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INVESTIGATING EVIDENCE OF SUSTAINABLE PROCUREMENT, LIFE CYCLE COST EFFICIENCY AND ENVIRONMENTAL PERFORMANCE IN THE FEDERAL CAPITAL TERRITORY ABUJA, NIGERIA

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Abstract

The building industry is a significant contributor to global resource consumption and emissions, accounting for a significant portion of energy demand and carbon dioxide (CO_2) emissions. Sustainable public procurement is promoted progressively, as a challenging driver for cleaner production because these procurement decisions shape the choices of materials, behavior of contractors, and the impacts of life cycles. However, in most developing countries, it is still not clear whether sustainable procurement translates into measurable life cycle cost efficiency in public construction systems. The effects of sustainable procurement practices on life cycle cost efficiency and environmental performance in public construction projects in Abuja, Nigeria's Federal Capital Territory was evaluated. A mixed-method design was used, and evidence from survey data of 350 procurement and construction stakeholders, project-level evidence from 60 completed public projects, and semi -structured expert interviews were utilized. The data was analyzed using quantitative tests including correlation, t-test, and regression, and the results indicate that sustainable procurement is associated with significantly better environmental performance and improved life cycle cost efficiency. The findings explain that mechanisms such as cleaner production practices, waste prevention, enhanced energy efficiency, and upstream supplier and material selection provide more insights into these relationships. At the same time, they highlight essential constraints which include price-dominated tendering processes, limited life cycle costing capability, and organizational risk aversion. The study concludes that integrating sustainable procurement with life cycle cost consideration significantly enhances environmental performance and long-term value in public construction projects. It recommends that life cycle procurement frameworks that prioritize low-carbon materials be institutionalized.

Keywords: sustainable procurement; green public procurement; lifecycle costing; environmental performance; cleaner production.

1. Introduction

The construction sector has been identified progressively as an essential area for advancing sustainability and cleaner production owing to its intensive use of natural resources, energy consumption and generation of waste. Goh (2019) stated that construction activities exercise significant pressure on environmental systems, which makes the sector central to global sustainability efforts. However, experts have argued that onsite environmental controls alone cannot achieve sustainability in construction but requires early-stage interventions that shape decisions across the entire project life cycle (Sanchez-Flores et al., 2020). Rimtip and Ekekezie (2025) provide early empirical evidence that the adoption of alternative, low-carbon construction materials such as sugarcane bagasse ash can reduce material-related environmental impacts and long-term cost burdens, thereby reinforcing the role of sustainable procurement decisions in enhancing life cycle cost efficiency and environmental performance in public construction projects.

Sustainable procurement is one of the early-stage interventions which incorporate environmental, economic, and social considerations into decisions that pertain to purchasing and contracting (Delmonico et al., 2018). Okonta (2023), explained that sustainable procurement has evolved from a largely compliance-driven approach into a strategic management tool that shapes supplier behavior, guides material selection, and enhances long-term project performance. Procurement decisions in public construction are significant because they are determined not only by what is built, but by how it is built and operated over time (Ruparathna & Hewage, 2015). Sustainable procurement plays a crucial role in improving environmental performance. Esfahbodi et al., (2017) presented that most organizations that adopted Sustainability-oriented procurement practices achieved lower emissions, reduced waste, and improved resource efficiency. In similar studies, Alsharkawy et al. (2025), recorded that when sustainability criteria are integrated at the procurement stage, it enables environmental impacts to be addressed proactively rather than reactively, and this aligns strongly with cleaner production principles.

