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Readiness Assessment of Construction Firms for Fourth Industrial Revolution Implementation in Nigeria

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Abstract

The construction industry remains one of the least digitalised major economic sectors despite the global diffusion of Fourth Industrial Revolution (4IR) technologies such as building information modelling, the Internet of Things, big data analytics, robotics, drones and cyber-physical systems. This paper examines the readiness of construction firms in Nigeria for 4IR implementation through a structured narrative-systematic review and synthesis of literature on technology readiness, the diffusion of innovation, and Construction 4.0. Based on established readiness models in developed and developing economies, the study develops a sixteen-variable readiness framework across technological, organisational and environmental dimensions. The findings indicate that the readiness of Nigerian construction firms is generally low to moderate, mainly constrained by inadequate ICT infrastructure, limited financial capacity for technology investment, scarcity of digitally skilled personnel, weak government policy support, and cautious organisational culture towards innovation. Emerging enablers include increased awareness among younger professionals and greater exposure to building information modelling in polytechnic and university curricula. The paper argues that the readiness assessment must be conducted before the large-scale 4IR rollout; otherwise misallocation of resources and failure of implementation are likely to occur, especially among small and medium-sized contracting firms that dominate the Nigerian market.

It recommends a staged, stakeholder-led adoption pathway based on capacity building, infrastructure investment and supportive policy. The sixteen-variable framework presented is a pragmatic diagnostic tool that construction firms, policymakers and researchers can adapt for empirical readiness assessment in the six geopolitical zones of Nigeria.

Keywords: Fourth Industrial Revolution; Readiness Assessment; Construction 4.0; Digital Transformation; Construction Firms

1.1 Introduction

The Fourth Industrial Revolution (4IR), characterised by the convergence of physical, digital and biological systems, has introduced technologies such as the Internet of Things (IoT), Building Information Modelling (BIM), big data analytics, cyber-physical systems, robotics, drones and additive manufacturing into industrial production worldwide (Kagermann *et al.*, 2013; Schwab, 2016; Rojko, 2017). While manufacturing, finance and retail have recorded measurable productivity gains from these technologies, the construction sector continues to lag behind in adoption, a phenomenon widely attributed to its fragmented project-based structure, risk-averse culture, and continued reliance on traditional procurement and delivery methods (Alaloul *et al.*, 2020; Oesterreich & Teuteberg, 2016).

In Nigeria, the construction industry occupies a strategic position within the national economy, contributing significantly to gross domestic product and providing employment for a substantial proportion of the workforce. Despite this importance, the industry is beset by chronic challenges of cost overruns, project delays, low productivity and weak quality assurance, much of which has been linked to its slow embrace of digital and automated technologies (Ezeokoli *et al.*, 2016; Adepoju & Aigbavboa, 2020). Comparative evidence from Malaysia, South Africa, China and Germany shows that countries which have made deliberate, government-backed efforts toward 4IR readiness have recorded improved competitiveness within their construction and manufacturing sectors (Kagermann *et al.*, 2013; Mukwawaya *et al.*, 2018; Moshood *et al.*, 2020; Ling *et al.*, 2020). The case of Nigeria, however, remains comparatively under-examined, with limited literature establishing the actual state of readiness of indigenous construction firms to adopt 4IR-related technologies.

Readiness assessment is recognised in the technology adoption literature as a necessary precondition for the successful diffusion of any innovation, since premature or unplanned adoption of new technology without due regard for organisational, technological and environmental preparedness often results in implementation failure, wasted investment and stakeholder resistance (Olaitan *et al.*, 2021). For Nigerian construction firms, which are predominantly small and medium-sized enterprises (SMEs) operating with limited capital and largely informal management structures, an evidence-based understanding of readiness is even more critical. Yet, existing studies on 4IR within the Nigerian construction industry have tended to focus narrowly on awareness levels or general digitalisation challenges, without offering a structured, multi-dimensional framework for assessing organisational readiness (Ezeokoli *et al.*, 2016; Ogbu & Olatunde, 2019).

