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Article

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Management dynamics in the knowledge economy

Reference: Lawal, Yusuf Adedayo/Abdul-Azeez, Ibraheem Forson et. al. (2024). Sustainable project management practices and the performance of construction companies. In: Management dynamics in the knowledge economy 12 (3/45), S. 302 - 320.
https://www.managementdynamics.ro/index.php/journal/article/download/602/504/2847.
doi:10.2478/mdke-2024-0018.

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Sustainable Project Management Practices and the Performance of Construction Companies

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Received: April 29, 2024
Revised: May 28, 2024
Accepted: June 8, 2024
Published: September 25, 2024

Abstract: Sustainability and project management are interconnected concepts that are crucial in today's world. The Nigerian construction industry faces sustainability challenges such as poor project performance, low quality, high costs, waste generation, environmental degradation, and social conflicts. These issues compromise the industry's ability to support sustainable development. This research investigates the prospects, challenges, and benefits of adopting sustainable project management techniques in Lagos State, Nigeria, using resource optimization and rework reduction measures. The research involved a cross-sectional survey of 232 staff members from selected companies, with a sample size of 172. The study used covariance-based structural equation modelling (CB-SEM) to evaluate complex relationships among variables. Path analysis was conducted and revealed a strong positive relationship between the variables tested. The study reveals that resource optimisation and rework reduction are positively related to economic, social, and environmental sustainability, suggesting that optimizing resources and reducing reworks can lead to better social and environmental outcomes for construction companies. This study reveals that sustainable project management practices positively impact the performance of construction companies in Lagos State, Nigeria, in terms of social and environmental outcomes. The study suggests that these practices are interrelated and mutually reinforcing. The study recommended, among others, that the government should promote sustainable construction by providing incentives, regulations, and guidelines and fostering collaboration among stakeholders to exchange knowledge and best practices.

Keywords: sustainable project management; rework reduction; resource optimization; construction industry; project management.

Introduction

Sustainability and project management are two interrelated concepts that have gained increasing attention and importance in the contemporary world. Sustainability refers to the ability to meet the needs of the present without compromising the ability of future generations to meet their own needs (Akinshipe et al., 2019). Sustainability is the capacity to be maintained at a certain level (Akindele et al., 2023; Chow et al., 2021). In this study, sustainability refers to the economic, environmental, and social benefits of project management in a manufacturing firm. Sustainability is an integral part of project management practices that ensure the long-term viability and value of the project for the stakeholders and the planet. According to Kivilä et al. (2017), sustainable project management (SPM) incorporates the triple bottom line (TBL) of economic, environmental, and social aspects into the project objectives, processes, and outcomes and has a significant impact on project success. SPM involves planning, monitoring, controlling, and delivering the project in a way that balances the needs and expectations of the stakeholders while minimizing the negative effects on the environment and society

How to cite
Lawal, Y. A., Abdul-Azeez, I. F., & Olateju, O. I. (2024). Sustainable Project Management Practices and the Performance of Construction Companies. *Management Dynamics in the Knowledge Economy, 12*(3), 302-320. DOI 10.2478/mdke-2024-0018
ISSN: 2392-8042 (online)
www.managementdynamics.ro
https://content.sciendo.com/view/journals/mdke/mdke-overview.xml

Vol.12 (2024) no.3, pp.302-320; DOI 10.2478/mdke-2024-0018

throughout the project lifecycle. Project managers are responsible for overseeing the project management process with the integration of sustainability as one of the project's key goals. Sustainable project management can lead to effective and efficient sustainable project planning, which reflects the manufacturing firm's sustainable project performance. Sustainable project planning (SPP) consists of three main dimensions: managerial control, risk response, and work consensus (Kivilä et al., 2017).

The construction industry is one of the most important sectors in any economy, as it provides the physical infrastructure and facilities that enable social and economic development (Chawla et al., 2018). However, the construction industry also has significant environmental, social, and economic impacts that can affect the present and future generations. Therefore, there is a growing need to adopt sustainable practices in the construction industry to ensure that the projects are delivered in a way that balances the needs and expectations of the stakeholders while minimizing the negative effects on the planet and its resources.

Sustainable project management is an approach that integrates sustainability principles and practices into the project management processes, methods and tools. It aims to create value for the stakeholders while considering the environmental, social, and economic impacts of the project throughout its lifecycle. Sustainable project management also involves restoring and improving the natural systems that support human society and well-being. By adopting sustainable project management techniques, the construction industry can enhance its performance and outcomes, as well as contribute to the global goals of sustainable development and climate action.

The Nigerian construction industry plays a vital role in the country's economy and development, contributing 3.8% of the GDP in 2020 (National Bureau of Statistics, 2021). However, the industry also faces various challenges that affect its sustainability, such as poor project performance, low quality, prohibitive cost, time overrun, waste generation, environmental degradation, and social conflicts. The social challenges include conflicts among stakeholders, lack of awareness, and negative impacts on local communities. The environmental challenges include degradation, pollution, waste generation, resource depletion, and climate change, while the economic challenges include economic instability, cost overruns, low profitability, and low-value creation. Financial difficulties may arise due to fluctuations in global oil prices, exchange rates, inflation rates, and interest rates. High costs may result from poor quality, rework, delays, waste, corruption, or litigation. Addressing these challenges requires adopting sustainable project management techniques in the Nigerian construction industry. These challenges compromise the industry's ability to support the national vision of sustainable development. Therefore, it is essential to enhance the project management practices in the Nigerian construction industry to improve its sustainability performance and outcomes.