The economic implications of sustainable procurement practices have attracted a growing scholarly attention beyond environmental outcomes. Onubi et al. (2020), suggests that sustainable procurement can enhance cost efficiency by reducing waste-related expenses, improve operational performance, and minimize costs associated with environmental non-compliance. Nevertheless, Esfahbodi et al. (2016) cautioned that for emerging economies, these benefits are not always evident immediately primarily due to higher upfront costs and limited access to sustainable technologies. This has contributed largely to the persistent skepticism among public sector decision-makers regarding the cost implications of sustainability-oriented procurement. Therefore, Life cycle costing (LCC) has been widely endorsed as an instrument for reconciling environmental objectives with economic performance. Consequently, Vidal and Sánchez-Pantoja (2019), assert that rather than initial price alone, the LCC enables procurement decisions to reflect total cost of ownership thereby supporting more balanced and transparent tender evaluation. According to Husgafvel et al., (2022), the integration of life cycle-based tools

within public procurement systems is essential for advancing both sustainability and value for money.

Recent studies in the Nigerian Framework, have begun to explore sustainable procurement within public construction. Oyewobi and Jimoh (2022) observed that even though sustainability awareness is increasing, there is limited implementation due to weak institutional capacity and a continued emphasis on lowest cost tendering. On a similar note, Oke et al., (2025) noted that practices that are energy-efficient and sustainability-oriented are often constrained by regulatory, financial, and knowledge-based barriers. Within Abuja's public construction environment, these challenges raise important questions about whether sustainable procurement in practice is delivering measurable cleaner outcomes. Traditionally, prioritizing lowest initial cost has been the primary criterion for contract award in public construction procurement systems. Vidal and Sánchez-Pantoja (2019) noted that this price dominated approach persists because it is viewed as transparent, auditable, and risk-averse within the governance of the public sector. However, according to (Sanchez-Flores et al., 2020; Onubi et al., 2020), researchers have argued that such an approach often challenges the performance of long-term projects by overlooking life cycle costs, environmental externalities, and operational inefficiencies.

These challenges are intensified by capacity and institutional constraints in emerging economies. Delmonico et al., (2018), noted that sustainable public procurement initiatives often remain at the policy level owing to the limited technical expertise, inadequate assessment tools, and organizational resistance to change. In the same way, Montalbán-Domingo et al., (2018) reasoned that sustainability criteria are often fused superficially into procurement procedures, which puts little influence on selection of contractor or project delivery decisions. Within Nigeria's context, Abuja based evidence, mirrors comparable limitations. Sustainable procurement practices according to Oyewobi and Jimoh (2022) are constrained by weak regulatory enforcement and limited practitioner understanding of life cycle cost analysis. Oke et al., (2025), also noted similarly that the procurement practices that limit the successful implementation of procurement processes that bring about sustainability are aversion of risk, financial restrictions, and low stakeholder capacity. Subsequently, in public construction a gap critical gap exists between the conceptual promise of sustainable procurement and its measurable outcomes. Although prior research has studied awareness levels and implementation barriers, empirical evidence that demonstrates whether sustainable procurement improves life cycle cost efficiency and environmental performance is still limited, or even whether environmental gains results in corresponding economic benefits. This study fills in these gaps by examining the following hypotheses:

(H1) Life cycle cost efficiency is greatly increased by sustainable procurement practices; **(H2)** Environmental performance is greatly improved by sustainable procurement methods.; and **(H3)** Environmental performance and life cycle cost efficiency is positively correlated. By doing this, the study supports cleaner production-oriented procurement reform in public construction with integrated, life cycle-based evidence.

2. Literature Review

Existing studies increasingly view public construction procurement as more than an administrative process, recognizing it as a key lever for achieving long-term economic and environmental sustainability (Ruparathna & Hewage, 2015). The literature shows that procurement choices influence not only upfront costs, but also material selection, construction practices, operational efficiency, and environmental performance over a project's entire life cycle (Delmonico et al., 2018; Vidal & Sánchez-Pantoja, 2019). In response, researchers have proposed value-based and lifecycle-oriented procurement approaches that integrate sustainability and environmental criteria into public sector decision-making (Husgafvel et al., 2022). However, evidence from emerging economies such as Nigeria indicates that these approaches are often weakly implemented due to institutional barriers, inadequate policy incentives, and the continued dominance of linear procurement frameworks (Oyewobi & Jimoh, 2022; Oluleye et al., 2025). Consequently, literature underscores the need for context-specific empirical research to better understand how sustainable procurement can translate into improved life cycle cost efficiency and environmental performance in public construction projects.