This paper addresses this gap by developing and discussing a structured readiness assessment framework for 4IR implementation among construction firms in Nigeria. Specifically, the paper: (i) (i) (i) reviews global and African literature on 4IR readiness and Construction 4.0; (ii) synthesises a sixteen-variable readiness framework spanning technological, organisational and environmental dimensions; and (iii) discusses the implications of the framework for Nigerian construction firms, policymakers, professional bodies and academic institutions. The remainder of the paper is organised into four sections: literature review, methodology, discussion of findings, and conclusion with recommendations.

The significance of this undertaking extends beyond academic interest. Construction firms that proceed to invest in 4IR technologies without first establishing their level of readiness risk underutilising costly equipment, encountering workforce resistance, or abandoning digital initiatives midway, outcomes that have been documented in several developing-economy contexts where adoption preceded adequate groundwork (Bhuiya *et al.*, 2020; Ling *et al.*, 2020). A validated readiness framework, by contrast, allows firms and policymakers to identify specific gaps, such as inadequate connectivity or a shortage of BIM-competent staff, and to direct limited resources toward closing those gaps in a sequenced and cost-effective manner. The framework proposed in this paper is therefore intended not merely as an academic contribution but as a practical diagnostic tool capable of informing firm-level strategy, professional body guidance, and government policy formulation within the Nigerian construction sector.

2.0 Literature Review

2.1 Conceptual Overview of the Fourth Industrial Revolution

The fourth industrial revolution represents the convergence of cutting-edge industrial, communication and information technologies into synergistic systems comprising the Internet of Things, cyber-physical systems and smart factories (Kagermann *et al.*, 2013). It is the successor to three earlier industrial revolutions: the first, driven by steam power and mechanisation; the second, driven by electricity and mass production; and the third, driven by electronics, computing and automated production (Rojko, 2017). Schwab (2016) described the fourth industrial revolution as distinct from its predecessors in velocity, scope and systems impact, noting that it blurs the boundaries between the physical, digital and biological spheres. Central to this revolution are technologies such as artificial intelligence, robotics, the Internet of Things, big data, cloud computing, augmented reality, simulation, additive manufacturing and cyber-physical systems (Schwab, 2016; Kagermann *et al.*, 2013).

2.2 Construction 4.0 and Global Practice

Within the built environment, the application of 4IR principles has produced what is now widely termed Construction 4.0 (Osunsanmi *et al.*, 2018). Construction 4.0 denotes the digitisation of the construction site and supply chain through internet-connected sensors, drones, virtual simulation, robotics and building information modelling, which has become the central repository for collating digital project information (King, 2018; Maskuriy *et al.*, 2019). Craveiro *et al.* (2019) identified additive manufacturing, popularly known as 3D printing, as a key enabling technology for digital construction, capable of reducing material waste and construction time. Li and Yang (2017) similarly demonstrated how BIM-driven industrialisation of construction processes under the Industry 4.0 paradigm could enhance prefabrication efficiency and design accuracy. A systematic review by Maskuriy *et al.* (2019) of Construction 4.0 literature indexed in Scopus and Web of Science between 2015 and 2019 found that while interest in the field is growing rapidly, empirical readiness studies, particularly from developing regions, remain scarce.

Country-level evidence further illustrates the uneven global diffusion of 4IR within construction. Osunsanmi *et al.* (2018) found that the South African construction industry had begun to embrace Construction 4.0 principles, although adoption remained concentrated among large, foreign-affiliated firms. Mukwawaya *et al.* (2018) observed that the South African government had taken deliberate steps to reposition the country for 4IR through policy and skills-development interventions, a pattern echoed in Malaysia, where Moshood *et al.* (2020) and Ling *et al.* (2020) reported both growing awareness of Industry 4.0 within the construction sector and persistent skills and infrastructural gaps limiting full-scale adoption. In Bangladesh, Bhuiya *et al.* (2020) documented similar barriers of cost, skills and policy inertia constraining Industry 4.0 uptake in an emerging-economy construction and manufacturing context.

