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# EVALUATING THE ROLE OF PROJECT MANAGEMENT IN REDUCING EMBODIED AND OPERATIONAL CARBON IN HOUSING CONSTRUCTION PROJECTS IN ABUJA, NIGERIA

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## ABSTRACT

The construction industry is a major contributor to greenhouse gas emissions, necessitating the integration of carbon reduction strategies into project management practices. This study evaluated the role of project management in reducing embodied and operational carbon emissions in housing construction projects in Abuja, Nigeria. A mixed-methods research design was adopted, involving a survey of 354 construction professionals from 389 administered questionnaires (91.0% response rate) and 10 key informant interviews. Quantitative data were analysed using descriptive statistics and the Relative Importance Index (RII), while qualitative data were analysed thematically. The findings revealed that systematic project planning was the most adopted project management practice (Mean = 4.229; RII = 0.846). Energy-efficient building systems emerged as the leading carbon reduction measure (Mean = 4.314; RII = 0.863), while effective coordination was identified as the greatest project management contribution to carbon reduction (Mean = 4.192; RII = 0.838). Strong project leadership was the most influential factor affecting project management effectiveness (Mean = 3.992; RII = 0.798). The findings support the Triple Bottom Line and Institutional theories by demonstrating that structured project management, supported by organisational commitment and enabling institutional frameworks, enhances carbon reduction in housing construction. The study recommends embedding sustainability objectives into project governance and strengthening regulatory support to promote low-carbon housing development in Nigeria.

**KEYWORDS:** Project management; Carbon reduction; Embodied carbon; Operational carbon; Sustainable housing construction; Nigeria.

## INTRODUCTION

The construction industry plays a vital role in economic development by providing infrastructure, creating employment opportunities, and supporting urbanisation. Despite these contributions, it remains one of the largest sources of global greenhouse gas (GHG) emissions because it relies on carbon-intensive materials and the substantial energy required throughout the building life cycle (UNEP, 2023). As concerns over climate change continue to intensify, governments and industry stakeholders are increasingly promoting low-carbon construction as a strategy for improving resource efficiency, reducing environmental impacts, and achieving national and global climate objectives (IEA, 2023).

Carbon emissions from buildings are commonly categorised as embodied carbon and operational carbon. Embodied carbon refers to emissions generated during the extraction, processing, manufacture, transportation, and installation of construction materials before a building is occupied (Hertwich, 2021). Operational carbon, by contrast, results from energy consumed during the use of buildings for heating, cooling, lighting, ventilation, and other operational activities (Röck et al., 2020). Pomponi and Moncaster (2020) argued that meaningful reductions in building-related emissions require both sources to be addressed across the entire building life cycle. Furthermore, Habert et al. (2020) observed that improvements in energy efficiency have increased the relative importance of embodied carbon, making early project decisions increasingly critical to overall carbon performance.

Growing sustainability concerns have expanded the scope of project management beyond the traditional objectives of cost, time, and quality. Silvius and Schipper (2021) contended that environmental sustainability should be integrated into project governance rather than treated as a supplementary objective. Building on this perspective, Martens and Carvalho (2022) demonstrated that incorporating sustainability considerations into project planning improves organisational decision-making and long-term project performance. These developments position project management as an important mechanism for translating sustainability objectives into practical construction outcomes.

Project management influences carbon reduction throughout the life cycle of housing construction projects. Carvalho and Rabechini (2020) showed that decisions made during project planning shape resource allocation, procurement strategies, and sustainability objectives, thereby influencing overall environmental performance. Scrivener et al. (2021)

demonstrated that sustainable procurement facilitates the selection of low-carbon and recycled construction materials, reducing embodied carbon without compromising project performance. Darko and Chan (2021) further reported that effective stakeholder engagement and project monitoring improve compliance with environmental objectives during project implementation. More recently, Zhang et al. (2022) found that Building Information Modelling (BIM) strengthens project managers' ability to optimise material use, minimise construction waste, and improve carbon performance throughout project delivery.

The need for sustainable project management is particularly evident in Nigeria, where rapid urbanisation and rising housing demand have accelerated residential construction, especially within the Federal Capital Territory (FCT), Abuja. The continued use of conventional materials such as cement and steel, together with increasing energy demand during building operation, has contributed to growing embodied and operational carbon emissions in the housing sector (Adeyemi et al., 2024). Although Nigeria has committed to climate change mitigation through its Nationally Determined Contributions (NDCs), the practical integration of carbon reduction strategies into housing construction projects remains limited (Federal Ministry of Environment, 2023).

Although substantial research has examined sustainable construction, green building technologies, and energy-efficient building systems, comparatively little attention has been given to the project management practices that enable these technical solutions to be effectively implemented within construction projects. Ogunbiyi et al. (2022) noted that existing research has focused primarily on technological innovations and alternative construction materials while paying less attention to the managerial processes that drive successful implementation. Similarly, Akinyemi et al. (2021) reported that although awareness of sustainable construction has increased in Nigeria, practical implementation remains inconsistent. Consequently, empirical evidence on how project management contributes to reducing embodied and operational carbon emissions in housing construction projects remains limited. This study addresses that gap by evaluating the role of project management in reducing embodied and operational carbon in housing construction projects in Abuja, Nigeria.

## LITERATURE REVIEW

### Sustainable Project Management and Low-Carbon Housing Construction

The increasing emphasis on climate change mitigation has expanded the scope of project management beyond the traditional objectives of cost, time, and quality to include

environmental sustainability. Within the construction industry, sustainable project management is increasingly recognised as a governance approach that integrates environmental considerations into project planning, procurement, implementation, and stakeholder engagement to improve project performance throughout the building life cycle (Silvius & Schipper, 2021). This shift reflects the broader sustainability agenda advanced by Elkington (1997), which advocates balancing economic, environmental, and social objectives in organisational decision-making.

Silvius and Schipper (2021) argued that sustainability should be embedded within project governance rather than treated as an additional project objective. Likewise, Martens and Carvalho (2022) found that integrating sustainability into project management improves organisational decision-making by encouraging environmentally informed resource allocation and procurement practices. Carvalho and Rabechini (2020) further demonstrated that sustainability-oriented planning enhances project performance by aligning managerial decisions with environmental objectives. Collectively, these studies suggest that project management provides the organisational framework through which low-carbon construction strategies are coordinated and implemented.