2.1 Sustainable Procurement in Public Construction

In public construction, sustainable procurement is becoming more widely acknowledged as a tactical tool for enhancing long-term project outcomes. Sustainable procurement, according to Goh (2019), entails satisfying an organization's needs for labor, products, and services in a way that minimizes environmental damage and produces broader societal benefits while delivering value for money throughout the entire life cycle. This viewpoint shifts procurement from a narrow emphasis on the lowest initial cost to a more comprehensive consideration of life cycle value.

Supply-chain and organizational practices that incorporate sustainability principles are closely related to sustainable procurement. According to Okonta (2023), rather than treating sustainability as an afterthought, effective sustainable procurement necessitates the early establishment of environmental and social standards with suppliers. This early integration is especially crucial in public construction settings since procurement choices have a significant impact on long-term operational performance, construction techniques, and material selections.

However, adoption of sustainable procurement is still uneven in developing economies. According to Delmonico et al. (2018), institutional rigidity, a lack of technical capacity, and lax enforcement mechanisms frequently limit the application of sustainability principles in procurement practice, despite their widespread recognition in policy discourse. These issues are clear in Nigeria's public construction industry, where price-based tendering is still given priority by procurement systems despite growing sustainability concerns.

2.2 Sustainable Procurement and Environmental Performance

Environmental performance and sustainable procurement are positively correlated, according to a substantial body of research. Organizations that incorporate environmental considerations into procurement decisions typically see decreased emissions, decreased waste production, and increased resource efficiency (Esfahbodi, , Zhang, Watson, & Zhang, 2017). Cleaner construction technologies, environmentally certified suppliers, and the use of environmentally friendly materials are the main factors influencing these results.

Alsharkawy et al. (2025) went on to say that rather than concentrating only on compliance during the building phase, sustainable procurement enhances environmental performance by promoting systematic environmental evaluation throughout the project life cycle. This is consistent with the increasing focus on lifecycle-based assessment instruments, especially life cycle assessment (LCA). LCA, according to Delmonico et al. (2018), enables decision-makers to find environmental "hotspots" early in the project, preventing avoidable environmental costs.

Ehiosun et al. (2025) noted that improvements in environmental performance are frequently mediated through the roles of Health, Safety, and Environment (HSE) officers in the Nigerian construction context. The authors claim that HSE specialists are increasingly taking on the role of sustainability advocates, encouraging ecologically friendly project planning and implementation. However, limited authority within procurement decision-making structures limits their efficacy, indicating that environmental gains are still only partial rather than systemic.

2.3 Sustainable Procurement and Life cycle Cost Efficiency

Sustainable procurement has been closely associated with life cycle cost efficiency in addition to environmental outcomes. Onubi et al. (2020) state that the main sources of cost savings from sustainable procurement are decreased energy use, less material waste, fewer maintenance needs, and avoidance of fines related to environmental non-compliance. These savings are frequently realized during the operational phase. The literature does, however, also draw attention to significant trade-offs. According to Esfahbodi et al. (2016), due to higher upfront costs and restricted access to sustainable technologies, sustainable procurement does not always result in immediate cost savings in emerging economies. This has contributed to persistent skepticism among public sector decision-makers, who often perceive sustainable procurement as financially risky.

As a result, life cycle costing (LCC) has been promoted as a crucial instrument for resolving this conflict. According to Vidal and Sánchez-Pantoja (2019), LCC makes it possible for procurement decisions to take into consideration expenses related to construction, operation, maintenance, and end-of-life phases. Husgafvel et al. (2022) suggest that public procurement decisions are more likely to favor solutions that provide long-term economic and environmental value when LCC and environmental assessment are combined. Oluleye et al. (2025) revealed that projects in Nigeria that used circular economy and lifecycle thinking principles outperformed traditional

linear construction methods in terms of eco-efficiency. However, the authors noted that institutional resistance, skill shortages, and data gaps continue to limit the use of LCC in public construction.