2.3 The Nigerian Construction Industry and the Digitalisation Gap

Within Nigeria, several studies have documented a slow and uneven transition toward digital construction practice. Ezeokoli *et al.* (2016) reported that Nigerian construction professionals possessed only a modest understanding of digital transformation tools and that adoption remained largely informal and unsystematic. Adepoju and Aigbavboa (2020) found that the workforce implications of Construction 4.0 in Nigeria were poorly understood, with both opportunities for productivity gains and threats of job displacement inadequately addressed in firm-level planning. Ogbu and Olatunde (2019) linked the organisational effectiveness of

Nigerian SME contractors to their project performance, noting that the informal structure typical of many Nigerian construction firms constrains their capacity to absorb new technology and management systems systematically. Oke *et al.* (2018), studying the South African context but with findings broadly transferable to Nigeria, identified fragmented digital collaboration among construction professionals as a recurring obstacle to technology-enabled project delivery. Collectively, this body of work suggests that the Nigerian construction industry's digitalisation gap is rooted not merely in technological deficiency but in deeper organisational and environmental constraints that a holistic readiness assessment must capture.

This structural picture is compounded by the fact that the vast majority of registered contracting firms in Nigeria operate as small and medium-sized enterprises with limited access to long-term capital, a characteristic shared with several other emerging construction markets (Ogbu & Olatunde, 2019; Adepoju & Aigbavboa, 2020). Such firms typically procure equipment and technology on a project-by-project basis rather than through sustained capital budgeting, which constrains their ability to invest in 4IR tools whose return on investment is realised only over multiple projects or years. Large multinationals and a small number of well-capitalised indigenous firms, by contrast, have begun to pilot BIM and drone-based site monitoring on flagship projects, illustrating that readiness within Nigeria is unevenly distributed across firm size and ownership structure rather than uniformly low across the industry.

2.4 Theoretical Underpinning: Technology Readiness and Diffusion of Innovation

Theoretical treatments of technology readiness commonly examine an organisation's preparedness across technological, organisational and environmental dimensions before large-scale adoption is undertaken. According to Olaitan *et al.* (2021), in developing a framework to test South Africa's readiness for the fourth industrial revolution, conceptualised readiness in terms of the fit between the tasks an organisation must perform, the technology available to perform them, and the degree to which that technology matches organisational requirements. Mukwawaya *et al.* (2018) extended this view by emphasising government policy, skills development and education as environmental enablers without which firm-level readiness cannot translate into sectoral transformation. These perspectives jointly inform the present study's adoption of a tripartite technological-organisational-environmental lens for classifying readiness variables relevant to Nigerian construction firms, consistent with the broader pattern observed across the reviewed Construction 4.0 and Industry 4.0 readiness literature (Kagermann *et al.*, 2013; Moshood *et al.*, 2020; Olaitan *et al.*, 2021).

2.5 Readiness Variables for 4IR Implementation in Construction Firms

Synthesising the variables recurring across the reviewed literature, sixteen readiness indicators were identified and grouped into technological, organisational and environmental dimensions, as presented in Table 1 brelow. These variables collectively constitute the diagnostic framework proposed in this paper for assessing the 4IR readiness of construction firms in Nigeria.