Despite these contributions, existing studies provide limited evidence on the extent to which sustainable project management translates into measurable reductions in embodied and operational carbon emissions. While Silvius and Schipper (2021) developed a conceptual framework for sustainable project management, they did not examine its effectiveness within resource-constrained environments. Similarly, Martens and Carvalho (2022) focused primarily on organisational performance rather than carbon-specific outcomes. Consequently, the practical contribution of project management to carbon reduction remains insufficiently understood, particularly in developing economies.

This limitation is evident in Nigeria, where sustainable construction continues to face institutional, financial, and regulatory challenges. Akinyemi et al. (2021) reported that although awareness of sustainable construction practices is relatively high among construction professionals, implementation remains weak because of inadequate institutional support. Ogunbiyi et al. (2022) similarly identified limited regulatory enforcement and financial constraints as major barriers to sustainable construction. These findings indicate that achieving low-carbon housing development requires not only technological innovation but also effective project management supported by an enabling institutional environment. Accordingly, this study examines how project management contributes to reducing embodied and operational carbon emissions in housing construction projects in Abuja, Nigeria.

**Project Management and Embodied Carbon Reduction**

Embodied carbon has become a major concern in sustainable construction because it is generated before a building becomes operational through the extraction, manufacture, transportation, and installation of construction materials (Röck et al., 2020). As operational emissions decline through improvements in energy efficiency, embodied carbon accounts for an increasing proportion of whole-life building emissions, making early project decisions critical to achieving low-carbon construction (Pomponi & Moncaster, 2020). Consequently, project management has emerged as an important mechanism for influencing embodied carbon through planning, design coordination, procurement, and resource management (Habert et al., 2020).

Evidence suggests that reducing embodied carbon requires more than technological innovation. Scrivener et al. (2021) demonstrated that the adoption of low-carbon materials depends on procurement decisions and supplier engagement, while Lu et al. (2021) found that Building Information Modelling (BIM) improves material optimisation, quantity estimation, and waste minimisation during project delivery. Habert et al. (2020) similarly argued that integrating material efficiency and circular economy principles throughout the project life cycle offers greater carbon reduction than isolated design interventions. Collectively, these studies indicate that project management provides the organisational framework through which technical carbon reduction measures are implemented.

However, existing evidence is drawn predominantly from developed countries with relatively mature regulatory systems, established markets for low-carbon materials, and widespread adoption of digital construction technologies. Consequently, their findings may not be directly transferable to developing economies where institutional and financial constraints influence project delivery. In Nigeria, Akinyemi et al. (2021) reported that despite growing awareness of sustainable construction, implementation remains constrained by weak institutional support and the high cost of sustainable materials. Ogunbiyi et al. (2022) similarly identified inadequate regulatory enforcement and limited professional capacity as significant barriers to sustainable construction.

Although previous studies have advanced knowledge on lifecycle assessment, low-carbon materials, and digital technologies, comparatively little attention has been given to the project management practices that enable these solutions to be implemented effectively in housing projects. This gap is particularly evident in Nigeria, where empirical evidence linking project management with embodied carbon reduction remains limited. Accordingly, this study

examines the contribution of project management to reducing embodied carbon in housing construction projects in Abuja, Nigeria.

**Project Management and Operational Carbon Reduction**

Operational carbon remains a major contributor to building-related greenhouse gas emissions because it arises from energy consumed during a building's use for heating, cooling, lighting, ventilation, and other operational activities (Röck et al., 2020). Although these emissions occur after construction, they are largely determined by decisions made during project planning, design, procurement, and construction. Consequently, project management plays a critical role in shaping the long-term energy performance of housing developments by integrating sustainability objectives into project delivery (Silvius & Schipper, 2021).

Existing studies consistently identify energy-efficient design as the primary pathway for reducing operational carbon. Ürge-Vorsatz et al. (2020) demonstrated that passive design, improved thermal insulation, efficient building envelopes, and natural ventilation substantially reduce energy demand throughout a building's life cycle. Similarly, the International Energy Agency (2023) reported that early integration of energy-efficient technologies, renewable energy systems, and intelligent building management solutions delivers greater carbon reductions than retrofitting completed buildings. While these studies provide strong evidence for the effectiveness of technical interventions, they devote limited attention to the managerial processes required to ensure that such strategies are incorporated into project planning and implemented during construction.

Emerging evidence suggests that effective project management is essential for translating low-carbon design into operational performance. Martens and Carvalho (2022) argued that sustainability-oriented project management improves decision-making by integrating environmental objectives into project planning and resource allocation. Carvalho and Rabechini (2020) likewise highlighted the importance of project governance in aligning project delivery with sustainability goals, while Darko and Chan (2021) emphasised that stakeholder coordination and project monitoring improve compliance with environmental requirements during implementation. Together, these studies indicate that operational carbon reduction depends not only on engineering solutions but also on effective planning, coordination, and governance throughout the project life cycle.

Within the Nigerian context, Onuoha et al. (2023) identified poor building design, inadequate insulation, and dependence on fossil fuel-based electricity as major drivers of operational carbon emissions. Akinyemi et al. (2021) further reported that weak institutional support and

inconsistent implementation of sustainable construction practices continue to constrain environmental performance. However, these studies focus primarily on technical and institutional barriers, providing limited empirical evidence on how project management practices influence operational carbon reduction in residential construction. Accordingly, this study addresses that gap by evaluating the contribution of project management to reducing operational carbon in housing construction projects in Abuja, Nigeria.

**Theoretical Perspective**

This study is anchored on the Triple Bottom Line (TBL) Theory and Institutional Theory because they provide complementary explanations for how project management influences carbon reduction in housing construction. While the Triple Bottom Line Theory explains sustainability as a measure of project success, Institutional Theory explains how external pressures influence the adoption of sustainable project management practices. Together, the theories provide a comprehensive framework for understanding both the managerial and institutional drivers of embodied and operational carbon reduction.

The Triple Bottom Line Theory, proposed by Elkington (1997), argues that organisational performance should be evaluated using three interconnected dimensions: economic viability, environmental responsibility, and social well-being. Within construction, the theory broadens the definition of project success beyond the traditional objectives of cost, time, and quality to include environmental performance throughout the project life cycle. Accordingly, project management is expected to integrate sustainability into planning, procurement, resource allocation, and project execution, thereby supporting the selection of low-carbon materials, efficient resource utilisation, and energy-conscious building design (Silvius & Schipper, 2021). Despite its relevance, the theory has been criticised for providing broad sustainability principles without adequately explaining how organisations balance competing economic and environmental priorities, particularly in resource-constrained environments where financial and institutional limitations often dominate project decisions (Martens & Carvalho, 2022).