2.4 Circular Economy, Life cycle Thinking, and Procurement Decisions

Sustainable procurement is increasingly being positioned in recent literature as a crucial enabler of circular economy principles in the construction industry. Husgafvel et al. (2022) argued that procurement decisions shape supply-chain and design choices, which in turn affect material reuse, recyclability, and long-term system resilience. According to Oluleye et al. (2025), decision-makers can evaluate environmental impacts beyond project boundaries, such as end-of-life and reuse scenarios, by incorporating circularity indicators with life cycle assessment (LCA).

Evidence from Nigeria indicates that circular economy principles are still only loosely incorporated into public construction procurement despite these developments. According to the literature, this restriction reflects more general structural issues, such as underdeveloped recycling markets, insufficient policy incentives, and procurement frameworks that are still primarily linear in nature (Oyewobi & Jimoh, 2022; Oluleye, Chan, & Antwi-Afari, 2025).

2.5 Barriers to Sustainable Procurement in Public Construction

Despite the well-established advantages of sustainable procurement, many obstacles still stand in the way of its successful application. Montalbán-Domingo et al. (2018) state that resistance to change within public institutions, a lack of objective assessment tools, and a limited understanding of sustainability criteria are the main obstacles. According to Delmonico et al. (2018), these obstacles are especially noticeable in developing nations because of their inadequate institutional capacity and governance frameworks. Oke et al. (2025) noted other limitations in the Nigerian context, including low stakeholder awareness, insufficient regulatory enforcement, and financial constraints. The authors clarified that sustainable procurement runs the risk of remaining symbolic rather than transformative in the absence of focused capacity-building and policy reform.

Research consistently shows that sustainable procurement can improve lifecycle cost efficiency and environmental performance in public construction. Nevertheless, most of the research treats these results independently, and there is little empirical research looking at how they interact within public procurement systems in developing nations. Furthermore, life cycle cost implications are rarely quantified alongside environmental outcomes in Nigerian studies that are currently available. Thus, empirical research that concurrently looks at cost effectiveness, environmental performance, and sustainable procurement practices within a life cycle and institutional framework is clearly needed, according to the reviewed literature. In Nigeria's Federal Capital Territory, where there is a lot of public construction activity and procurement decisions have long-term sustainability implications, this gap is especially pertinent.

2.6 Conceptual Framework Mapping

The conceptual framework in figure 1 and Table 1 explains how sustainable procurement practices in public projects drive long-term economic and environmental outcomes through defined causal pathways. Sustainable procurement serves as an independent variable, encompassing life cycle-oriented tender criteria, value-based evaluation, and sustainable material selection. These practices operate through mediating mechanisms, such as life cycle-based decision-making and environmentally responsible construction processes, with environmental performance acting both as an outcome of procurement decisions and as a pathway through which economic benefits are realized. Life cycle cost efficiency represents the primary dependent variable, capturing value for money across the project life cycle. The relationships within the framework are influenced by moderating factors, including institutional capacity, policy and regulatory support, market readiness, and project characteristics, which collectively shape the effectiveness of sustainable procurement implementation.

Table 1: Conceptual framework summary

Component	Role in Framework	Function
Sustainable procurement practices	Independent variables	Initiate influence
Lifecycle decision processes	Mediating mechanisms	Explain how effects occur
Environmental performance	Mediator / Dependent	Pathway or outcome
Lifecycle cost efficiency	Dependent variable	Outcome
Institutional, policy, market factors	Moderators	Condition the relationships

