

Digital Challenges and Technological Advancements in the Nigerian Built Environment: An Exploratory Review

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Abstract

The Nigerian built environment, comprising the construction and heavy engineering sectors, plays a critical role in national economic growth and infrastructure delivery. However, despite global advancements in digital construction technologies, Nigeria continues to experience significant barriers to digital transformation. This study adopts an exploratory review approach to examine the digital challenges and technological advancements influencing the Nigerian built environment. Drawing on recent literature (2016–2025) and sectoral policy reports, the study identifies major barriers including infrastructure deficiencies, digital skill gaps, financial constraints, regulatory uncertainties, and data governance concerns. It further evaluates emerging technologies such as Building Information Modelling (BIM), Digital Twins, Artificial Intelligence (AI), Internet of Things (IoT), Blockchain, and Big Data analytics, highlighting their transformative potential alongside contextual adoption limitations. The study also examines national policy initiatives such as the 3 Million Technical Talent (3MTT) programme aimed at bridging digital workforce gaps. Findings reveal a widening digital divide between professionals and non-professionals, as well as structural barriers limiting inclusive technological uptake. The paper concludes with strategic recommendations for policymakers, educational institutions, and industry stakeholders to accelerate sustainable and inclusive digital transformation in Nigeria's built environment.

Keywords: Building Information Modelling (BIM); Digital Transformation; Digital Twin; Fourth Industrial Revolution; Nigerian Construction Industry; Technological Adoption.

Introduction

The Nigerian built environment, encompassing construction and heavy engineering activities, remains a cornerstone of national economic development and infrastructural expansion. The sector is responsible for delivering housing, transportation networks, and essential utilities that underpin socioeconomic progress (Aliu & Oke, 2023). Historically, the industry has relied heavily on conventional methods characterized by manual processes, fragmented project coordination, and limited technological integration. While these traditional practices have sustained the sector for decades, they increasingly constrain efficiency, sustainability, and global competitiveness.

Globally, industries are undergoing rapid transformation driven by the Fourth Industrial Revolution (4IR), defined by the convergence of digital, physical, and intelligent systems (Farouk et al., 2024; Aliu et al., 2025). Within the built environment, this transformation manifests through technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), Big Data analytics, Building Information Modelling (BIM), Digital Twins (DT), and Blockchain (Shahzad et al., 2022). These technologies enable real-time monitoring, predictive analytics, automation, improved stakeholder collaboration, and lifecycle optimization (Dubinin, 2024; Asif et al., 2024).

Despite the documented benefits of digitalization—including improved productivity, enhanced safety, cost efficiency, and sustainability—Nigeria’s built environment faces contextual constraints that complicate widespread adoption (Oke et al., 2023). Infrastructure limitations, skill shortages, financial barriers, and weak regulatory frameworks continue to impede digital integration. Consequently, a significant divergence exists between global digital progress and local implementation realities. Although several studies have examined digital technologies in Nigeria’s construction industry, limited integrative research simultaneously evaluates both the digital challenges and the technological advancements shaping the sector within a unified analytical framework. This gap restricts holistic understanding and weakens policy formulation.

This study aims to examine digital challenges and technological advancements influencing the Nigerian built environment. The objectives include Identify key digital challenges affecting the Nigerian built environment, Examine emerging technological advancements within the sector, Analyze the interplay between contextual barriers and digital innovation and Propose strategic recommendations for inclusive digital transformation.

To achieve these objectives, the study adopts an exploratory literature review approach synthesizing recent scholarly and policy sources.

Conceptualizing Digital Transformation and Challenges in the Built Environment

Digital transformation in Nigeria’s built environment is constrained by persistent infrastructure deficiencies. Erratic electricity supply significantly disrupts continuous digital operations (Amusan et al., 2021). In addition, limited broadband penetration—especially in remote project sites—restricts real-time data exchange required for BIM, IoT, and Digital Twin integration (Oke et al., 2024). These infrastructural gaps form foundational barriers to digital implementation.

Human capital deficiencies further complicate transformation efforts. Research consistently identifies insufficient IT competencies, limited digital literacy, and a shortage of trained professionals capable of managing advanced digital systems (Achuama, 2024; Oyedokun et al., 2022; Ezeokoli et al., 2016). Resistance to change and limited managerial awareness of digital benefits exacerbate the situation (Aliu & Oke, 2023; Oke et al., 2023). Addressing these skill deficits through structured professional training and curriculum reform is critical.