Table 1: Readiness Framework for 4IR Implementation in Construction Firms

S/N	Readiness	Description / Indicator	Source(s)
1	Top management commitment	Extent to which firm leadership champions and allocates resources to 4IR adoption	Kagermann *et al.* (2013); Mukwawaya *et al.* (2018)
2	ICT infrastructure availability	Presence of adequate computing, networking and digital infrastructure	Oesterreich & Teuteberg (2016)
3	Internet connectivity and network stability	Reliability and speed of internet access at project sites and offices	Alaloul *et al.* (2020)
4	Financial capacity for technology investment	Availability of capital to acquire and sustain 4IR tools	Moshood *et al.* (2020)
5	Workforce digital/ICT competence	Skill level of personnel in operating digital construction tools	Maskuriy *et al.* (2019)
6	Availability of BIM/CAD skilled personnel	Presence of staff proficient in Building Information Modelling and digital design	King (2018); Li & Yang (2017)
7	Awareness of 4IR technologies and benefits	Stakeholders' knowledge of what 4IR entails and its value proposition	Osunsanmi *et al.* (2018)
8	Organisational culture toward innovation	Openness of firm culture to change and technology adoption	Olaitan *et al.* (2021)
9	Firm size and organisational structure	Scale and formal departmentalisation that supports systematic adoption	Ogbu & Olatunde (2019)
10	Cybersecurity and data protection capacity	Firm's ability to secure digital data generated from 4IR tools	Kagermann *et al.* (2013)
11	Equipment and automation tools availability	Access to robotics, drones, sensors and automated machinery	Craveiro *et al.* (2019)
12	Standardisation and system interoperability	Compatibility of digital systems and platforms across project teams	Rojko (2017)
13	Government policy and regulatory support	Existence of enabling national policy, standards and incentives	Mukwawaya *et al.* (2018); Olaitan *et al.* (2021)
14	Collaboration among construction stakeholders	Level of inter-firm and inter-professional digital collaboration	Oke *et al.* (2018)
15	Training and capacity-building programmes	Availability of structured 4IR-related training for staff	Mukwawaya *et al.* (2018)

16	Cost-benefit perception of 4IR adoption	Stakeholders' perceived value of adoption relative to its cost	Bhuiya *et al.* (2020)

Source: Authors' Compilation (2026)

As shown in Table 1, the technological dimension (variables 1 to 6) centres on the physical and digital infrastructure, equipment and competencies required to operate 4IR tools, reflecting the emphasis placed on infrastructure and skills in the work of Oesterreich and Teuteberg (2016) and Maskuriy *et al.* (2019). The organisational dimension (variables 7 to 12) captures internal firm-level factors such as leadership commitment, culture, structure and security capacity, drawing on Kagermann *et al.* (2013) and King (2018). The environmental dimension (variables 13 to 16) reflects external enablers and constraints, including policy support, inter-firm collaboration, training infrastructure and economic perception of adoption costs, consistent with the arguments of Mukwawaya *et al.* (2018), Oke *et al.* (2018) and Bhuiya *et al.* (2020). This tripartite structure mirrors the readiness logic advanced by Olaitan *et al.* (2021) and provides a coherent basis for assessing, and ultimately scoring, the readiness of individual construction firms or firm categories such as small, medium and large contractors operating within Nigeria's six geopolitical zones.

2.6 Readiness as a Continuum

Taken together, the literature reviewed in this section indicates that readiness for 4IR implementation in construction is best understood not as a binary state but as a continuum along which firms, and indeed entire national industries, can be positioned according to their technological capacity, organisational preparedness and environmental support. Firms in mature markets such as Germany sit toward the higher end of this continuum, benefiting from coordinated infrastructure, policy and skills ecosystems (Kagermann *et al.*, 2013). Emerging-economy firms in South Africa, Malaysia and Bangladesh occupy intermediate positions, with pockets of advanced adoption alongside persistent structural constraints (Mukwawaya *et al.*, 2018; Moshood *et al.*, 2020; Bhuiya *et al.*, 2020). The evidence reviewed for Nigeria suggests the industry sits toward the lower-to-intermediate end of this continuum, a position the sixteen-variable framework in Table 1 is designed to diagnose with greater precision than has previously been available in the Nigerian construction literature.

3.0 Methodology

This paper adopts a narrative-systematic literature review methodology, consistent with established practice in the synthesis of conceptual readiness frameworks within the built environment and information systems literature (Maskuriy *et al.*, 2019; Olaitan *et al.*, 2021). A desk-based qualitative document analysis approach was used in place of primary field data collection, as the objective of the paper is to synthesise an evidence-based diagnostic framework rather than to report empirical survey outcomes; the framework is, however, designed for subsequent empirical validation.

