of digital resources contributes to its favorable perception among library professionals. However, the adoption of blockchain technology is not without challenges. Key concerns include high implementation and maintenance costs, energy consumption, scalability limitations, data privacy risks, governance complexities, and legal and ethical uncertainties. These barriers highlight the need for strategic planning and institutional support to ensure successful integration.

Recommendations

To address these challenges and harness the benefits of blockchain technology, the following recommendations are proposed:

- Collaborative Networks: Academic libraries should consider forming partnerships with other institutions or joining blockchain consortia to share resources and reduce implementation costs.
- User-Friendly Platforms: Select blockchain solutions that are intuitive and require minimal technical expertise for daily operations.
- Capacity Building: Organize training programs for library staff to develop the skills needed to manage and interact with blockchain-based systems.
- Policy Development: Establish clear policies that address the implications of blockchain adoption for records management, access control, and data preservation.
- System Integration: Work closely with institutional IT departments to ensure seamless integration of blockchain systems with existing digital infrastructure.
- Lifecycle Management: Implement mechanisms for long-term access, secure disposal, and archival preservation of blockchain records and transactional data.
- Funding Support: Secure adequate funding to cover infrastructure, energy, and network requirements essential for sustainable blockchain deployment.

By thoughtfully implementing these strategies, academic libraries can leverage blockchain technology to improve the management, preservation, and accessibility of digital archives—ensuring that these valuable resources remain secure, authentic, and available for future generations.

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