Institutional Theory complements this perspective by explaining how organisational behaviour is shaped by external pressures rather than managerial decisions alone. Meyer and Rowan (1977) argued that organisations adopt practices that enhance legitimacy, while DiMaggio and Powell (1983) identified coercive, normative, and mimetic pressures as the principal mechanisms driving organisational change. Within the construction industry, these pressures arise through environmental regulations, professional standards, client expectations, and competitive market practices, encouraging firms to adopt sustainable project

management and carbon reduction measures (Carvalho & Rabechini, 2020). However, Institutional Theory does not adequately explain why organisations operating under similar institutional conditions often demonstrate different levels of commitment to sustainability, suggesting that internal managerial capability also influences implementation.

The integration of both theories provides a stronger explanation than either theory alone. The Triple Bottom Line Theory explains why sustainability should be incorporated into project management, whereas Institutional Theory explains why organisations adopt sustainable practices in response to regulatory, professional, and market pressures. Together, they acknowledge that successful carbon reduction depends on both effective project management and an enabling institutional environment. This integrated perspective is particularly relevant to Nigeria, where project delivery is influenced not only by managerial decisions but also by evolving environmental regulations, institutional capacity, and stakeholder expectations. Accordingly, the combined theoretical framework provides an appropriate foundation for evaluating the role of project management in reducing embodied and operational carbon in housing construction projects in Abuja, Nigeria.

**Empirical Review and Research Gap**

Empirical research on sustainable construction has increasingly focused on reducing greenhouse gas emissions throughout the building life cycle. Röck et al. (2020) demonstrated that both embodied and operational carbon significantly influence the environmental performance of buildings, highlighting the need for whole-life carbon management. Pomponi and Moncaster (2020) similarly argued that effective decarbonisation requires integrating carbon reduction strategies across all stages of project delivery rather than concentrating solely on building operations. Although these studies advanced knowledge on lifecycle carbon assessment, they provided limited consideration of the project management practices required to implement carbon reduction measures.

Sustainable project management has also received increasing empirical attention. Silvius and Schipper (2021) found that embedding sustainability within project governance improves environmental performance and promotes responsible project delivery. Martens and Carvalho (2022) further reported that integrating sustainability into project planning strengthens decision-making relating to procurement, stakeholder engagement, and resource allocation. Carvalho and Rabechini (2020) likewise observed that project governance plays an important role in aligning organisational objectives with environmental sustainability. Despite these contributions, the studies evaluated sustainability primarily from organisational and

managerial perspectives without establishing whether these practices produce measurable reductions in embodied and operational carbon.

Empirical studies on embodied carbon have been dominated by engineering and material-based research. Habert et al. (2020) emphasised that reducing embodied carbon requires whole-life thinking that incorporates material efficiency and circular economy principles. Scrivener et al. (2021) demonstrated that low-carbon cement and alternative construction materials can substantially reduce emissions associated with construction activities. Lu et al. (2021) further showed that Building Information Modelling enhances material optimisation and reduces construction waste through improved planning and coordination. While these studies identify effective technical interventions, they provide limited evidence on how project managers facilitate the adoption of these practices during project implementation.

Research on operational carbon has followed a similar trajectory. Ürge-Vorsatz et al. (2020) established that passive building design, efficient building envelopes, and improved insulation significantly reduce operational energy demand. The International Energy Agency (2023) reported that integrating energy-efficient technologies during project planning delivers greater carbon savings than retrofitting completed buildings. Darko and Chan (2021) argued that achieving these outcomes depends on effective stakeholder coordination and continuous project monitoring. Nevertheless, the managerial processes linking project delivery with operational carbon reduction remain insufficiently investigated.

Within Nigeria, empirical evidence remains comparatively limited. Akinyemi et al. (2021) found that although awareness of sustainable construction has improved among construction professionals, implementation remains constrained by weak institutional support and limited client demand. Ogunbiyi et al. (2022) identified inadequate regulatory enforcement, financial constraints, and limited professional capacity as major barriers to sustainable construction. Adeyemi et al. (2024) similarly reported that the widespread use of carbon-intensive materials and increasing building energy demand continue to undermine environmental performance in the housing sector. Collectively, these studies demonstrate that institutional and implementation challenges remain significant.

The empirical literature therefore reveals three important gaps. First, existing studies have concentrated on technological innovations while giving comparatively less attention to project management as a determinant of carbon reduction. Second, most empirical evidence originates from developed economies, limiting its applicability to developing countries with different institutional and market conditions. Third, studies conducted in Nigeria have focused primarily on barriers to sustainable construction rather than evaluating how project

management influences embodied and operational carbon reduction. Accordingly, this study addresses these gaps by examining the role of project management in reducing embodied and operational carbon in housing construction projects in Abuja, Nigeria.

## METHODOLOGY

### Research Design

This study adopted a mixed-methods research design to evaluate the role of project management in reducing embodied and operational carbon in housing construction projects in Abuja, Nigeria. The adoption of both quantitative and qualitative approaches was considered appropriate because carbon reduction in construction projects is influenced by measurable project management practices as well as contextual organisational and institutional factors. The quantitative component employed a cross-sectional survey to collect data from construction professionals, while the qualitative component utilised key informant interviews to obtain in-depth insights into sustainable project management practices. The integration of both approaches enhanced the robustness of the findings through methodological triangulation.

### Data Collection

The study was conducted in the Federal Capital Territory (FCT), Abuja, Nigeria, which was selected because of its rapid urbanisation, growing housing sector, and high concentration of construction professionals involved in residential project delivery. These characteristics make Abuja an appropriate setting for investigating project management practices for carbon reduction in housing construction.

The study targeted architects, builders, civil engineers, quantity surveyors, and project managers engaged in housing construction projects. These professionals were selected because they are directly involved in project planning, design, procurement, construction supervision, and project delivery, enabling them to provide informed assessments of sustainable project management practices. A multi-stage sampling technique was employed to ensure adequate representation of the different professional groups. Using Cochran's sample size determination formula, 389 questionnaires were administered, yielding 354 valid responses, representing a 91.0% response rate. In addition, ten experienced professionals were purposively selected for semi-structured interviews to provide deeper insights into project management practices and carbon reduction strategies.

Primary data were collected using a structured questionnaire and an interview guide. The questionnaire comprised items on project management practices, embodied carbon reduction, operational carbon reduction, implementation challenges, and the contribution of project management to sustainable housing construction. Responses were measured using a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The interview guide explored participants' experiences of implementing sustainable construction practices and the institutional factors influencing carbon reduction.

