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Drivers Influencing the Adoption of Innovative Building Materials (IBM) for Sustainable Construction in Nigeria

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ABSTRACT

Amidst the drive for a more sustainable future, the construction industry faces a significant crossroads, a juncture demanding a reimagining of how we occupy our built environment. Within the dynamic backdrop of developing nations, where growth and progress intersect with pressing ecological concerns, adopting innovative building materials (IBM) emerges as essential for realising sustainable construction practices. This study explores the driving factors that influence the adoption of IBM for promoting sustainable construction practices in Nigeria. Employing a descriptive analysis methodology, explicitly harnessing the mean score ranking technique (MS), this study evaluates and ranks the 14 identified drivers influencing IBM adoption. The findings of this study show that the respondents strongly agreed with all the drivers for IBM. Clients' requirements, government regulations, availability of IBM suppliers and developments in information communication technology (ICT)/technology-push are the top drivers of IBM adoption. These findings also highlight the importance of client demand, regulatory policies, access to suppliers, technological advancements, and improved operational efficiency in driving the adoption of IBM. This analysis illustrates the significant role of specific drivers in shaping adoption decisions, thus providing guidance for future policy formulations, strategic planning, and industry practices in the Nigerian construction industry.

Keywords: Innovative building materials, Sustainable construction, Drivers, Construction industry, Sustainable development

INTRODUCTION

The construction industry significantly impacts global greenhouse gas emissions and contributes to the depletion of resources (Mewomo & Ejidike, 2021; Ejidike & Mewomo, 2022; Chen et al., 2023). As a result, there is an increasing need for environmentally friendly building practices and materials to tackle these issues (Amaral et al., 2020). Shittu (2021) reports that the construction industry in Nigeria is also facing the challenge of increasing levels of carbon dioxide emissions and environmental

pollution. However, the global construction industry is shifting towards sustainable building practices, and one crucial aspect of this shift is the adoption of innovative building materials (IBM). These materials enhance the environmental performance, energy efficiency, and overall sustainability of construction projects (Mewomo et al., 2023). While developed countries have made considerable progress in integrating IBM into their construction practices, developing nations, such as Nigeria, face unique challenges in embracing these innovations. Sustainable construction practices are increasingly essential for addressing environmental concerns and promoting long-term economic viability (Oke et al., 2019; Mewomo et al., 2017; Amaral et al., 2020). The choice of building materials significantly influences the environmental impact of construction projects (Bamigboye et al., 2019). Therefore, understanding the drivers that influence the adoption of IBM becomes imperative, particularly in developing countries like Nigeria, where rapid urbanisation and infrastructure development are ongoing.

Despite the potential benefits, various factors often hinder the adoption of IBM in developing countries. Limited awareness, financial constraints, and a lack of regulatory frameworks tailored to sustainable construction contribute to the slow uptake of these materials (Ayarkwa et al., 2022; Mewomo et al., 2023). In Nigeria, where the construction sector is a crucial driver of economic growth, there is a pressing need to explore the specific drivers influencing the adoption of IBM for sustainable construction. With its large population and increasing urbanisation, Nigeria is at a critical juncture where today's decisions will profoundly impact its future sustainability. Understanding the drivers that facilitate or impede the adoption of IBM is essential for clients or building owners, industries, stakeholders, and researchers seeking to contribute to sustainable development in the Nigerian construction sector. This research aims to address this gap in knowledge by examining the various drivers that shape the adoption of IBM in Nigeria. By identifying and analysing these drivers, the study seeks to provide valuable knowledge that can inform strategies and policies to promote the sustainable use of building materials in the construction industry of developing countries. Through this exploration, the research contributes to the global discourse on sustainable construction practices, offering context-specific recommendations for Nigeria.

Literature Review

Innovative Building Materials (IBM)

Innovative building materials refer to conventional construction materials designed with a novel approach to achieve specific performance goals. These materials address global needs by focusing on high energy efficiency, promoting environmentally friendly practices, and ensuring long-lasting structures (Soliman et al., 2021). The innovative design approach distinguishes these materials from traditional ones, making them key players in advancing sustainable and resilient civil infrastructure (Soliman et al., 2021). These materials are essential for sustainable

construction, contributing to the sector's evolution by incorporating cutting-edge technologies and environmentally responsible practices. IBM is crucial in enhancing energy efficiency, reducing environmental impact, and promoting long-term durability in construction projects (Mewomo et al., 2023; Nilimaa, 2023).