One of the possible ways to enhance project management practices is to adopt sustainable project management techniques. These are methods, tools and processes that consider the environmental, social, and economic impacts of the project throughout its lifecycle. They aim to create value for the stakeholders while minimizing the negative effects on the planet and its resources. Sustainable project management techniques also involve restoring and improving the natural systems that support human society and well-being. However, the adoption of sustainable project management techniques in the Nigerian construction industry is still limited and faces many barriers. Some of the barriers include lack of awareness, knowledge and skills, resistance to change, inadequate policies and regulations, insufficient incentives and support, and conflicting interests and expectations among stakeholders (Dubois & Silvius, 2020). Therefore, there is a need to understand how sustainable project management techniques can be adopted and implemented in the Nigerian construction industry and what are the factors that influence their adoption and impact.

The aim of this research is to address this need by investigating the prospects, challenges, and benefits of adopting sustainable project management techniques in the construction industry in Lagos State, Nigeria. This study utilises resource optimisation and rework reduction as measures of sustainable project management practices, while the performance of construction companies is measured by their economic, social, and environmental practices. Lagos State was chosen as the case study because it is the most populous and urbanized state in Nigeria and has many ongoing and planned construction projects. According to a report by ResearchAndMarkets.com (2020), Lagos State accounted for 26% of the total building construction projects in Nigeria in 2019.

The study aims to explore the impact of two key practices - resource optimization and rework reduction - on the sustainability of construction projects within Lagos State. Specifically, it seeks to:
Objective 1: Evaluate how optimizing resources influences the economic efficiency, societal benefits, and environmental protection of construction endeavors in the region.
Objective 2: Investigate the potential improvements in economic outcomes, social welfare, and environmental preservation that can result from minimizing rework in construction processes.

To guide this inquiry, the research poses the following questions:
Research Question 1: In what ways does the optimization of resources affect the economic prosperity, social progress, and environmental health of construction projects in Lagos State?
Research Question 2: How does reducing rework contribute to the economic viability, social improvement, and environmental integrity of construction projects in Lagos State?
The hypotheses formulated to drive the research forward are:
Hypothesis 1: Resource optimization significantly impacts the economic, social, and environmental sustainability of construction projects in Lagos State.
Hypothesis 2: Rework reduction significantly influences the economic, social, and environmental sustainability of construction projects in Lagos State.

These objectives, questions, and hypotheses will form the foundation of the study, aiming to shed light on the effectiveness of these practices in enhancing the sustainability of the construction industry in Lagos State.

Literature review

Sustainable project management practices

In today's world, sustainable project management has become an essential aspect of successful project execution. It broadens the traditional focus on time, cost, and scope to encompass environmental, social, and economic considerations (Blak et al., 2023). This holistic approach aims to deliver lasting value to stakeholders while minimizing negative impacts on the planet and society. One key element of sustainable project management is resource efficiency and waste reduction. Sustainable practices focus on optimizing resource use throughout the entire project lifecycle. This can involve employing recycled materials, minimizing energy consumption, and implementing lean processes to reduce waste (Chen et al., 2020). These strategies not only benefit the environment but also lead to cost savings and improved profitability through reduced material consumption and

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waste disposal expenses (Blak et al., 2023). Additionally, efficient resource management can streamline project execution, shortening cycles and enhancing output quality (Fesenko, 2022).

Sustainable project management goes beyond just resource management. It incorporates specific principles into all project phases, as outlined by Silvius et al. (2012). These principles include commitment and accountability from project leaders, ethical and environmentally conscious decision-making, transparent communication among stakeholders, and a focus on conserving and enhancing natural resources for future generations. Social and ecological equity are also crucial principles, ensuring projects promote fairness and reduce inequalities. Finally, sustainable project management fosters long-term economic prosperity that benefits all stakeholders, not just short-term gains. By adhering to these principles, sustainable project management can generate long-lasting societal benefits beyond the immediate project goals. Examples include job creation through sustainable infrastructure projects (United Nations Environment Programme (UNEP), 2020), improved public health through green building initiatives (Ding et al., 2023), and fostering social inclusion through equitable project development processes (World Bank, 2022).

The value of sustainable project management extends across all areas of project-based work, not just specific industries. Procurement teams, for instance, can prioritize sourcing materials from sustainable vendors and work to optimize supply chains to minimize environmental impact (Blome et al., 2018). Ultimately, all project professionals have a responsibility to ensure their work minimizes negative sustainability impacts or even contributes positively to long-term environmental and social well-being (Chen et al., 2020; Silvius & Schipper, 2014).

Resource optimization

Resource optimization goes beyond the mere allocation of human capital, equipment, materials, and finances. It encompasses the strategic management of these resources throughout the entire project lifecycle. The core objective is to utilize them in the most effective way possible to achieve project objectives across key performance indicators (KPIs) like cost, time, and quality (Jimoh et al., 2021). However, the focus has broadened to encompass sustainability goals as well. By minimizing waste generation, optimizing resource consumption, and adopting environmentally conscious practices, resource optimization contributes significantly to reducing a project's environmental footprint (Qu et al., 2024). Additionally, it helps mitigate resource-related conflicts within the project environment, ensuring smooth and efficient project execution (Peters et al., 2021; Shahzad et al., 2021).

Project managers have at their disposal a variety of techniques to ensure that resources are allocated in the most effective way possible. One such technique is resource levelling, which involves adjusting the project schedule to align with the availability of critical resources. When these resources are scarce, tasks that are not critical can be rescheduled, allowing for the efficient use of what is available and preventing bottlenecks in the workflow (Isang, 2023).

Another strategy is resource smoothing, which differs from resource levelling in that it maintains the original project schedule but redistributes resources within the available time. This method is particularly useful for preventing the overuse of resources during busy periods and their underuse during slower times, thus achieving a more even distribution of resource usage throughout the project (Aithal & Aithal, 2023).