The literature search was conducted across Scopus, Web of Science and Google Scholar using combinations of the keywords "Fourth Industrial Revolution", "Industry 4.0", "Construction 4.0", "readiness assessment" and "construction industry", restricted to publications between 2013 and 2024 to capture the period during which 4IR scholarship matured globally. Inclusion criteria comprised peer-reviewed journal articles, conference proceedings and authoritative technical or policy reports directly addressing 4IR readiness, adoption barriers or Construction 4.0 within developed and developing economies. Studies not addressing the construction or built-environment sector, or not available in English, were excluded.

Content analysis was applied to the retained literature to extract recurring readiness constructs. Each construct was coded, compared across sources for conceptual overlap, and clustered into thematic categories. The resulting clusters were cross-validated against two established readiness models, namely the task-technology-fit-based framework of Olaitan *et al.* (2021) and the policy-skills-education model of Mukwawaya *et al.* (2018), to ensure that the synthesised variables reflected recognised dimensions of technology readiness rather than idiosyncratic interpretation. This process yielded the sixteen-variable framework presented in Table 1, organised along technological, organisational and environmental dimensions. The discussion in Section 4 interprets these variables specifically within the context of the Nigerian construction industry, drawing on country-level evidence reviewed in Section 2.3, and presents the resulting readiness ratings, cross-country comparisons and phased adoption pathways in Tables 2, 3 and 4, respectively.

4.0 Discussion

Building on the readiness framework developed in Section 2.5, Table 2 presents a created readiness rating for each variable, derived from the qualitative evidence reviewed across Sections 2.2 to 2.4 and interpreted specifically for the Nigerian construction context. Sections 4.1 to 4.3 discuss the ratings, which are expressed as Low, Low–Moderate, or Moderate, across the technological, organisational, and environmental dimensions.

Table 2: Readiness Rating among Nigerian Construction Firms

S/N	Readiness Variable	Dimension	Readiness Level	Justification
1	Top management commitment	Organisational	Low–Moderate	Constrained by short-term, project-based thinking that limits sustained investment commitment
2	ICT infrastructure availability	Technological	Low	Undermined by unreliable power supply and inconsistent digital infrastructure
3	Internet connectivity and network stability	Technological	Low–Moderate	Reasonable in urban hubs; poor at peri-urban and rural project sites
4	Financial capacity for technology investment	Technological	Low	Predominance of SMEs with limited access to long-term capital
5	Workforce digital/ICT competence	Technological	Low–Moderate	Improving among younger graduates; weak among incumbent workforce
6	Availability of BIM/CAD skilled personnel	Technological	Low–Moderate	Concentrated mainly in Lagos, Abuja and a few large firms
7	Awareness of 4IR technologies and benefits	Organisational	Moderate	Growing among younger professionals and within academia
8	Organisational culture toward innovation	Organisational	Low–Moderate	Risk-averse culture typical of project-based SMEs
9	Firm size and organisational structure	Organisational	Low	Informal, non-departmentalised structures dominate the market
10	Cybersecurity and data protection capacity	Organisational	Low	Largely undeveloped across firms of all sizes
11	Equipment and automation tools availability	Technological	Low	Confined mainly to large infrastructure and oil-and-gas projects
12	Standardisation and system interoperability	Organisational	Low–Moderate	Disparate, non-integrated software platforms across project teams
13	Government policy and regulatory support	Environmental	Low	No dedicated national 4IR construction policy yet exists
14	Collaboration among construction stakeholders	Environmental	Low–Moderate	Fragmented inter-firm and inter-professional collaboration
15	Training and capacity-building programmes	Environmental	Low	Sparse outside donor-funded or university-led initiatives
16	Cost-benefit perception of 4IR adoption	Environmental	Low–Moderate	Perceived cost often outweighs perceived long-term benefit

Source: Authors' Compilation Based on the Discussion in Sections 4.1–4.3 (2026)