Pursuing an improved quality of life has driven humanity to establish safer and enhanced living environments. These spaces must encompass reliability, durability, functionality, harmony, and beauty (Khitab et al., 2015). When evaluating innovative construction materials, their acceptance should hinge on meeting various criteria (Andrade et al., 2018). These include sustainability, durability, reliability, safety, cost reduction, enhanced quality, improved mechanical and physical characteristics, flexibility in extreme conditions, ease of assembly, and environmentally friendly attributes (Andrade et al., 2018; Amaral et al., 2020). In summary, innovative building materials represent a progressive shift in the construction industry, leveraging creative design and technology to meet the demands of sustainability and resilience.

Drivers for the Adoption of IBM for Sustainable Construction

The construction industry has a significant environmental impact, and as a result, there is a growing demand for more sustainable building practices. One of the primary motivators for adopting IBM is reducing construction's environmental footprint and promoting a more sustainable future. With this in mind, using these materials is becoming increasingly popular as they provide various benefits that help address the challenges associated with traditional construction methods.

Ozorhon et al. (2010) and Gambatese and Hallowell (2011) found that cost reduction, competitive advantage, improved quality, and increased productivity drive the adoption of IBM technology for sustainable construction in developed nations and can inspire innovation within the industry. The economic benefits of IBM are also a significant motivator for their widespread use. With the rising cost of traditional building materials, using more sustainable alternatives can help reduce construction costs and make sustainable building practices more accessible and affordable to a broader range of clients (Kaburu, 2017). Brandon and Lu (2008) extensively studied the role of clients and end-users in theoretically and empirically contributing to innovation. Educating clients on the advantages of using IBM can drive demand and growth in the IBM market and sustainable construction. The contribution of building component firms and building materials companies to driving innovation in the construction industry is significant.

Research and development activities play a significant role in exploring the drivers of IBM in the construction industry. Other factors, such as promoting environmental sustainability through reducing waste, energy consumption, and carbon emissions, are also drivers of innovation (Ozorhon et al., 2010; Qi et al., 2010). Reducing carbon emissions connected with construction is one of the key drivers for adopting innovative building materials. This is especially significant given the growing concern about climate change

and the need to minimise greenhouse gas emissions (Ejidike et al., 2022). Materials with a reduced carbon footprint than standard concrete and steel, such as cross-laminated timber (CLT) and engineered wood products, appeal to companies wishing to reduce their environmental impact. This study is significant as it explores the drivers influencing the adoption of IBM for sustainable construction in Nigeria. In a world increasingly focused on sustainable living, IBM stands out for addressing global needs with a focus on energy efficiency, environmentally friendly practices, and durable structures. The research contributes to tailored sustainable construction practices, considering Nigeria's unique environmental, economic, and social dynamics, which are crucial for aligning with global sustainability goals and addressing local challenges. Identifying specific drivers, such as environmental sustainability, cost reduction, and enhancing innovation, according to Owolabi and Faleye (2019), contributes not only to research advancements but also guides industry practices towards more sustainable and innovative construction methods. This research serves as a valuable resource, bridging global knowledge with local requirements and paving the way for sustainable construction practices in Nigeria. Table 1 lists 14 drivers for promoting IBM adoption in the construction industry which were identified from the literature.

Research Methodology

This study aims to empirically investigate the drivers influencing IBM adoption in Nigeria's construction industry. This research utilised quantitative techniques for gathering and analysing data. The methodology involved developing a questionnaire based on factors identified from existing literature and discussions with industry experts. Field (2013) states that this method effectively generates items for measuring constructs. It was deemed appropriate for this study, given its ability to provide quantifiable data suitable for statistical analysis. This analytical approach enables drawing conclusions that can be applied to a broader audience. Thus, the research method consists of (i) data collection and (ii) data analysis techniques. A brief discussion on these is provided below.