To ensure instrument quality, the questionnaire was reviewed by subject experts and pilot-tested before the main survey. Reliability was assessed using Cronbach's alpha, with all constructs exceeding the recommended threshold of 0.70, indicating satisfactory internal consistency (Cronbach, 1951).

### 3.3 Data Analysis

The quantitative data were analysed using the Statistical Package for the Social Sciences (SPSS). Descriptive statistics, including frequencies, percentages, means and standard deviations, were used to summarise respondents' characteristics and evaluate the extent of project management practices adopted in housing construction projects. Inferential statistical techniques were subsequently employed to examine the relationship between project management practices and the reduction of embodied and operational carbon emissions, with statistical significance assessed at the 5% level.

The qualitative interview data were analysed using thematic analysis, whereby interview transcripts were coded and organised into recurrent themes relating to sustainable project management, carbon reduction strategies and implementation challenges. The qualitative findings were integrated with the quantitative results to provide richer interpretation and explanation of the observed relationships, thereby strengthening the overall validity of the study through data triangulation.

## RESULTS AND DISCUSSION

### Characteristics of the Respondents

A total of 389 questionnaires were administered to construction professionals involved in housing construction projects in the Federal Capital Territory (FCT), Abuja. Of these, 354 questionnaires were valid for analysis, representing a 91.0% response rate. The high response rate provides a reliable basis for evaluating project management practices aimed at reducing embodied and operational carbon emissions in housing construction projects.

**Table 1. Characteristics of Respondents. (n = 354)**

| Characteristic | Category | n (%) |
|---|---|---|
| **Gender** | Male | 290 (81.9) |
| | Female | 64 (18.1) |
| **Highest Qualification** | HND | 29 (8.2) |
| | Bachelor's Degree | 162 (45.8) |
| | Master's Degree | 127 (35.9) |
| | PhD | 36 (10.1) |
| **Professional Discipline** | Engineer | 236 (66.7) |
| | Architect | 42 (11.9) |
| | Environmental Planner | 27 (7.6) |
| | Quantity Surveyor | 25 (7.1) |
| | Builder | 15 (4.2) |
| | Regulatory Officer | 9 (2.5) |
| **Professional Experience** | < 5 years | 43 (12.1) |
| | 5–10 years | 106 (29.9) |
| | 11–15 years | 92 (26.0) |
| | > 15 years | 113 (31.9) |

**Source:** Field Survey (2025).

The predominance of systematic project planning and the incorporation of lessons learned indicate that project management within Abuja's housing construction sector remains strongly oriented toward structured project governance. This finding directly addresses the first objective by demonstrating that established project management practices are widely adopted. However, the relatively lower ranking of sustainability integration suggests that environmental considerations remain secondary to conventional project management priorities.

This finding lends partial support to the Triple Bottom Line Theory, which advocates balancing economic, social and environmental objectives throughout the project lifecycle. While organisations appear to have institutionalised traditional planning and coordination mechanisms, sustainability has not yet been fully embedded into routine project governance. This observation is consistent with Silvius and Schipper (2021), who argued that many organisations continue to treat sustainability as an additional project requirement rather than a core management principle.

It also corroborates the findings of Akinyemi et al. (2021), who reported that sustainability practices in Nigeria's construction industry remain largely project-specific rather than

institutionally embedded. Consequently, although project management practices provide a foundation for reducing carbon emissions, further institutional reforms are required to integrate sustainability into routine project decision-making.

**Project Management Practices Employed in Housing Construction Projects**

The first objective of this study was to examine the project management practices employed in housing construction projects in Abuja to facilitate the reduction of embodied and operational carbon emissions. Respondents evaluated the extent to which selected project management practices were adopted during project planning, procurement, implementation and monitoring. The results are presented in Table 2.

**Table 2. Project Management Practices Employed in Housing Construction Projects.**

| Project Management Practice | Mean | RII | Rank |
|---|---|---|---|
| Project planning is systematically carried out before project execution | 4.229 | 0.846 | 1 |
| Lessons learned are incorporated into subsequent projects | 4.155 | 0.831 | 2 |
| Environmental risks are considered during project planning | 4.116 | 0.823 | 3 |
| Project monitoring includes sustainability indicators | 4.102 | 0.820 | 4 |
| Procurement decisions consider environmental sustainability | 4.093 | 0.819 | 5 |
| Stakeholders are actively engaged throughout project implementation | 4.079 | 0.816 | 6 |
| Project teams coordinate effectively during design development | 4.056 | 0.811 | 7 |
| Sustainability objectives are incorporated into project planning | 4.042 | 0.808 | 8 |

**Source:** Field Survey (2025).

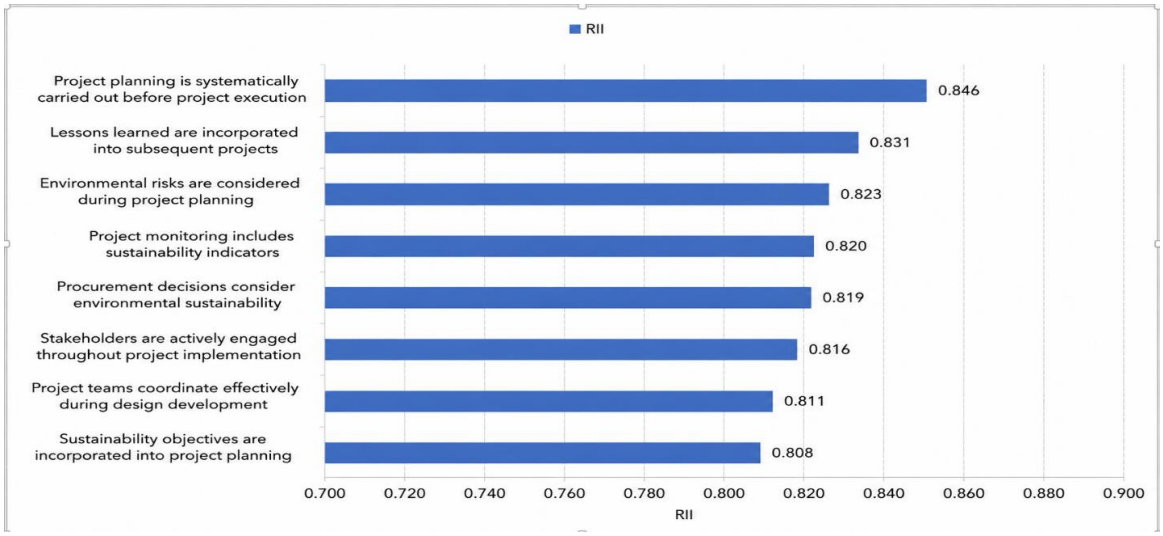


**Figure 1. Relative Importance Index (RII) of Project Management Practices.**

**Source:** Field Survey (2025)

The findings indicate that project management practices are well established across housing construction projects in Abuja, particularly in project planning, knowledge management, and environmental risk assessment. This suggests that construction firms possess the organisational structures needed to support carbon reduction initiatives. However, the relatively lower emphasis on sustainability objectives indicates that environmental considerations have not yet been fully integrated into core project management processes, remaining secondary to traditional performance measures such as cost, time, and quality.