4.1 Technological Readiness Dimension

As indicated in Table 2, three of the six technological variables, namely ICT infrastructure availability, financial capacity for technology investment, and equipment and automation tool availability, are rated low, while internet connectivity and network stability, workforce digital/ICT competence, and availability of BIM/CAD-skilled personnel are rated low-moderate. The technological dimension of the proposed framework (variables 1 to 6 and variable 11 in Table 1) reflects the physical and digital infrastructure required to operationalise 4IR tools on construction sites. This dimension consistently faces constraints in Nigeria. Unreliable electricity supply undermines the continuous operation of computing and networking equipment necessary for BIM, cloud-based collaboration and sensor-enabled monitoring, a constraint rarely faced to the same degree in the German, Malaysian or South African contexts examined by Kagermann *et al.* (2013), Moshood *et al.* (2020) and Osunsanmi *et al.* (2018). Internet connectivity, particularly outside major urban centres, remains inconsistent, limiting the feasibility of real-time data exchange envisaged under cyber-physical construction models (Oesterreich & Teuteberg, 2016). Workforce digital competence, including proficiency in BIM and CAD platforms, is similarly constrained by a polytechnic and university curriculum that has only recently begun to integrate digital construction tools into core building technology training, echoing the skills gap documented by Maskuriy *et al.* (2019) and Li and Yang (2017).

The cost of acquiring and maintaining 4IR-related equipment, ranging from drones and laser scanners to licensed BIM software and cloud subscriptions, further compounds the technological readiness gap, since these costs are typically denominated in foreign currency and therefore exposed to exchange-rate volatility, a constraint less pronounced in the manufacturing-led economies from which much of the foundational 4IR literature originates (Kagermann *et al.*, 2013; Rojko, 2017). Equipment and automation tool availability is consequently uneven, with robotics and automated machinery largely confined to a small number of large infrastructure and oil-and-gas-related construction projects rather than being diffused across the mainstream building construction sub-sector that dominates the Nigerian market, a pattern consistent with the low rating assigned to this variable in Table 2.

4.2 Organisational Readiness Dimension

Table 2 similarly rates most organisational variables as low or low–moderate, with awareness of 4IR technologies and benefits the only variable reaching a moderate rating. The organisational dimension (variables 7 to 10 and variable 12 in Table 1) captures internal firm-level readiness factors. Nigerian construction firms are overwhelmingly small and medium-sized, often lacking the formal departmental structure that Ogbu and Olatunde (2019) identified as necessary for systematic technology adoption. Top management commitment to 4IR is frequently constrained by short-term project-based thinking rather than long-term capital investment planning, a pattern consistent with the diffusion-of-innovation literature's emphasis on organisational culture as a precondition for adoption (Olaitan *et al.*, 2021). Awareness of 4IR technologies and their benefits, while improving among younger graduates and professionals exposed to international literature and training, remains limited among the broader population of practising contractors, particularly outside Lagos, Abuja and a handful of other construction hubs. Cybersecurity and data-protection capacity, an increasingly important organisational readiness factor as firms begin to generate and store digital project data, remains largely undeveloped, mirroring concerns raised by Kagermann *et al.* (2013) regarding the data-governance demands of Industrie 4.0 adoption.

Standardisation and system interoperability, the twelfth variable in the framework, presents a further organisational challenge, since Nigerian project teams frequently comprise consultants and contractors using disparate, non-integrated software platforms with limited capacity for seamless data exchange. Rojko (2017) identified interoperability as a recurring bottleneck even within more advanced Industry 4.0 ecosystems, suggesting that this constraint is unlikely to resolve organically within the Nigerian context without deliberate firm-level or industry-wide standardisation efforts, such as the adoption of common BIM data exchange protocols across consulting and contracting firms working on the same project.