Data Collection

A questionnaire emerged as the chosen method for collecting quantitative data. Questionnaires offer a standardised means to engage with a broad audience, as emphasised by Walliman (2019). The questionnaire, developed based on literature, comprises two sections: one for respondent information and another addressing drivers influencing the adoption of IBM for sustainable construction. A five-point Likert scale was employed to investigate the drivers of IBM, with 1 indicating strong disagreement and 5 indicating strong agreement. A pilot study validated the questionnaire's appropriateness for measuring the intended construct. This involved assessing language clarity, question logic, and depth and conducting a preliminary check of the proposed statistical analysis, as Field (2013) suggested. Opting for an online questionnaire administration through Google

Table 1. Summary of the drivers of the adoption of IBM (Author 2023).

Code	Drivers	References
D1	Client's requirement	Owolabi and Faleye (2019); Kulatunga et al. (2011); Ozorhon et al. (2010)
D2	End-user requirement	Kulatunga et al. (2011); Ozorhon et al. (2010)
D3	Demand-pull (client) vs capability-push (contractor)	Ozorhon et al. (2010)
D4	Availability of manufacturing firms	Kulatunga et al. (2011); Ozorhon et al. (2010)
D5	Developments in ICT/technology-push	Owolabi and Faleye (2019); Ozorhon et al. (2010)
D6	Design/aesthetics trends	Ozorhon et al. (2010); Owolabi and Faleye (2019)
D7	Increase performance and productivity (cost saving, desired duration, improved quality)	Owolabi and Faleye (2019); Ozorhon et al. (2010); Gambatese and Hallowell (2011)
D8	Cost reduction	Owolabi and Faleye (2019)
D9	Availability of IBM suppliers	Kulatunga et al. (2011); Ozorhon et al. (2010)
D10	Procurement system for IBM	Kulatunga et al. (2011); Ozorhon et al. (2010)
D11	Improved efficiency of the firm	Gambatese and Hallowell (2011); Ozorhon et al. (2010); Owolabi and Faleye (2019)
D12	Environmental sustainability	Ozorhon et al. (2010); Owolabi and Faleye (2019)
D13	Government regulations	Kulatunga et al. (2011); Ozorhon et al. (2010); Owolabi and Faleye (2019)
D14	Competitive advantage	Owolabi and Faleye (2019); Gambatese and Hallowell (2011)

Forms, researchers could efficiently reach a wider audience by sharing questionnaire links with prospective participants. Using a purposive sampling method, approximately 363 construction professionals were contacted via emails and professional platforms. Two hundred eighty-two (282) responses were received and deemed suitable for further analysis with no missing data. Table 2 provides an overview of the demographic distribution of the respondents.

Table 2. Background information of respondents.

Demographic Information	Categories	Frequency	Percentage (%)
Profession	Architect	52	18.4
	Builder	101	35.8
	Engineer	65	23.0
	Quantity Surveyor	64	22.7
	Total	282	100.0

(Continued)

Table 2. Continued

Demographic Information	Categories	Frequency	Percentage (%)
Type of organisation	Contractors	37	13.1
	Consultants	59	20.9
	Clients	21	7.4
	Educational Institution Researcher	97	34.4
	Site Engineer/Supervisors	41	14.5
	Sub-contractors	14	5.0
	Professional Bodies Representative	13	4.6
	Total	282	100.0
Years of experience	1 - 5 years	37	13.2
	6 - 10 years	81	28.8
	11 - 15 years	93	33.4
	16 - 20 years	52	18.3
	Over 20 years	18	6.3
	Total	282	100.0

The respondents' demographic information indicates their experience and knowledge, affirming their ability to exercise sound judgment. This supports the trustworthiness and reliability of their responses for the research, establishing that the participants are academically and professionally qualified with significant experience to contribute meaningfully to the study's objective.