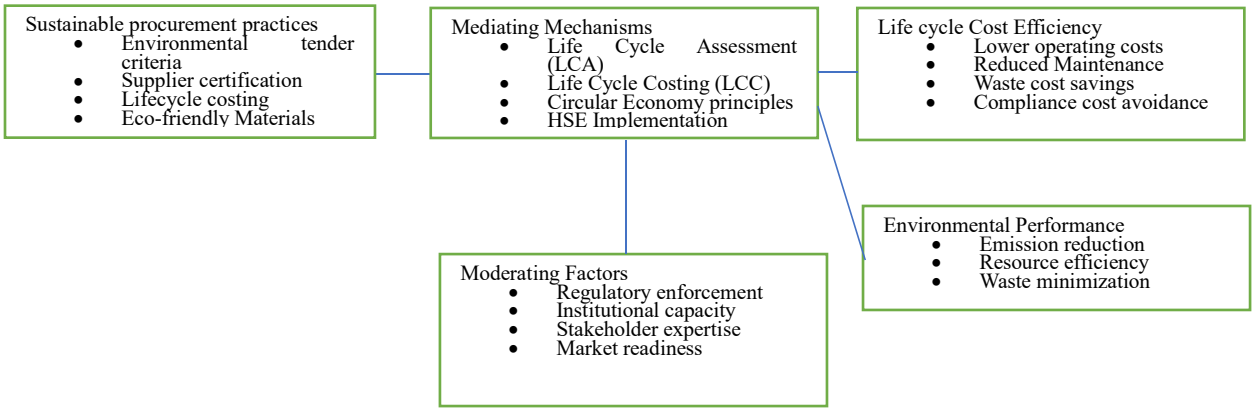

Figure 1: Author's Conceptual framework

3. Materials and Method

This study adopts a mixed-methods research approach to provide a comprehensive understanding of how sustainable procurement influences life cycle cost efficiency and environmental performance in public construction projects within Nigeria's Federal Capital Territory. The mixed-methods design enables the integration of quantitative evidence with qualitative insights, allowing both measurable outcomes and contextual factors to be examined in a complementary manner (Creswell & Plano Clark, 2018). Quantitative data is used to assess patterns and relationships among procurement practices, life cycle costs, and environmental performance indicators, while qualitative data help explain institutional, policy, and market conditions shaping procurement decisions. This methodological approach is particularly suitable for sustainability-oriented construction research, where complex interactions between technical, economic, and governance factors must be captured to generate robust and policy-relevant findings (Ruparathna & Hewage, 2015; Delmonico et al., 2018).

3.1 Study Area and Scope

The Federal Capital Territory (FCT) of Nigeria, Abuja, was the site of the study located between a latitude of 8°25′N to 9°20′N, and longitude of 6°45′E to 7°39′E (Wikipedia, 2025) figure 2. Abuja was chosen because of its concentration of federally funded public construction projects and its function as an administrative and policy center where national procurement laws are actively carried out (Oyewobi & Jimoh, 2022). The study concentrated on public construction projects carried out in Nigeria between 2018 and 2024, a time when sustainability, environmental compliance, and procurement reform received more attention.