These results are consistent with those of Silvius and Schipper (2021), who argued that although sustainability has become an important component of project management, its integration into routine project governance remains uneven. Martens and Carvalho (2022) likewise found that organisations with mature project management systems are more likely to incorporate sustainability into project planning and decision-making. In contrast, Marcelino-Sádaba et al. (2015) reported a higher level of sustainability integration within European construction projects. This difference may reflect stronger regulatory frameworks, institutional support, and market incentives for sustainable construction in developed economies than currently exist in Nigeria.

The results support the Triple Bottom Line Theory by demonstrating that environmental sustainability is increasingly recognised within project management, although it has not yet achieved parity with traditional project performance objectives. They also reinforce Institutional Theory, which suggests that organisational practices evolve in response to external regulatory and normative pressures. The relatively low prioritisation of sustainability objectives indicates that such pressures remain insufficient to drive the full institutionalisation of carbon-conscious project management in Nigeria's housing sector. Consequently, the study highlights that the key challenge is not the adoption of project management practices but their systematic alignment with carbon reduction and sustainability objectives.

**Carbon Reduction Measures Adopted in Housing Construction Projects**

The second objective of this study was to assess the carbon reduction measures adopted in housing construction projects in Abuja. Respondents evaluated the extent to which selected measures aimed at reducing embodied and operational carbon emissions were implemented during project delivery. The results are presented in Table 3.

**Table 3. Carbon Reduction Measures Adopted in Housing Construction Projects.**

| Carbon Reduction Measure | Mean | RII | Rank |
|---|---|---|---|
| Energy-efficient building systems are incorporated into project designs | 4.314 | 0.863 | 1 |
| Construction waste is minimised through effective material management | 4.266 | 0.853 | 2 |
| Sustainable construction materials are used where feasible | 4.223 | 0.845 | 3 |
| Renewable energy technologies are considered during project planning | 4.181 | 0.836 | 4 |
| Water-efficient technologies are incorporated into projects | 4.147 | 0.829 | 5 |
| Material reuse and recycling are encouraged during construction | 4.121 | 0.824 | 6 |
| Low-carbon construction techniques are adopted | 4.087 | 0.817 | 7 |
| Carbon emissions are monitored throughout project implementation | 4.054 | 0.811 | 8 |

**Source:** Field Survey (2025).

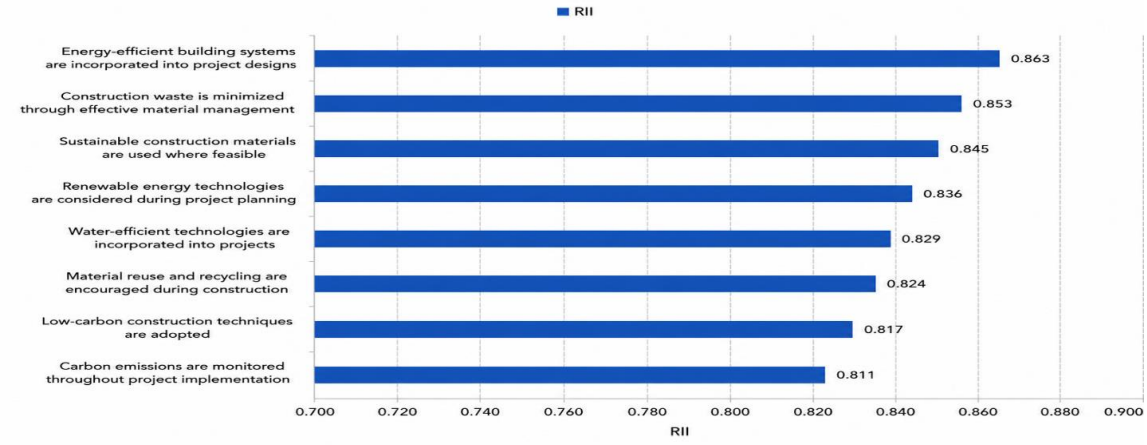


**Figure 2. Relative Importance Index (RII) of Carbon Reduction Measures.**

**Source:** Field Survey, 2025

The analysis indicates that energy-efficient building systems and construction waste minimisation are the most widely adopted carbon reduction measures in housing construction projects in Abuja, whereas carbon emissions monitoring remains the least adopted practice. This suggests that construction firms prioritise interventions with immediate operational and economic benefits, while systematic carbon measurement receives comparatively less attention. The findings therefore indicate that carbon reduction efforts are driven more by implementation than by formal carbon management.

The results are consistent with Pomponi and Moncaster (2017), who observed that construction organisations tend to prioritise energy efficiency because its environmental and economic benefits are readily realised. Darko et al. (2022) likewise reported that waste minimisation and energy-efficient technologies are among the most widely implemented sustainable construction practices in developing countries because they require fewer

institutional and technical resources. In contrast, Akanbi et al. (2021) found that lifecycle carbon assessment has become an integral component of sustainable building delivery in developed economies. This disparity likely reflects differences in regulatory frameworks, technological capacity, and the availability of carbon accounting systems.

The evidence provides partial support for the Triple Bottom Line Theory by demonstrating that environmental sustainability is increasingly incorporated into project delivery through resource-efficient practices. However, the limited adoption of carbon monitoring suggests that environmental performance is still assessed indirectly rather than through measurable carbon indicators. The study therefore shows that, within Abuja's housing sector, practical carbon reduction measures have advanced more rapidly than the institutional systems required for carbon measurement, reporting, and performance management.

**Contribution of Project Management to Reducing Embodied and Operational Carbon Emissions**

The third objective of this study was to evaluate the contribution of project management to reducing embodied and operational carbon emissions in housing construction projects in Abuja. Respondents assessed the extent to which project management practices contribute to carbon reduction throughout the project life cycle. The results are presented in Table 4.