Data Analysis Techniques

Cronbach's Alpha Technique

Cronbach's alpha is a statistical tool to evaluate the internal consistency or average correlation among various factors within a survey questionnaire. This measure is employed to assess the reliability of the questionnaire by gauging how consistently the items within it measure the same underlying concept. In essence, Cronbach's alpha helps ensure the reliability and consistency of the survey results. A reliability check was conducted to validate the 5-point Likert scale using SPSS, and the Cronbach alpha result was computed at 0.894, indicating that the 5-point Likert scale used is statistically reliable and can be subjected to further analysis.

Mean Score Ranking Technique

The results of the 14 identified IBM drivers subjected to a survey among Nigerian built environment professionals were processed using the mean score (MS) ranking technique. MS is used to assess the significance or criticality of factors, a typical quantitative analytical approach involving ranking. Its purpose was to establish the relative ranking of the 14 identified drivers for enhancing IBM based on perceived significance by respondents. The result of the MS ranking in Table 3 indicated that the respondents strongly agreed with all 14 identified factors as the drivers of IBM for sustainable construction. The MS ranges from 4.12 to 4.46.

Table 3. Drivers for the adoption of innovative building materials.

Code	Drivers	Mean	Std. Dev.	Rank
D1	Client's requirement	4.46	0.620	1st
D13	Government regulations	4.41	0.626	2nd
D9	Availability of IBM suppliers	4.36	0.634	3rd
D5	Developments in ICT/ Technology-push	4.34	0.618	4th
D11	Improved efficiency of the firm	4.30	0.631	5th
D7	Increase performance and productivity (cost saving, desired duration, improved quality)	4.29	0.608	6th
D12	Environmental sustainability	4.26	0.577	7th
D4	Availability of manufacturing firms	4.26	0.558	8th
D3	Demand-pull (client) vs Capability-push (contractor)	4.22	0.664	9th
D6	Design/Aesthetics trends	4.22	0.572	10th
D10	Procurement system for IBM	4.21	0.574	11th
D2	End-user requirement	4.20	0.593	12th
D8	Cost reduction	4.18	0.561	13th
D14	Competitive advantage	4.12	0.553	14th

DISCUSSION OF FINDINGS

Based on Table 3, the 14 drivers of adopting IBM are discussed below in order of significance determined by the respondents. The respondents ranked "clients' requirements (D1)" as the most significant driver of adopting IBM for sustainable construction. Brandon and Lu (2008) noted that clients drive innovation. Clients can drive the stakeholders and construction team to adopt IBM and sustainable construction to get value for their money. With clients and stakeholders increasingly looking for ways to improve the sustainability and efficiency of their buildings, this can drive demand for IBM, which offers improved performance and reduced environmental impact. Also, "government regulations (D13)" on IBM can drive IBM adoption. It was the second-most significant driver for IBM. Governments worldwide are implementing policies and regulations aimed at reducing the environmental impact of construction, including requirements for energy-efficient buildings, the use of renewable materials, and the reduction of greenhouse gas emissions (Nikyema & Blouin, 2020). However, by imposing these requirements, governments can create a market for IBM and incentivise clients and stakeholders to adopt these materials (Eze et al., 2023).

"Availability of IBM suppliers (D9)", which is the third-ranked driver, can also drive the adoption of IBM mainly when IBM suppliers are widely available (Kulatunga et al., 2011). A well-established, reliable and competitive IBM supply chain will help to ensure that the materials are available and accessible, reducing the time and costs associated with procurement. This makes IBM more appealing and accessible to building professionals, encouraging wider adoption of these materials.