4.3 Environmental Readiness Dimension

As shown in Table 2, all four environmental variables are rated Low or Low–Moderate, underscoring the weight of external constraints relative to firm-level effort alone. The environmental dimension (variables 13 to 16 in Table 1) reflects the broader policy, collaborative and economic context within which Nigerian construction firms operate. Unlike South Africa and Malaysia, where Mukwawaya *et al.* (2018) and Ling *et al.* (2020) documented explicit government policy initiatives, skills frameworks and readiness indices directed at Industry 4.0, Nigeria currently lacks a dedicated national policy or regulatory instrument targeting 4IR adoption within the construction sector specifically. Collaboration among construction stakeholders, including contractors, consultants, regulators and academia, remains fragmented, consistent with the digital collaboration challenges identified by Oke *et al.* (2018) in the broader Southern African context. Training and capacity-building programmes tailored to 4IR technologies are similarly sparse outside a small number of donor-funded or university-led initiatives. Finally, the cost-benefit perception of 4IR adoption among Nigerian contractors tends to weigh heavily toward perceived cost and uncertainty rather than long-term productivity gain, a pattern Bhuiya *et al.* (2020) similarly observed among construction and manufacturing firms in Bangladesh facing comparable capital constraints.

4.4 Cross-Country Reflection

A cross-country reflection across the literature reviewed reinforces the conclusion that 4IR readiness is not solely a function of technology availability but of the interaction between technological capacity, organisational preparedness and a supportive environmental context. Germany's pioneering Industrie 4.0 initiative succeeded substantially because it combined strong industrial infrastructure with coordinated government, academic and industry collaboration (Kagermann *et al.*, 2013). South Africa and Malaysia, while still developing economies, have nonetheless instituted formal readiness assessment mechanisms and skills strategies that have measurably advanced sectoral adoption (Mukwawaya *et al.*, 2018; Moshood *et al.*, 2020; Olaitan *et al.*, 2021). Nigeria's construction industry, by contrast, exhibits a combination of technological, organisational and environmental constraints that collectively position the sector at a low-to-moderate readiness level, with isolated pockets of higher readiness typically found among large, foreign-affiliated or urban-based contracting firms. Table 3 summarises this comparison across the five countries and three readiness dimensions examined in this study.

Table 3: Cross-Country Comparison of 4IR Readiness

Country	Technological Readiness	Organisational Readiness	Environmental Readiness	Overall Position	Source(s)
Germany	High	High	High	Advanced / Mature	Kagermann *et al.* (2013)
South Africa	Moderate	Moderate	Moderate–High	Intermediate, Advancing	Mukwawaya *et al.* (2018); Olaitan *et al.* (2021); Osunsanmi *et al.* (2018)
Malaysia	Moderate	Moderate	Moderate	Intermediate	Moshood *et al.* (2020); Ling *et al.* (2020)
Bangladesh	Low–Moderate	Low–Moderate	Low	Emerging, Constrained	Bhuiya *et al.* (2020)
Nigeria (Construction Sector)	Low	Low–Moderate	Low	Low-to-Moderate, Constrained	Authors' synthesis (Sections 2.3 & 4)

Source: Authors' Compilation of Reviewed Literature (2026)

It is instructive that even within Africa, readiness levels differ markedly between South Africa and Nigeria, despite broadly comparable income levels and shared colonial-era construction practices. Mukwawaya *et al.* (2018) attributed South Africa's relatively stronger readiness position to deliberate post-2017 government policy attention following the country's formal recognition of the fourth industrial revolution as a national priority, including targeted skills and education interventions. Nigeria has not yet articulated an equivalent construction-sector-specific policy response, suggesting that the environmental dimension of the framework, particularly government policy and regulatory support, may represent the single most consequential lever available to Nigerian policymakers seeking to accelerate sectoral readiness in the near term, as Table 3 illustrates through Nigeria's comparatively constrained overall position.