In the realm of construction, project managers may also consider alternative methods such as prefabrication or off-site construction. These approaches help to reduce the environmental impact of construction by minimizing the activities and materials used on-site, thereby supporting the sustainability of the project. They also offer additional benefits, such as enhancing safety measures and reducing the time needed to complete the project (Papal & Kalokhe, 2022).

The benefits of resource optimization extend far beyond mere efficiency gains. It contributes significantly to creating long-term value for project stakeholders. By minimizing waste and environmental impact, projects become more competitive and gain a sustainable edge in the marketplace (Qu et al., 2024). Furthermore, resource optimization fosters a positive project reputation by showcasing a commitment to environmental responsibility and sustainable practices – a key differentiator in today's environmentally conscious business landscape. Recent research by Qu et al. (2024) highlights the positive correlation between resource optimization and project team morale and productivity. By ensuring efficient resource allocation and minimizing resource conflicts, project managers can create a more positive work environment, leading to increased team engagement and improved project outcomes.

The United Nations (2015) emphasizes that successful resource optimization hinges on meticulous planning, forecasting, and allocation of resources. Project managers must schedule and utilize resources strategically to ensure they contribute effectively to achieving defined project objectives. As project complexity continues to rise and environmental concerns intensify, resource optimization will remain a cornerstone of successful project delivery in the years to come. Recent studies by Hijji et al. (2022), Almansour (2023), and Taboada et al. (2023) suggest that integrating resource optimization with digital project management tools and techniques can further enhance its effectiveness, leading to even greater project success rates.

In conclusion, resource optimization is no longer an optional add-on in project management; it's a core competency. It fosters responsible project execution, maximizes stakeholder value, and minimizes negative environmental impact. By embracing resource optimization practices and continuously refining techniques, project managers can navigate a world of increasing complexity and deliver projects that are not only successful but also sustainable for the future.

Rework reduction

Rework reduction, the practice of minimizing or eliminating the need to redo or correct faulty tasks or products, has become a crucial element in successful project management. It extends beyond simply improving efficiency; it contributes to project quality, profitability, and environmental responsibility. By minimizing rework, projects generate less waste, incur lower costs, and reduce their environmental footprint (Qu et al., 2024). To effectively mitigate the need for rework, several strategies can be employed, each addressing different aspects of project management and execution.

Establishing a robust quality management process is fundamental to achieving consistent and error-free work. This process involves setting clear standards and guidelines for each task or product, followed by rigorous quality checks at every project stage. Such checks ensure that the work adheres to the set standards, thereby preventing defects from progressing through the project lifecycle and necessitating rework (Chong & Low, 2006; Willar et al., 2023). Recent research by Akindele et al. (2023) underscores the value of integrating digital tools with traditional quality management methods. These digital tools

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enable real-time quality monitoring, which allows for the immediate identification and correction of issues, significantly reducing the need for rework.

Meticulous planning and scheduling are also crucial in minimizing rework. Effective project planning entails the advance scheduling of resources—including human capital, equipment, and materials—and activities. This foresight helps to prevent delays, interruptions, and last-minute changes that can disrupt workflows (Kumar et al., 2019). Additionally, employing advanced planning techniques such as Building Information Modelling (BIM) can improve project visualization and coordination, thereby decreasing the likelihood of errors and subsequent rework, especially in construction projects (Awasho & Alemu, 2023).

Also, leveraging checklists and documentation is a proactive strategy that ensures all necessary steps and requirements are completed and recorded for each task. Checklists help prevent omissions or overlooked details that could lead to rework. Furthermore, maintaining thorough documentation throughout the project is essential for promoting transparency, facilitating communication, and enabling knowledge transfer, thus minimizing the risk of errors that arise from misunderstandings or incomplete information (Willar et al., 2023).

Strategic task assignment and skill development are critical components in the management of any project. Assigning tasks strategically, based on the individual skills and experience of team members, is essential. When tasks are matched with the right personnel, it significantly increases the chances of tasks being completed correctly and efficiently, thereby reducing the need for any rework. Kumar et al. (2019) highlight the importance of this alignment for project success.

In addition to careful task assignment, continuous training and development of project personnel cannot be overstated. Such programs are crucial for providing team members with the up-to-date knowledge and skills required to perform their duties effectively. By investing in upskilling and reskilling initiatives, organizations can address existing knowledge gaps among their staff. This is particularly important in reducing the likelihood of errors that stem from a lack of expertise, which in turn minimizes the demands for rework. Awasho and Alemu (2023) emphasize the value of continuous learning and development in maintaining a competent and efficient workforce, capable of meeting the evolving demands of the industry.

The benefits of minimizing rework extend far beyond mere cost savings and efficiency gains. Rework reduction contributes significantly to creating long-term value for project stakeholders. By delivering high-quality work on time and within budget, projects gain a competitive edge and enhance their reputation for reliability (Qu et al., 2024). Additionally, a strong commitment to minimizing rework fosters a culture of quality and continuous improvement within the project team.

Furthermore, reducing rework aligns perfectly with the growing emphasis on sustainability in project management. By minimizing waste generation, optimizing resource utilization, and ensuring efficient project execution, rework reduction strategies contribute positively to a project's environmental footprint (Willar et al., 2023). Effective rework reduction necessitates commitment, accountability, and open communication among all project stakeholders. Project managers must foster a collaborative environment where team members feel empowered to voice concerns and identify potential issues early on. Additionally, promoting knowledge sharing and lessons learned from past projects can contribute significantly to minimizing rework in future endeavours (Kumar et al., 2019).

In conclusion, minimizing rework is no longer just a desirable outcome; it's a core competency in project management. By implementing robust strategies that emphasize quality, planning, knowledge management, and collaboration, project managers can deliver successful projects while upholding environmental responsibility and maximizing value for all stakeholders. As project complexity grows and sustainability concerns intensify, continuous improvement in rework reduction practices will remain essential for ensuring the long-term success of projects in the years to come.