**Table 4. Contribution of Project Management to Carbon Reduction.**

| Contribution of Project Management | Mean | RII | Rank |
|---|---|---|---|
| Effective coordination minimises rework and associated carbon emissions | **4.192** | **0.838** | **1*** |
| Overall, project management significantly contributes to reducing embodied and operational carbon emissions | **4.192** | **0.838** | **1*** |
| Project management contributes to reducing operational carbon emissions through better building performance | 4.144 | 0.829 | 3 |
| Project planning reduces material wastage during construction | 4.138 | 0.828 | 4 |
| Sustainable procurement reduces embodied carbon emissions | 4.116 | 0.823 | 5 |
| Effective scheduling reduces fuel and energy consumption on construction sites | 4.107 | 0.821 | 6 |
| Project monitoring improves environmental performance | 4.096 | 0.819 | 7 |
| Project management promotes the use of low-carbon construction technologies | 4.082 | 0.816 | 8 |

**Source:** Field Survey (2025).

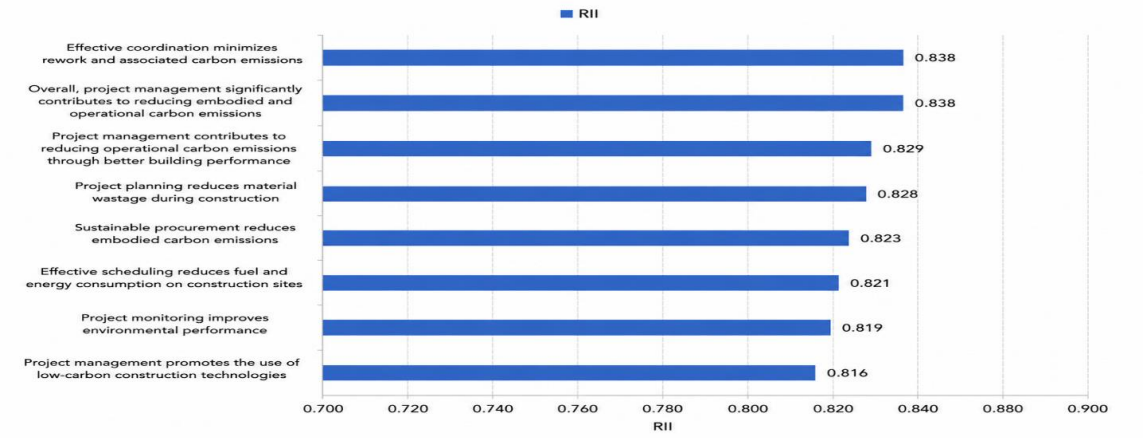


**Figure 3. Relative Importance Index (RII) of Project Management Contributions.**

**Source:** Field Survey, 2025

The findings demonstrate that project management is a significant driver of carbon reduction in housing construction projects, particularly through effective coordination, project planning, and improved building performance. The prominence of project coordination suggests that reducing rework and improving resource utilisation are important managerial mechanisms for minimising embodied and operational carbon emissions. However, the relatively lower emphasis on low-carbon construction technologies indicates that technological innovation has yet to become an integral component of project delivery within the study area.

These findings are consistent with Hwang et al. (2022), who reported that effective project planning, coordination, and monitoring improve environmental performance by reducing construction waste and resource inefficiencies. Osmani et al. (2021) similarly found that minimising rework through better project coordination significantly lowers material losses and associated carbon emissions. In contrast, Carvalho and Rabechini (2020) observed that organisations with mature sustainability practices increasingly rely on technological innovation to improve environmental performance. The difference may be explained by the high cost of low-carbon technologies, limited technical expertise, and weaker institutional support that continue to constrain their adoption in Nigeria's construction industry.

The findings support the Triple Bottom Line Theory by showing that effective project management enhances both project efficiency and environmental performance through improved planning, coordination, and resource utilisation. They also reinforce Institutional Theory, which emphasises the influence of regulatory and professional environments on organisational practices. The comparatively lower adoption of technology-based carbon reduction measures suggests that institutional support for sustainable innovation remains inadequate. Consequently, the study demonstrates that project management currently

contributes more to carbon reduction through effective governance and coordination than through technology-driven interventions, highlighting the need for stronger institutional support to accelerate the adoption of low-carbon construction technologies in Nigeria.

**Factors Influencing Project Management Effectiveness**

The fourth objective of this study was to examine the factors influencing the effectiveness of project management in reducing embodied and operational carbon emissions in housing construction projects in Abuja. Respondents assessed the significance of selected organisational, institutional, financial and technical factors. The results are presented in Table 5.

**Table 5. Factors Influencing Project Management Effectiveness.**

| Influencing Factor | Mean | RII | Rank |
|---|---|---|---|
| Strong project leadership improves the implementation of carbon reduction initiatives | **3.992** | **0.798** | **1** |
| Availability of organisational support enhances the implementation of carbon reduction practices | 3.977 | 0.795 | 2 |
| Government policies and regulatory enforcement support carbon reduction initiatives | 3.966 | 0.793 | 3 |
| Availability of financial resources influences the implementation of carbon reduction measures | 3.941 | 0.788 | **4*** |
| Stakeholder collaboration enhances the implementation of carbon reduction measures | 3.938 | 0.788 | **4*** |
| Effective communication among project stakeholders improves carbon reduction outcomes | 3.938 | 0.788 | **4*** |
| Technical knowledge and professional competence influence effective carbon reduction | 3.887 | 0.777 | 7 |
| High cost of sustainable materials limits the adoption of carbon reduction measures | 3.816 | 0.763 | 8 |