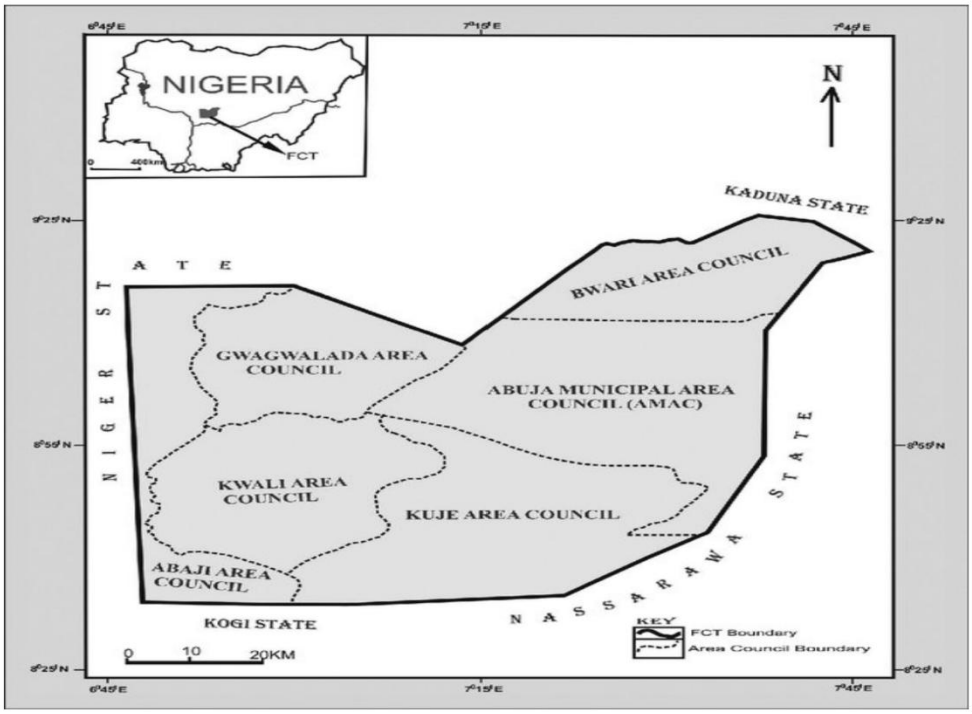

Figure 2: Map of Abuja (Source: Nwachukwu, 2014)

3.2 Quantitative Data Collection and Analysis

Quantitative data was collected using a structured questionnaire administered to key-built-environment professionals involved in public construction procurement and delivery. These respondents included procurement officers responsible for public purchasing decisions, project managers overseeing project planning and execution, engineers providing technical design and construction supervision, contractors engaged in project implementation, consultants offering professional advisory services, and environmental experts responsible for assessing and managing environmental impacts. To ensure balanced representation across institutional affiliations and professional categories, a stratified random sampling technique was adopted. In total, 350 valid responses were obtained and analyzed. R statistical software was used for data analysis because of its robustness, flexibility, and strong capability for handling complex statistical procedures, enabling reliable analysis, reproducibility, and transparent interpretation of the study's quantitative data. The characteristics of the respondents and their adoption levels of sustainable procurement were compiled using descriptive statistics.

3.3 Qualitative Design and Rationale

The study included a qualitative inquiry to improve explanatory insight. Given the institutional limitations of Nigeria's public procurement system, the qualitative component was intended to investigate how and why sustainable procurement practices affect cost and environmental outcomes. Such qualitative investigation is crucial in emerging economies where capacity and governance concerns significantly influence sustainability outcomes (Delmonico et al., 2018).

3.3.1 Qualitative Sampling and Data Collection

Participants who were directly involved in sustainability implementation or procurement decision-making were chosen using a purposive sampling technique (Creswell & Plano Clark, 2018). A total of 15 semi-structured interviews were conducted across stakeholders in procurement, project managers, consultancy, and contracting with at least five years of experience working on public projects were among the participants. An interview guide based on conceptual framework and literature was used to conduct semi-structured interviews (Delmonico et al., 2018). Procurement decision-making procedures, the use of sustainability standards, perceived cost consequences, environmental compliance procedures, and institutional difficulties were the main topics of interview questions. With participants' permission, interviews took place in English and lasted between thirty and sixty minutes.

3.3.2 Qualitative Data Analysis and Rigor

Thematic analysis was used to analyze qualitative data after a methodical process of familiarization, open coding, theme development, and refinement. Throughout the interviews, recurring themes included life cycle thinking, institutional risk aversion, cost perception versus actual performance, and regulatory influence. The study used established qualitative trustworthiness criteria to guarantee methodological rigor. Data triangulation from documents, interviews, and quantitative findings increased credibility. Transferability was addressed by providing a thorough explanation of the study context, while dependability and confirmability were bolstered by uniform interview protocols and transparent analytical techniques (Creswell & Plano Clark, 2018).