Economic, social, and environmental sustainability of construction companies

The concept of sustainable construction has transcended a mere trend; it's become a core principle for responsible and successful project delivery. It embodies the ability to meet the current needs of a construction project without compromising the ability of future generations to meet their own (Isang & Ebiloma, 2023). Achieving this necessitates a holistic approach that balances economic, social, and environmental considerations throughout the entire project lifecycle. Construction companies that embrace this balanced approach are not only contributing to a sustainable future but also enhancing their own long-term success.

Economic sustainability focuses on ensuring the financial viability and long-term success of the construction company. Several key practices contribute to this objective. Minimizing waste and optimizing resource use through techniques like lean construction methodologies can lead to significant cost savings (Qu et al., 2024). Additionally, prioritizing quality management and minimizing rework reduces unnecessary expenditures and project delays. Exploring alternative construction methods, such as prefabrication or modular construction, can lead to increased efficiency and cost savings (Almansour, 2023). Furthermore, pursuing sustainable certifications like LEED (Leadership in Energy and Environmental Design) can enhance a company's market value and attract environmentally conscious clients (Schipper & Silvius, 2018).

Social sustainability focuses on the well-being of the people and communities impacted by construction projects. Construction companies have a responsibility to prioritize the health and safety of their workers by implementing rigorous safety protocols and providing proper training (Haslam et al., 2020). Additionally, creating comfortable and healthy spaces for building occupants contributes to improved occupant well-being and overall building performance (Feige et al., 2013; Kulkarni et al., 2024). Furthermore, social sustainability practices encompass promoting skills development and training opportunities for local communities, fostering social inclusion, and respecting cultural heritage (United Nations, 2015). By prioritizing these aspects, construction companies can build trust and positive relationships with stakeholders, leading to a more sustainable and equitable future.

Environmental sustainability focuses on minimizing the negative impact of construction projects on the environment. Construction companies can achieve this through various practices. Reducing greenhouse gas emissions through energy-efficient construction methods, utilizing renewable energy sources, and minimizing transportation needs are crucial steps (Almansour, 2023; Chen et al., 2020). Additionally, construction companies can prioritize waste reduction by implementing recycling initiatives and using sustainable materials with lower embodied energy (Kulkarni et al., 2024). Furthermore, minimizing water consumption during construction and promoting water-efficient practices in the final building design contributes significantly to environmental sustainability. Protecting ecosystems and biodiversity by minimizing land use and employing responsible sourcing practices for materials are also essential aspects of environmental sustainability (United Nations Environment Programme (UNEP), 2020). By prioritizing these practices,

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construction companies contribute to environmental conservation, comply with evolving environmental regulations, and play a crucial role in achieving global sustainability goals outlined in the UN's Sustainable Development Goals (SDGs).

The construction industry has a significant role to play in achieving the SDGs, which address critical economic, social, and environmental challenges facing our planet. Through innovation, collaboration with stakeholders, and continuous improvement in sustainability practices, construction companies can create enduring value for society while minimizing their environmental footprint. By embracing a balanced and holistic approach to economic, social, and environmental sustainability, construction companies can pave the way for a more sustainable and prosperous future for generations to come.

Triple Bottom Line theory

Elkington (1994) introduced the concept of the triple bottom line. He argued that companies should measure their performance not only by their financial results but also by their social and environmental impacts. He proposed that there should be three bottom lines: profit, people, and the planet. He aimed to promote sustainability in business practices, in which companies consider the economic, social, and environmental aspects of their activities and their consequences for the present and future generations. The triple bottom line theory had some benefits, such as helping companies create value for their stakeholders while minimizing the negative effects on the planet and its resources (Elkington, 1994). It also encouraged companies to adopt innovative and responsible solutions to address the economic, social, and environmental challenges of the world (Norman & MacDonald, 2004). Furthermore, it enhanced the reputation, marketability, and value of the companies that adopted it (Norman & MacDonald, 2004). The theory also aligned with the global goals of sustainable development, such as the United Nations' Sustainable Development Goals (SDGs) (United Nations, 2015).

However, the triple bottom line theory also had some drawbacks, such as being difficult to measure and compare the social and environmental impacts of different companies and projects. There was no standard or universal method or indicator for assessing these impacts (Norman & MacDonald, 2004). It was also costly and time-consuming to implement and report on the triple bottom line. It required additional resources, data, and expertise to collect, analyse, and disclose the information (Norman & MacDonald, 2004). Moreover, it created conflicting or competing strategies across the three bottom lines. For example, some actions that increase profits may harm people or the planet, or vice versa (Norman & MacDonald, 2004). The theory was also criticized by some scholars and practitioners for being too vague and ambiguous to be useful for decision-making and accountability. It did not provide clear guidance on how to balance or prioritize the three bottom lines or how to resolve trade-offs among them (Norman & MacDonald, 2004). It was also based on a flawed assumption that there was a positive correlation between economic, social, and environmental performance. There may be a negative or no correlation between them, depending on the context and circumstances (Norman & MacDonald, 2004). Additionally, it was a form of greenwashing or window-dressing that allowed companies to claim sustainability without making significant changes to their core business models or practices. It may divert attention from the root causes of unsustainability and create a false sense of progress or achievement (Banerjee, 2008). The theory was supported by some organizations and movements that advocated for a business case for sustainability that considered economic, social, and environmental value creation. For example, the World Business Council for Sustainable Development (WBCSD), (Norman & MacDonald, 2004).

The theory was relevant to this study because it provided a framework for understanding and evaluating the sustainability performance of construction companies in Lagos State, Nigeria. The study could use the three bottom lines (profit, people, and planet) as indicators or criteria for measuring how resource optimization and rework reduction affected the economic, social, and environmental practices of construction projects in Lagos State. The study could also use the theory to identify and analyse the prospects, challenges, and benefits of adopting sustainable project management techniques in construction projects in Lagos State.