**Source:** Field Survey (2025).

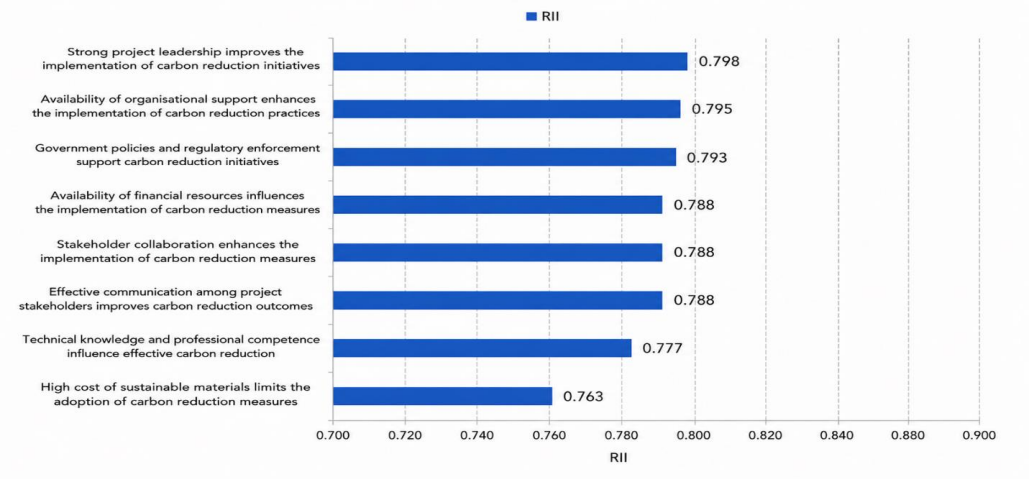


**Figure 4. Relative Importance Index (RII) of Influencing Factors.**

**Source:** Field Survey, 2025

The findings indicate that effective carbon reduction in housing construction projects depends primarily on strong project leadership, organisational support, and an enabling regulatory environment. The prominence of leadership suggests that managerial commitment is essential for translating sustainability objectives into project decisions and day-to-day practices. Although the cost of sustainable materials remains a challenge, respondents considered organisational and institutional factors to have a greater influence on the successful implementation of carbon reduction initiatives.

These findings are consistent with Aigbavboa et al. (2022), who identified leadership commitment and organisational capacity as key drivers of sustainable construction in developing economies. They also support the Federal Ministry of Environment (2023), which emphasised that achieving Nigeria's climate objectives requires stronger regulatory institutions and policy enforcement. In contrast, Ogunbiyi and Oladapo (2023) identified financial constraints as the principal barrier to green housing development. The present findings suggest that while financial resources are important, they are unlikely to produce meaningful carbon reduction without effective leadership, organisational commitment, and supportive governance structures.

The findings provide strong support for Institutional Theory, which argues that organisational behaviour is shaped by regulatory pressures, leadership, and stakeholder expectations. The prominence of leadership, organisational support, and government policy demonstrates that carbon reduction depends as much on institutional capacity as on technical or financial resources. The study therefore contributes to the literature by showing that strengthening

leadership and institutional governance may have a greater impact on carbon reduction in Nigeria's housing construction sector than financial investment alone.

## CONCLUSION

This study evaluated the role of project management in reducing embodied and operational carbon emissions in housing construction projects in Abuja, Nigeria. The findings demonstrate that structured project management practices provide an important foundation for integrating carbon reduction initiatives throughout the project life cycle. Although conventional project management practices, including systematic planning, stakeholder coordination and project monitoring, are widely adopted, sustainability objectives have not yet been fully embedded within routine project management processes. This indicates that project success continues to be driven largely by the traditional performance dimensions of cost, time and quality, with comparatively less emphasis on environmental performance.

The study further established that carbon reduction measures are increasingly incorporated during the planning and design stages of housing construction projects, particularly through renewable energy considerations, energy-efficient building design and the integration of carbon reduction objectives into project planning. However, comparatively limited attention is given to environmental performance monitoring during project implementation and operational carbon management after project completion. The findings also demonstrate that effective project management contributes significantly to reducing embodied and operational carbon emissions through improved planning, coordination, procurement, scheduling and resource efficiency. Furthermore, project leadership, organisational support and regulatory enforcement were identified as the most influential factors affecting the successful implementation of carbon reduction initiatives.

From a theoretical perspective, the findings extend the application of the Triple Bottom Line Theory by demonstrating that project management can serve as a practical mechanism for integrating environmental sustainability into construction project delivery. The study also reinforces Institutional Theory by showing that organisational commitment, leadership and regulatory support significantly influence the adoption of low-carbon project management practices. These findings provide empirical evidence from Nigeria's housing construction sector, where research examining the relationship between project management and carbon reduction remains limited.

Practically, the findings suggest that improving carbon performance in housing construction requires more than the adoption of conventional project management techniques. Greater

emphasis should be placed on integrating sustainability objectives into project governance, strengthening institutional and regulatory support, enhancing professional capacity, and promoting the adoption of low-carbon technologies throughout the project life cycle. Such measures would enable project managers to contribute more effectively to national climate change mitigation objectives and the transition towards a more sustainable construction sector.

Overall, the study demonstrates that project management should be viewed not only as a mechanism for achieving project delivery objectives but also as a strategic tool for advancing low-carbon and sustainable housing construction in emerging economies.

## PRACTICAL IMPLICATIONS

The findings of this study have important implications for project managers, construction firms, policymakers and professional bodies involved in housing development. First, the study demonstrates that project management should be recognised as a strategic mechanism for reducing embodied and operational carbon emissions rather than merely a tool for controlling project cost, time and quality. Consequently, project managers should integrate sustainability objectives into project planning, procurement, scheduling, risk management and performance monitoring from the early stages of project development.

Second, construction organisations should strengthen institutional support for sustainable project management by incorporating carbon reduction targets into organisational policies, project governance frameworks and performance evaluation systems. Such initiatives would encourage the routine consideration of environmental performance alongside traditional project success indicators.

Third, the findings underscore the need for government agencies and professional regulatory bodies to strengthen policies, standards and enforcement mechanisms that promote low-carbon construction practices. Providing incentives for the adoption of sustainable materials, energy-efficient technologies and carbon assessment tools could accelerate the transition towards more sustainable housing development in Nigeria.

Finally, institutions responsible for professional education and capacity building should incorporate sustainable project management and carbon management into engineering, architecture, quantity surveying and project management training programmes. Strengthening professional competencies would improve the industry’s capacity to implement effective carbon reduction strategies throughout the project life cycle.

## LIMITATIONS OF THE STUDY

This study was limited to housing construction projects within the Federal Capital Territory (FCT), Abuja. Consequently, the findings may not fully represent project management practices and carbon reduction initiatives in other regions of Nigeria, where regulatory environments, construction practices and institutional capacities may differ.

The study relied primarily on respondents' perceptions obtained through questionnaire surveys and key informant interviews. Although these respondents possessed considerable professional experience, perception-based data may be influenced by individual judgement and organisational context.

Furthermore, the study adopted a cross-sectional research design, capturing project management practices at a single point in time. As construction practices and sustainability policies continue to evolve, longitudinal studies would provide a better understanding of how project management contributes to carbon reduction over time.

## DIRECTIONS FOR FUTURE RESEARCH

Future studies should examine the role of project management in reducing carbon emissions across different categories of construction projects, including commercial, industrial and infrastructure developments, to determine whether the patterns identified in housing construction are applicable across the wider construction sector.

Further research should also employ longitudinal research designs to evaluate how improvements in project management practices influence embodied and operational carbon emissions throughout the entire building life cycle. Such studies would provide stronger evidence of causal relationships than cross-sectional investigations.