4.5 Implications for a Phased Adoption Pathway

These findings carry practical implications for a phased approach to 4IR adoption within the Nigerian construction industry, rather than an abrupt, sector-wide rollout. A sequenced pathway comprising awareness creation, structured readiness assessment, strategic planning, phased implementation, and continuous evaluation, consistent with the staged adoption logic underlying the readiness models reviewed in this paper (Olaitan *et al.*, 2021), offers a more realistic route to sustainable digital transformation than wholesale technology transfer. Such a pathway would allow construction firms, regulators and training institutions to address the most binding readiness constraints, such as infrastructure and skills deficits, before committing significant capital to advanced 4IR tools whose benefits cannot yet be fully realised within the prevailing operating environment. Table 4 outlines this proposed phased pathway, specifying the focus, key actions and responsible stakeholders associated with each phase.

Table 4: Proposed Phased Pathway for 4IR Adoption among Nigerian Construction Firms

Phase	Focus	Key Actions	Responsible Stakeholders
1. Awareness	Build understanding of 4IR concepts and their relevance to construction	Seminars and professional body CPD sessions; curriculum sensitisation in polytechnics and universities	Professional bodies; polytechnics/universities; firm management
2. Assessment	Diagnose firm-level readiness using the sixteen-variable framework	Administer a readiness instrument based on Table 1; identify priority gaps per dimension	Firm management; researchers; consultants
3. Planning	Develop a phased investment and capacity-building plan	Budget for infrastructure, training and pilot tools; set measurable milestones	Firm management; finance and lending institutions
4. Implementation	Pilot and progressively scale selected 4IR tools	Deploy BIM, drones or sensor-based monitoring on pilot projects; train staff; integrate platforms	Firms; technology vendors; training institutions
5. Evaluation	Monitor outcomes and refine the adoption strategy	Track productivity and quality indicators; periodically re-assess readiness scores	Firm management; regulators; researchers

Source: Authors' Construction, Adapted from the Staged Adoption Logic of Olaitan et al. (2021)

5.0 Conclusion and Recommendations

This paper has examined the readiness of construction firms in Nigeria for Fourth Industrial Revolution implementation through a structured review and synthesis of global, African and Nigerian literature on technology readiness and Construction 4.0. A sixteen-variable readiness framework, organised along technological, organisational and environmental dimensions, was developed to provide a practical diagnostic instrument for assessing firm-level and sector-level preparedness. The review establishes that Nigerian construction firms currently exhibit low-to-moderate readiness for 4IR adoption, constrained principally by inadequate ICT and power infrastructure, limited financial capacity, scarcity of digitally skilled personnel, weak government policy support, fragmented stakeholder collaboration, and a cautious organisational culture toward innovation, while benefiting from emerging enablers such as growing awareness among younger professionals and increasing integration of BIM within polytechnic curricula.

Based on these findings, the paper recommends that (i) government, through relevant ministries and the National Board for Technical Education, develop a dedicated policy framework and incentive scheme for 4IR adoption within the construction industry; (ii) sustained investment be directed toward power and broadband infrastructure that underpins reliable use of digital construction tools; (iii) professional bodies, polytechnics and universities expand structured training and capacity-building programmes in BIM, IoT and related digital construction competencies; and (iv) financing institutions design SME-targeted schemes that lower the capital barrier to 4IR technology acquisition for the predominantly small and medium-sized contracting firms that characterise the Nigerian market. This study has limitations.

As a literature-based conceptual synthesis, the sixteen-variable framework has not yet been subjected to empirical scoring through primary data collection from construction firms across Nigeria's geopolitical zones. The relative weighting of variables, as well as differences in readiness between small, medium and large contracting firms, therefore remains an empirical question for future research employing instruments such as Likert-scale questionnaires, mean item score ranking, and statistical tests of significance between firm categories.

Notwithstanding this limitation, the framework offers a theoretically grounded and practically applicable starting point for such empirical validation. Therefore, (v) future research will empirically validate and weight the proposed sixteen-variable framework using primary survey data collected across Nigeria's six geopolitical zones, employing statistical techniques such as mean item score ranking and tests of significance between firm categories. Collectively, these measures would position the Nigerian construction industry to transition more deliberately and sustainably toward the productivity, safety and quality gains that the Fourth Industrial Revolution offers.

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