Empirical review

Jimoh et al. (2021) conducted a study on sustainable construction in the Nigerian construction industry. They identified the unsustainable construction practices on construction sites, the barriers to sustainable construction and strategies to improve sustainable construction in Nigeria. They used a questionnaire survey of fifty construction sites and descriptive and inferential analysis of the data. They found that there is a disparity in the ranking of unsustainable practices, barriers, and strategies among the respondents. They also suggested that cooperation, partnership, participation, protection of biodiversity, conservation of natural resources, and sustainability assessment systems are some of the key strategies used to promote sustainable construction in Nigeria. Isang and Ebiloma (2023) explored the challenges and strategies for sustainable project performance in the Nigerian construction sector in the post-Covid era. They used a qualitative research method with data collected from thirteen stakeholders in the built environment. They employed percentages and thematic analysis to analyse the data. They revealed that stakeholders are facing operational and financial challenges such as increased price of materials, labour and material shortage, project delays, increased construction cost, reduced profit, and payment delays. They also developed managerial, contractual, and governmental strategies to address these challenges, such as market surveys and bulk purchases, remote working and adherence to COVID-19 protocols, contracts reviews, smart contracts, working overtime and night shift, provision of funds, loans, and incentives for workers.

Akinshipe et al. (2019) examined the level of awareness and implementation of sustainable construction practices among construction firms in Nigeria. They used a questionnaire survey of fifty construction firms and descriptive statistics to analyse the data. They showed that a substantial percentage (76%) of construction firms in Nigeria are aware of sustainable construction, but only 38% have implemented it in their projects. They also identified the drivers, benefits, and barriers of sustainable construction from the firm-level perspective. They suggested that government policies, client demand, cost savings and environmental protection are some of the drivers and benefits, while lack of awareness, lack of technical expertise, lack of incentives and high initial cost are some of the barriers.

Research methods

This study used a cross-sectional survey research design to examine how sustainable project management practices affect the performance of construction companies in Lagos State, Nigeria. The study aimed to test two hypotheses using covariance-based structural equation modelling (CB-SEM), a statistical method that allows you to evaluate complex relationships among multiple variables using latent constructs. The study population consisted of all 232 staff members working at the Project Management Offices of the selected companies and engaged in various construction projects. The study sample was determined using a simple random sampling technique, which selected a random number

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of participants from the population without any subgrouping or stratification. The sample size was calculated using Krejcie and Morgan table with a margin of error of 0.05. The final sample size was 172, which consisted of eighty participants from Arab contractors and ninety-two participants from Arbico Plc.

Data was collected from July to September 2023 through online questionnaire distribution. To analyse the data, IBM SPSS AMOS 28, a software program that allows the use of CB-SEM, was used. The latent constructs in this study were resource optimisation (RO), rework reduction (RR), economic sustainability (EcoSus), social sustainability (SocSus) and environmental sustainability (EnvSus). The measurement model of the study was evaluated according to the criteria of reliability, convergent validity, and discriminant validity (Hair et al., 2010). The results showed that all the constructs met the required standards of reliability and validity, as shown in Table 1 and Table 2. The results also indicated that there was no problem with common method bias in the data, as the total variance extracted by one factor was 26.32%, which was less than the recommended threshold of 50%. The structural model of the study was evaluated according to the criteria of model fit, path coefficients, and effect sizes (Hair et al., 2017). The results showed that the model had a good fit with the data and supported both hypotheses, as shown in Figure 1 and Table 3.

Data analysis and results

To support the research model, the research questions, and the hypotheses, this part displays the different analyses of the data obtained via the survey questionnaire (Tables 1, 2, 3 and Figure 1).

Measurement model

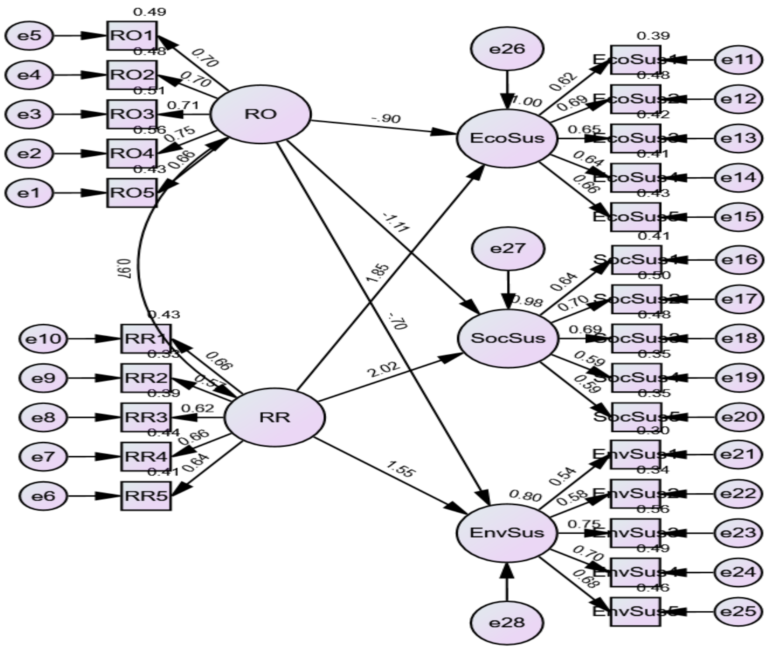

Figure 1. Measurement model
Source: own processing based on data analysis

This study performed a Confirmatory Factor Analysis (CFA) using SPSS AMOS to evaluate the measurement model. The factor loadings for each item were assessed as part of the

CFA. The model's overall goodness of fit was measured using the model-fit indices (CMIN/df, GFI, CFI, TLI, SRMR, and RMSEA), and all values met their corresponding common acceptability criteria (Bentler, 1990; Hu & Bentler, 1998; Ullman, 2006). The three-factor model (Stakeholders' Engagement, Stakeholders' Satisfaction, and Project Performance) showed an excellent fit (Table 1) for the data: CMIN/df = 2.572, GFI = .934, CFI = .951, TLI = .957, SRMR = .04, and RMSEA = .04. Figure 2 displays this model.