Financial constraints represent another major obstacle. High acquisition costs of digital tools, recurring software licensing fees, and maintenance expenses deter adoption—particularly among small and medium-sized enterprises (SMEs) (Amusan et al., 2021; Asif et al., 2024). Limited access to capital and weak investment incentives further reduce technological uptake (Unegbu et al., 2024).

Regulatory and policy uncertainty also hinders digital innovation. Inadequate legal clarity regarding digital contracts, data protection, and blockchain enforcement reduces stakeholder confidence (Oke et al., 2024; Ebekozien et al., 2023). The absence of structured national digital construction mandates slows institutional adoption.

Data governance concerns—including cybersecurity vulnerabilities, privacy risks, identity theft, and data inconsistency—introduce operational risks that discourage large-scale deployment (Mousavi, 2024; Oyedokun et al., 2022).

Overview of Technological Advancements in the Nigerian Built Environment

Building Information Modelling (BIM)

BIM integrates multidisciplinary data across project lifecycles, enhancing visualization, clash detection, cost optimization, and sustainability modelling (Lu et al., 2024; Dubinin, 2024). Although adoption is increasing in Nigeria, implementation remains uneven due to training and cost barriers (Ibrahim et al., 2024).

Internet of Things (IoT)

IoT enables real-time monitoring, equipment tracking, and enhanced safety compliance (Farouk et al., 2024). Smart building systems improve energy efficiency and operational performance in urban developments (Oladunmoye, 2020).

Artificial Intelligence (AI) and Machine Learning

AI enhances predictive analytics, design automation, safety forecasting, and resource optimization (Aliu et al., 2025; Garba et al., 2024). However, integration remains limited due to expertise and cost constraints.

Digital Twins (DT)

Digital Twins provide real-time virtual replicas of physical assets, enabling predictive maintenance and lifecycle optimization (Mousavi, 2024). Interoperability issues and limited technical capacity restrict widespread implementation (Bello et al., 2024).

Blockchain and Smart Contracts

Blockchain enhances transaction transparency and automates contractual processes (Ebekozien et al., 2022). Nonetheless, regulatory ambiguity and privacy concerns limit adoption (Oke et al., 2024).

Other Digital Tools

Cloud computing, Big Data analytics, drone technologies, and Project Management Information Systems (PMIS) further contribute to sectoral efficiency improvements (Aliu & Oke, 2023).

Collectively, these technologies represent transformative opportunities, yet contextual barriers limit their full realization.

Interplay Between Challenges and Technological Advancements

The relationship between digital challenges and technological advancements in Nigeria's built environment is inherently bidirectional.

Infrastructure deficiencies directly limit the operational efficiency of BIM, IoT, and Digital Twin systems that require stable electricity and reliable internet connectivity (Amusan et al., 2021). Similarly, skill

shortages and resistance to change undermine effective technology utilization, often resulting in underperformance of expensive digital systems (Oke et al., 2023).

Financial barriers further constrain adoption, particularly for capital-intensive solutions such as AI-driven analytics and Digital Twin platforms (Asif et al., 2024).

Conversely, technological advancements offer solutions to many longstanding inefficiencies. BIM improves coordination and reduces design conflicts (Lu et al., 2024). IoT enhances safety monitoring and energy optimization (Farouk et al., 2024). AI improves predictive risk management and resource allocation (Garba et al., 2024). Blockchain strengthens transparency and reduces contractual disputes (Ebekozen et al., 2023).

Therefore, while contextual challenges impede adoption, digital technologies simultaneously present viable pathways toward improved efficiency, transparency, and sustainability.

Methodology

This study adopted an exploratory literature review design to systematically examine digital challenges and technological advancements within the Nigerian built environment. The exploratory approach was selected because the study seeks to synthesize existing knowledge, identify emerging patterns, and provide integrative insights in an area characterized by fragmented evidence.

Data Sources and Search Strategy

A structured search was conducted across the following academic databases:

Scopus

Web of Science

Google Scholar

ScienceDirect

The search covered publications between 2015 and 2025 to ensure contemporary relevance.