Comparative studies involving multiple geopolitical zones or different countries would also enhance understanding of how institutional, regulatory and socio-economic contexts influence the effectiveness of project management in achieving low-carbon construction outcomes.

Finally, future research should integrate objective carbon assessment methods, such as Life Cycle Assessment (LCA), Building Information Modelling (BIM), and whole-life carbon accounting, with project management performance indicators. Such an approach would provide more robust evidence on the relationship between project management practices and measurable carbon reduction outcomes while advancing research on sustainable construction management.

## REFERENCES


1. Adeyemi, O., Ibrahim, A., & Bello, M. (2024). Carbon emissions and sustainable housing development in Nigeria: Challenges and opportunities. *Journal of Sustainable Construction*, 16(2), 112–128.
2. Aigbavboa, C., Thwala, W., & Akinradewo, O. (2022). Leadership and organisational capacity for sustainable construction in developing economies. *Journal of Construction in Developing Countries*, 27(1), 45–63.
3. Akanbi, L. A., Oyedele, L. O., Delgado, J. M. D., Bilal, M., Akinade, O. O., Ajayi, A. O., & Owolabi, H. A. (2021). Lifecycle carbon assessment for sustainable building delivery: A review. *Journal of Cleaner Production*, 281, 124882.
4. Akinyemi, B. A., Aigbavboa, C., & Oke, A. (2021). Sustainable construction practices in Nigeria: Awareness, implementation and barriers. *International Journal of Construction Management*, 21(8), 789–803.
5. Carvalho, M. M., & Rabechini, R. (2020). Project management and sustainability: Integrating environmental objectives into project governance. *International Journal of Project Management*, 38(7), 436–448.
6. Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, 16(3), 297–334.
7. Darko, A., & Chan, A. P. C. (2021). Strategies for promoting green building technologies in developing countries. *Building and Environment*, 189, 107530.
8. Darko, A., Chan, A. P. C., Yang, Y., Shan, M., He, B. J., & Gou, Z. (2022). Sustainable construction practices in developing countries: Current status and future directions. *Journal of Cleaner Production*, 330, 129834.
9. DiMaggio, P. J., & Powell, W. W. (1983). The iron cage revisited: Institutional isomorphism and collective rationality in organisational fields. *American Sociological Review*, 48(2), 147–160.
10. Elkington, J. (1997). *Cannibals with forks: The triple bottom line of 21st century business*. Capstone Publishing.
11. Federal Ministry of Environment. (2023). *Nigeria's climate change policy and implementation framework*. Federal Ministry of Environment.
12. Habert, G., Miller, S. A., John, V. M., Provis, J. L., Favier, A., Horvath, A., & Scrivener, K. L. (2020). Environmental impacts and decarbonisation strategies in the construction sector. *Nature Reviews Earth & Environment*, 1(11), 559–573.

13. Hertwich, E. G. (2021). Increased carbon footprint of materials production driven by rise in investments. *Nature Geoscience*, 14(3), 151–155.
14. Hwang, B. G., Shan, M., & Tan, E. K. (2022). Sustainable project management practices and environmental performance in construction. *Engineering, Construction and Architectural Management*, 29(4), 1625–1644.
15. International Energy Agency. (2023). *Buildings 2023: Analysis and outlook*. IEA.
16. Lu, W., Webster, C., Chen, K., Zhang, X., & Chen, X. (2021). Building Information Modelling for construction waste minimisation and carbon reduction: A review. *Automation in Construction*, 123, 103548.
17. Marcelino-Sádaba, S., Pérez-Ezcurdia, A., Lazcano, A. M., & Villanueva, P. (2015). Project sustainability management: A new proposal centred on the sustainable project life cycle. *International Journal of Project Management*, 33(2), 278–290.
18. Martens, M. L., & Carvalho, M. M. (2022). Sustainability and project management: Trends and future directions. *International Journal of Project Management*, 40(2), 123–137.
19. Meyer, J. W., & Rowan, B. (1977). Institutionalized organizations: Formal structure as myth and ceremony. *American Journal of Sociology*, 83(2), 340–363.
20. Ogunbiyi, O., & Oladapo, A. (2023). Financial barriers to green housing development in Nigeria. *Built Environment Project and Asset Management*, 13(4), 566–582.
21. Ogunbiyi, O., Oladapo, A., & Goulding, J. (2022). Barriers to sustainable construction in Nigeria: Evidence from construction professionals. *International Journal of Construction Management*, 22(11), 2147–2160.
22. Onuoha, C., Okafor, P., & Nwosu, I. (2023). Operational carbon emissions and energy performance of residential buildings in Nigeria. *Energy Reports*, 9, 4683–4696.
23. Osmani, M., Glass, J., & Price, A. D. F. (2021). Construction rework, waste minimisation and environmental performance. *Waste Management*, 120, 125–134.
24. Pomponi, F., & Moncaster, A. (2017). Embodied carbon mitigation and reduction in the built environment—What does the evidence say? *Journal of Environmental Management*, 181, 687–700.
25. Pomponi, F., & Moncaster, A. (2020). Embodied carbon and whole-life carbon assessment in buildings: A review. *Renewable and Sustainable Energy Reviews*, 134, 110269.
26. Röck, M., Saade, M. R. M., Balouktsi, M., Rasmussen, F. N., Birgisdottir, H., Frischknecht, R., Habert, G., Lützkendorf, T., & Passer, A. (2020). Embodied GHG

emissions of buildings—The hidden challenge for effective climate change mitigation. *Applied Energy*, 258, 114107.

27. Scrivener, K. L., John, V. M., & Gartner, E. M. (2021). Eco-efficient cements: Potential economically viable solutions for a low-$CO_2$ cement-based materials industry. *Cement and Concrete Research*, 114, 2–26.
28. Silvius, A. J. G., & Schipper, R. (2021). Sustainability in project management: A literature review and impact analysis. *Social Business*, 11(1), 7–34.
29. United Nations Environment Programme. (2023). *2023 global status report for buildings and construction: Towards a zero-emission, efficient and resilient buildings and construction sector*. UNEP.
30. Ürge-Vorsatz, D., Cabeza, L. F., Serrano, S., Barreneche, C., & Petrichenko, K. (2020). Heating and cooling energy trends and drivers in buildings. *Renewable and Sustainable Energy Reviews*, 41, 85–98.
31. Zhang, X., Wu, Y., Shen, L., & Skitmore, M. (2022). Building Information Modelling-enabled carbon management in construction projects. *Automation in Construction*, 136, 104160.