Table 1. Model fit

Fit Indices	Recommended Value	Source(s)	Obtained Value
P	Insignificant	Bagozzi and Yi, (1988)	.000
CMIN/df (Chi-	3-5	Less than 2 (Ullman, 2006) to 5	2.572
GFI	>.90	Hair et al. (2010)	.934
CFI	>.90	Bentler (1990)	.951
TLI	>.90	Bentler (1990)	.957
SRMR	<.08	Hu and Bentler (1998)	.04
RMSEA	<.08	Hu and Bentler (1998)	0.4

Source: own processing based on data analysis

Table 2. Loadings, reliability, and convergent validity

Items	Loadings	Cronbach's Alpha	Composite Reliability	AVE
Resource Optimisation		.831	.833	.599
RO5	0.659			
RO4	0.753			
RO3	0.718			
RO2	0.698			
RO1	0.704			
Rework Reduction		.786	.785	.522
RR5	0.654			
RR4	0.685			
RR3	0.638			
RR2	0.598			
RR1	0.671			
Economic Practices		.787	.789	.528
EcoSus1	0.624			
EcoSus2	0.694			
EcoSus3	0.651			
EcoSus4	0.643			
EcoSus5	0.658			
Social Practices		0.78	0.779	0.514
SocSus1	0.642			
SocSus2	0.703			
SocSus3	0.69			
SocSus4	0.588			
SocSus5	0.591			
Environmental Practices		0.778	0.787	0.527
EnvSus1	0.544			
EnvSus2	0.582			
EnvSus3	0.745			
EnvSus4	0.702			
EnvSus5	0.676			

Source: own processing based on data analysis

This study used Cronbach's Alpha and Composite Reliability to evaluate the construct reliability. All constructs in the study had a Cronbach's Alpha value higher than the required threshold of 0.70 (Nunnally & Bernstein, 1994). Composite reliabilities ranged from 0.909 to 0.925, which were higher than the standard of 0.70 (Hair et al., 2010). Therefore, the study established composite reliability for each construct (Table 2). The study also calculated the convergent validity of the scale items using the Average Variance Extracted (Fornell & Larcker, 1981). The average variance extracted values were higher than the criterion of 0.50 (Fornell & Larcker, 1981). Thus, the scale used in the present study had the necessary convergent validity (Table 2).

This study assessed the discriminant validity of the test using the Fornell and Larcker Criterion and the Heterotrait-Monotrait (HTMT) Ratio. The Fornell and Larcker Criterion states that a construct has discriminant validity if its square root of AVE is higher than its correlation with other constructs in the study. However, this criterion has been criticized recently, and the HTMT Ratio, a new method to assess discriminant validity, has been used more frequently. The current study did not fully demonstrate discriminant validity using the Fornell and Larcker Criterion. However, using the HTMT Ratio, all ratios were below the required upper limit of 0.85 (Henseler et al., 2015). Therefore, the study established discriminant validity. Table 3 and Table 4 show the results of discriminant validity.

Table 3. Fornell and Larcker criterion

	RO	RR	EcoSus	SocSus	EnvSus
RO	0.773951	0.623	0.683	0.646	0.699
RR	-0.216	0.722496	0.639	0.608	0.652
EcoSus	0.223	-0.292	0.726636	0.692	0.691
SocSus				0.716938	0.882
EnvSus					0.725948

Source: own processing based on data analysis

Table 4. Heterotrait-Monotrait ratio

	RO	RR	EcoSus	SocSus	EnvSus
RO		0.623	0.583	0.547	0.501
RR			0.639	0.609	0.553
EcoSus				0.663	0.592
SocSus					0.584
EnvSus					

Source: own processing based on data analysis

Path analysis

A path analysis was performed using SPSS AMOS to evaluate the causal relationships between the variables. If the value of the CMIN/df, the goodness-of-fit indices (GFI) (Hair et al., 2010), the Tucker and Lewis (1973) index (TLI), and the Confirmatory fit index (CFI) (Bentler, 1990) is > .90, the path was considered to be well-fitting (Hair et al., 2010). Additionally, an adequate-fitting model was approved if the root mean square error of approximation (RMSEA) is between 0.05 and 0.08 and the standardised root mean residual (SRMR) estimated value is .05 (Hair et al., 2010). The path's fit indices, as shown in Table 1, were within the allowed range. The path analysis (see Figure 2) shows how resource optimization (RO) and rework reduction (RR) affect the three measures of sustainability: economic practices (EcoSus), social practices (SocSus), and environmental practices (EnvSus).