"Developments in ICT/technology-push (D5)" was IBM's fourth most significant driver. This is the driving force of technology innovation (Abadi, 2014). Developments in ICT and technology-push help increase the availability of tools and solutions that enable building professionals to optimise their use of IBM, making it easier to choose and integrate these materials into their projects. "Improved efficiency of the firm (D11)" was identified as IBM's fifth most significant driver. According to (Gambatese & Hallowell, 2011; Ozorhon et al., 2010), improved organisation efficiency was a strong driver of construction innovation. This refers to the benefits building owners and contractors can achieve by using IBM, such as lower costs, improved quality, and reduced project duration. By incorporating IBM into their projects, building professionals can improve their performance and overall productivity, resulting in more efficient and cost-effective building processes. According to the respondents, the sixth most significant driver of IBM was an "increase in performance and productivity (cost saving, desired duration, improved quality) (D7)", which is a direct result of the improved efficiency of the firm. By using IBM, building professionals can reduce costs, complete projects faster, and improve the overall quality of their work, resulting in increased performance and productivity. "Environmental sustainability (D12)" refers to the growing awareness and concern for the impact of building and construction on the environment. This has increased the demand for environmentally sustainable building materials, including IBM, making it an attractive option for building professionals. According to Kibert (2016), one crucial area of environmental sustainability is sustainable construction, which is extensively pursued by governments, environmentalists, and other interested parties for its numerous benefits. "Availability of manufacturing firms (D4)" refers to the presence of companies that produce and supply IBM, making it easier for building professionals to access and use these materials in their projects. "Demand-pull (client) vs capability-push (contractor) (D3)" indicates the influence of clients and contractors (Ozorhon et al., 2010) in the adoption of IBM. If clients demand environmentally sustainable building materials, contractors may be more likely to use IBM as a sustainable building material. On the other hand, if contractors can use IBM and promote its benefits to clients, it can also drive its adoption.

"Design/aesthetics trends (D6)" indicate the growing emphasis on design and aesthetics in building and construction (Owolabi & Faleye, 2019; Ozorhon et al., 2010). As building professionals aim to create attractive and visually appealing structures, they may be more likely to adopt IBM as it can offer unique design features and benefits. The "procurement system for IBM (D10)" indicates acquiring and incorporating these materials into building projects (Kulatunga et al., 2011). If the procurement system is efficient and streamlined, it can make it easier and more attractive for building professionals to use IBM, driving its adoption. "End-user requirement (D2)" indicates the increasing demand for more sustainable, energy-efficient, and environmentally friendly building materials. End-users such as building owners, occupants, and tenants are becoming more aware of the environmental impact of buildings. They are increasingly looking for

materials that can help reduce their carbon footprint. "Cost reduction (D8)" indicates the potential cost savings that can be achieved using innovative building materials. These materials often provide the same performance benefits as traditional materials while being less expensive in the long run due to lower maintenance costs and improved energy efficiency. Also, as discussed by Bingham in 2003, innovation, particularly in the public sector, often prioritises cost reduction as the primary driver and sometimes the sole criterion for selection. According to the respondents, "competitive advantage (D14)" was the least significant driver of innovation. This may be because there needs to be a competitive advantage that supports or encourages IBM in the study area. (Magretta, 2012) defines competitive advantage as the capability of a company to outperform others in its industry or market, which can be attained through innovation. Many researchers and practitioners believe innovation is the starting point for gaining a competitive advantage (Xue et al., 2014). By using more sustainable, energy-efficient materials with a lower environmental impact, manufacturers can differentiate themselves in a crowded marketplace and attract more customers looking for environmentally responsible products and services.

CONCLUSION

Examining drivers influencing the adoption of IBM for sustainable construction in Nigeria reveals a detailed hierarchy of factors. Chief among these drivers is the client's requirement, underscoring the fundamental role of meeting client preferences in shaping material choices. Government regulations emerge as the second most influential driver, highlighting the substantial impact of regulatory frameworks on material adoption in the construction sector. The third critical driver is the availability of IBM suppliers, emphasising the crucial role of a reliable supply chain in facilitating the incorporation of innovative materials. Technological advancements, listed as the fourth driver, signal the influence of ICT in propelling the adoption of innovative materials. The fifth driver, improved efficiency of the firm, stresses the internal benefits firms seek through integrating IBM.

Considering the context of sustainable construction in a developing country like Nigeria, recommendations for stakeholders involve aligning strategies with these identified drivers. It is imperative to prioritise understanding and fulfilling client requirements, adapting to evolving government regulations, fostering a resilient supply chain, and leveraging technological advancements. Additionally, firms should prioritise internal efficiency improvements, consider environmental sustainability, collaborate with manufacturing firms, and stay attuned to market dynamics for competitive advantage. By incorporating these drivers into decision-making processes, stakeholders can contribute to successfully adopting innovative building materials and fostering sustainable construction practices in Nigeria.

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