Search Keywords

The following Boolean combinations were used:

“Digital transformation” AND “Nigerian construction”

“Building Information Modelling” AND “Nigeria”

“Digital Twin” AND “AEC industry”

“Artificial Intelligence” AND “built environment Nigeria”

“Blockchain” AND “construction industry Nigeria”

Inclusion and Exclusion Criteria

Inclusion Criteria:

Peer-reviewed journal articles

Conference papers with empirical or review evidence

Studies focused on Nigeria or comparable developing economies

Publications between 2015–2025

Articles written in English

Exclusion Criteria:

Opinion pieces without empirical grounding

Studies unrelated to construction or built environment

Duplicate publications

Screening and Selection Process

A PRISMA-guided procedure was followed:

Identification of articles through database search

Removal of duplicates

Title and abstract screening

Full-text assessment

Final inclusion for synthesis

Results and Discussion

The findings reveal that digital transformation in Nigeria is primarily constrained by structural and systemic factors rather than technological availability. While advanced tools such as BIM, AI, and Digital Twins are accessible, enabling infrastructure and institutional readiness remain inadequate.

Consistent with Lu et al. (2024), BIM improves coordination and reduces rework. However, without stable electricity and trained professionals, its benefits cannot be fully realized. Similarly, AI-driven predictive analytics offers safety improvements (Garba *et al.*, 2024), yet limited data governance frameworks restrict its effectiveness.

The results demonstrate a paradox: technological capacity exists, but contextual readiness remains low. Therefore, digital transformation in Nigeria requires simultaneous infrastructure development, skill enhancement, and regulatory reform (see Table 1).

Table 1: Database Search and Article Selection (2015–2025)

Data Base	Articles Received	Articles After Screening	Final Selected
Scopus	78	42	18
Web of Science	64	35	14
ScienceDirect	53	29	11
Google Scholar	120	58	22
Total	315	164	65

Source: Authors' Compilation (2025)

The screening process resulted in 65 high-quality studies forming the basis of thematic synthesis.

Thematic Ranking of Digital Challenges

A frequency-based thematic analysis was conducted to determine the prevalence of digital challenges cited in the reviewed literature as shown in Table 2.

Table 2: Ranking of Digital Challenges in Nigeria's Built Environment

Rank	Digital Challenge Category	Frequency of Citation	Relative Prevalence (%)
1	Infrastructure Deficiencies	48	22%
2	Human Capital & Skills Gap	45	21%
3	Financial Constraints	39	18%
4	Regulatory/Policy Gaps	32	15%
5	Data Security Concerns	28	13%
6	Organizational Resistance	24	11%

Source: Authors' Thematic Analysis (2025)

Infrastructure deficiencies and skill gaps emerged as the most frequently cited barriers, confirming that foundational systemic issues significantly constrain digital adoption. Results show that 22% infrastructural deficiencies is very high and followed by human and capital skills gap 21% which is key sustainable development. Financial constraint 18% which is a strong factor determining construction in the built environment. Regulatory/policy gaps are constraints that the regulatory authorities need to intensify efforts to ensure compliance. These regulatory authorities include Council of Registered builders of Nigeria (CORBON), Council for the Regulation of Engineering in Nigeria (COREN), to mention but a few. Other key issues include data security concerns and organizational resistance 13% and 11% respectively.

Conclusion

Based on the findings in this study, it is concluded that:

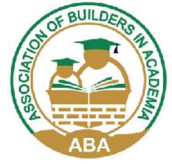
- Infrastructure deficiencies—particularly infrastructural deficiencies and human capital skills gap are most significant barriers to digital transformation.
- Human capital limitations, including inadequate digital skills and resistance to change, substantially hinder effective technological utilization.
- Financial constraints and regulatory uncertainties further limit large-scale digital adoption.
- Despite these challenges, technologies such as BIM, AI, IoT, Digital Twins, and Blockchain offer strong potential to enhance productivity, safety, transparency, and sustainability.
- The gap between technological availability and contextual readiness remains the central obstacle to transformation.

Based on the findings, the following strategic interventions are recommended:

- i. **Infrastructure Development:** Government investment in reliable electricity and broadband expansion is essential for digital readiness.
- ii. **Skills Development Reform:** Digital construction competencies should be embedded within university curricula, polytechnic programmes, and Technical and Vocational Education and Training (TVET) systems. Alignment with national initiatives such as the 3 Million Technical Talent (3MTT) programme should be strengthened.
- iii. **Regulatory Framework Strengthening:** Clear legal frameworks governing digital contracts, data protection, and blockchain enforcement must be established to build investor confidence.
- iv. **Financial Incentives:** Tax reliefs, innovation grants, and low-interest digitalization loans should be introduced to support SMEs.
- v. **Institutional Digital Mandates:** Gradual implementation of BIM mandates for public infrastructure projects could accelerate sector-wide adoption.

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