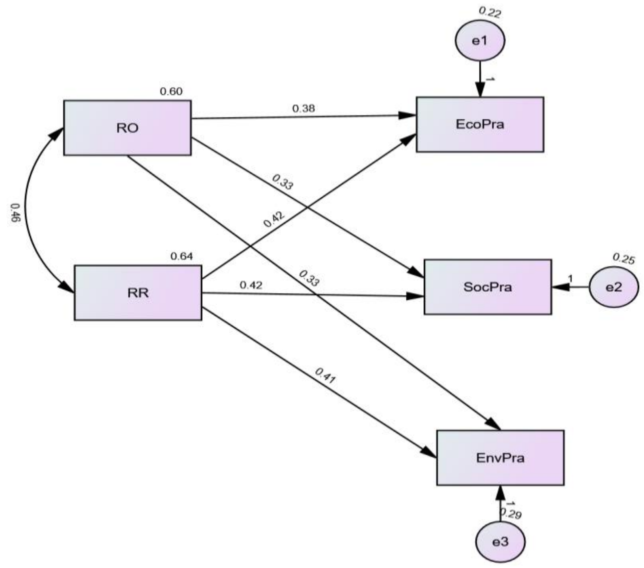

Figure 2. Path analysis
Source: own processing

The numbers on the arrows represent the standardized path coefficients, which indicate the strength and direction of the causal relationships between the variables. A positive number means that the variables have a positive relationship, meaning that as one variable increases, the other variable also increases. A negative number means that the variables have a negative relationship, meaning that as one variable increases, the other variable decreases. The closer the number is to 1 or -1, the stronger the relationship is. The closer the number is to 0, the weaker the relationship is.

The path analysis shows that RO has a strong positive relationship with Economic Sustainability (0.60), meaning that as RO increases, Economic Sustainability also increases. This suggests that optimizing resources can lead to better economic outcomes for construction companies. Resource Optimisation also has a positive relationship with Social Sustainability (0.39) and Environmental Sustainability (0.32), meaning that as Resource Optimisation increases, Social Sustainability and Environmental Sustainability also increase. This suggests that optimizing resources can also contribute to social and environmental benefits for construction companies, thus enhancing social and environmental sustainability.

The path analysis shows that Rework Reduction has a strong positive relationship with Environmental Sustainability (0.51), meaning that as Rework Reduction increases, Environmental Sustainability also increases. This suggests that reducing rework can lead to better environmental outcomes for construction companies. Rework Reduction also has a positive relationship with Social Sustainability (0.45), meaning that as Rework Reduction increases, Social Sustainability also increases. This suggests that reducing rework can also contribute to social benefits for construction companies. However, Rework Reduction has a weak negative relationship with Economic Sustainability (-0.12), meaning that as Rework Reduction increases, Economic Sustainability decreases. This suggests that reducing rework can have a negative impact on the economic outcomes for construction companies, possibly because of the costs involved in preventing or correcting errors.

The path analysis shows that Economic Sustainability, Social Sustainability, and Environmental Sustainability are positively correlated with each other, meaning that they tend to move in the same direction. This suggests that the three measures of sustainability

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are interrelated and mutually reinforcing for construction companies. For example, improving economic sustainability can also improve social and environmental sustainability and vice versa.

Discussion of findings

The findings of this study shed valuable light on the intricate relationship between resource optimization, rework reduction, and the various dimensions of sustainability in construction. The positive correlations between these practices and social and environmental sustainability metrics highlight the potential for construction companies to achieve positive societal and environmental outcomes by focusing on efficient resource management and minimizing rework. However, the observed weak negative relationship between rework reduction and economic sustainability warrants further exploration. Here, it's crucial to delve deeper into the potential reasons behind this counterintuitive finding. Perhaps rework reduction efforts are leading to increased upfront costs associated with implementing preventive measures or utilizing higher-quality materials. Future research could investigate these cost components to identify areas for optimization and ensure that the long-term economic benefits outweigh the initial investment. Additionally, exploring alternative strategies for rework reduction, such as improved communication and quality control processes, could potentially mitigate upfront costs while still achieving the desired reduction in rework.

The positive correlations observed between all three dimensions of sustainability (economic, social, and environmental) further emphasize the interconnected nature of sustainable construction practices. This aligns perfectly with existing research on the subject, which posits that achieving sustainability necessitates a holistic approach that balances all three dimensions (Almansour, 2023; Feige et al., 2013; Kulkarni et al., 2024). Essentially, optimizing resources and minimizing rework not only contribute to environmental benefits by reducing waste and emissions but also enhance social sustainability by creating safer work environments and promoting responsible resource management. Furthermore, these practices can lead to economic benefits through improved efficiency, cost savings, and enhanced project quality.

This study's contribution extends beyond simply confirming existing theoretical frameworks. By employing a robust statistical method and a large sample size, the research provides valuable empirical evidence for the positive impact of sustainable project management practices on construction companies in Lagos, Nigeria. This regional focus is particularly significant as developing countries often face unique challenges in implementing sustainable construction practices due to factors like limited awareness, educational gaps, regulatory hurdles, and technological constraints (Akindele et al., 2023). The study's methodology, using CB-SEM (Covariance-Based Structural Equation Modelling), offers a valuable tool for future research endeavours investigating the complex relationships within sustainable construction project management. Moreover, the study proposes a roadmap for prioritizing sustainability-focused construction and retrofitting projects in Nigeria. In the context of advancing sustainability in the construction industry, a comprehensive approach is essential. This approach may include a variety of strategies, although not exhaustively outlined in the present discussion.

One pivotal aspect is the promotion of awareness and education. Capacity-building initiatives are vital for construction professionals, policymakers, and the public. Such initiatives are the cornerstone for nurturing a culture of sustainability within the industry, ensuring that all stakeholders understand the importance of sustainable practices and are equipped to implement them. Another critical element is the enhancement of regulatory frameworks. The development and strict enforcement of regulations that reward sustainable construction practices and impose penalties for activities detrimental to the environment can catalyse significant progress. These regulations serve as both a guide and a deterrent, ensuring that sustainability is not just an option but a mandatory practice in construction.

Innovation also plays a key role in this roadmap. By supporting research and development, the industry can discover and adopt innovative construction methods, materials, and technologies. These advancements should aim to reduce the environmental footprint of construction activities and make optimal use of resources, thereby contributing to the overall sustainability of projects.

Lastly, fostering collaboration among various stakeholders is indispensable. When architects, engineers, construction companies, and material suppliers come together, they create a synergy that can lead to the sharing of knowledge and the development of effective sustainability strategies. This collaborative effort, as noted by Schipper & Silvius in 2018, is instrumental in achieving the collective goal of a more sustainable construction industry.

Through these concerted efforts, the construction industry can make strides towards a future where economic growth, social responsibility, and environmental stewardship are in harmony (Akindele et al., 2023). By implementing these elements, stakeholders in the Nigerian construction industry can create an environment that prioritizes sustainable practices and fosters long-term economic growth, social well-being, and environmental responsibility.

The findings of this study offer a compelling message: optimizing resources, minimizing rework, and embracing a holistic approach to sustainability are not merely noble aspirations but essential cornerstones for the success of construction companies. By prioritizing these practices, construction companies can not only contribute to a healthier planet and a more equitable society but also enhance their own long-term competitiveness and profitability. Building upon this research, future studies can delve deeper into the economic implications of rework reduction strategies, explore the effectiveness of various sustainability interventions in developing countries, and identify innovative techniques for optimizing resource use throughout the entire construction project lifecycle. By continuously seeking new knowledge and implementing effective, sustainable practices, the construction industry can pave the way for a more sustainable and prosperous future for generations to come.

Conclusions

This study delves into the intricate web of relationships between resource optimization, rework reduction, and the multifaceted concept of sustainability in construction. The findings illuminate the predominantly positive correlations between these practices and social and environmental sustainability metrics. However, the observed weak negative relationship between rework reduction and economic sustainability warrants further investigation. Potential explanations for this counterintuitive finding could lie in increased upfront costs associated with implementing preventive measures or utilizing higher-quality materials. Future research can explore these cost components and identify strategies for optimizing them, ensuring long-term economic benefits outweigh initial investments. Additionally, investigating alternative rework reduction strategies, such as improved communication and quality control, could potentially mitigate upfront costs while achieving desired reduction levels. The positive correlations observed between all three dimensions of sustainability (economic, social, and environmental) reinforce the interconnectedness of sustainable construction practices. This aligns perfectly with existing research (Akindele et al., 2023; Almansour, 2023; Kulkarni et al., 2024), emphasizing that achieving sustainability necessitates a holistic approach that balances all three dimensions.

Practical implications and a roadmap for action

Beyond validating existing theory, this study offers valuable practical implications for construction companies in Lagos, Nigeria, and potentially other developing countries. The robust methodology employed, using CB-SEM (Covariance-Based Structural Equation Modelling), provides a valuable tool for future research endeavours investigating the complex relationships within sustainable construction project management. Furthermore, the study proposes a roadmap for prioritizing sustainability-focused construction and retrofitting projects in Nigeria. The envisioned roadmap for enhancing sustainability in the Nigerian construction industry, while not exhaustively detailed here, includes several critical elements.

Capacity building is a fundamental aspect of this roadmap. It involves promoting awareness and education among construction professionals, policymakers, and the public. This is a key step in cultivating a culture of sustainability within the industry, ensuring that all parties understand the importance of sustainable practices and are committed to implementing them. Another essential element is the development of a regulatory framework. By establishing and enforcing regulations that encourage sustainable construction practices and penalize activities that harm the environment, stakeholders can drive significant positive change. Such a framework not only guides industry practices but also ensures that sustainability becomes an integral part of the construction process. Support for innovation is also a crucial component of this roadmap. It entails backing research and development efforts that focus on creating innovative construction methods, materials, and technologies. These innovations should aim to minimize environmental impact and optimize resource utilization, thereby contributing to the sustainability of construction projects.

Collaboration among stakeholders is equally important. When architects, engineers, construction companies, and material suppliers work together, they can share knowledge and develop effective sustainability strategies. As noted by Schipper & Silvius in 2018, such collaboration is instrumental in fostering a comprehensive approach to sustainability.

By incorporating these elements, stakeholders in the Nigerian construction industry can establish a framework that not only prioritizes sustainable practices but also supports long-term economic growth, social well-being, and environmental stewardship. This holistic approach is essential for ensuring that the industry contributes positively to the nation's development and the well-being of its citizens.

Theoretical contributions and directions for future research

This study contributes to the body of knowledge on sustainable construction project management in several ways. First, it provides empirical evidence for the positive impact of sustainable project management practices on construction companies in a developing country context. Second, it highlights the need for further exploration of the economic implications of rework reduction strategies. Third, it underscores the importance of considering the interconnectedness of the economic, social, and environmental dimensions of sustainability.

The continuation of research in this field is crucial for the advancement of sustainable construction practices. Future studies could focus on a variety of areas to deepen our understanding and enhance the effectiveness of these practices.
One area of interest is the economic impact of rework reduction. Through detailed cost analyses, researchers can pinpoint the specific cost components that are affected by rework reduction strategies. This would allow for a more targeted approach to optimization. Additionally, such research could shed light on the long-term economic benefits of rework reduction, which may include increased project efficiency and a decrease in warranty claims.

Another promising area for research is the examination of sustainability interventions in developing countries. Studies could assess the effectiveness of various interventions, like green building rating systems, and their role in promoting sustainable construction practices. This line of inquiry could also uncover the unique challenges and opportunities that arise when implementing these practices in different regional contexts.

Lastly, the optimization of resources throughout the project lifecycle presents a rich field for investigation. Researchers could explore innovative techniques for maximizing resource efficiency from the design phase through to procurement, construction, and even demolition. The potential for integrating digital technologies, such as Building Information Modelling (BIM), in facilitating these efforts is particularly noteworthy. Such technologies could play a pivotal role in streamlining resource optimization.

By persistently pursuing new knowledge and applying effective, sustainable practices, the construction industry can move towards a future where environmental responsibility, social well-being, and economic prosperity are not just ideals but realities.

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