3.4 Ethical Considerations

Prior to data collection, ethical approval was acquired. Participation was voluntary, informed consent was secured, and confidentiality was maintained throughout the study. The only use of all the data was for scholarly research.

4. Results and Discussion

This section presents and discusses the findings of the study, drawing on both quantitative and qualitative data to explain how sustainable procurement practices influence life cycle cost efficiency and environmental performance in public construction projects within Nigeria's Federal Capital Territory. The results are first presented to highlight key patterns, relationships, and trends emerging from the data, followed by a critical discussion that interprets these findings considering the study's conceptual framework and existing literature. By integrating statistical evidence with stakeholder insights, this section provides an understanding of procurement practices, implementation challenges, and performance outcomes, while situating the empirical results within broader debates on sustainable public procurement and construction sustainability.

4.1 Extent of Sustainable Procurement Implementation

The findings from Table 2 and 3 demonstrate that, despite uneven implementation, sustainable procurement practices are becoming more widely acknowledged in Abuja's public construction projects. Nearly 23% of respondents were unsure whether sustainability principles were formally applied, whereas 77% of respondents said their companies had implemented some sort of sustainable procurement. This ambiguity implies that while sustainable procurement is frequently present at the policy or documentation level, project teams may not always clearly operate it. One of the interview responders mentioned that *"Sustainability is now mentioned in most tender documents, but many officers still treat it as a requirement to tick rather than a guide for decision-making."* This response is consistent with what the literature on cleaner production refers to as symbolic or compliance-driven adoption, in which life cycle thinking is not yet ingrained in standard procurement procedures but sustainability language is.

Table 3 summarizes respondents' perceptions of the level of sustainable procurement implementation in public construction projects. The results indicate that implementation is predominantly perceived as moderate (54.6%) or high (36.3%), while relatively few respondents reported low (4.6%) or very high (4.5%) levels, suggesting that although sustainable procurement practices are increasingly adopted, their application remains uneven and has yet to reach full maturity across the sector.

Table 2: Interview findings linked to the conceptual framework

Framework Component	Key Insight from Interviews
Sustainable Procurement (Independent Variable)	Sustainability is referenced in procurement documents but remains secondary to lowest-cost selection.
Lifecycle Decision Processes (Mediator)	Life cycle costing is acknowledged but rarely applied systematically due to capacity and budget constraints.
Environmental Performance (Mediator/Outcome)	Environmental compliance is largely regulatory-driven, with limited performance monitoring beyond approvals.
Lifecycle Cost Efficiency (Dependent Variable)	Stakeholders recognize long-term cost benefits, but short-term financial priorities dominate decisions.
Institutional & Market Factors (Moderators)	Weak institutional capacity, policy gaps, and limited market readiness constrain effective implementation.

Table 3. Extent of Sustainable Procurement Implementation

Implementation Level	Percentage (%)
Low	4.6
Moderate	54.6
High	36.3
Very High	4.5

4.2 Dominant Sustainable Procurement Practices

Figure 3 shows that the most popular sustainable procurement practice is environmental impact assessment (EIA), which is followed by waste management techniques and energy-efficient design considerations. Less often used were techniques that call for more sophisticated life cycle-oriented thinking, like supplier environmental certification, life cycle cost analysis, and the methodical use of recycled materials. It shows that upstream procurement interventions that provide greater life cycle benefits are often subordinated to visible, regulation-driven environmental actions by public construction organizations. An interview participant stated that *"EIA is mandatory, so we cannot avoid it. But life cycle costing is seen as optional, and many times we don't have the data or time to apply it properly."*, thereby supporting that EIA is the most known sustainable practice.

Figure 3. Common Sustainable Procurement Practices in Public Construction

4.3 Impact of Sustainable Procurement on Life cycle Cost Efficiency

A statistically significant positive correlation between life cycle cost efficiency and sustainable procurement practices was found through regression analysis seen in Table 4. When compared to projects completed through conventional procurement methods, those that used sustainable

procurement techniques showed better cost performance. From the perspective of cleaner production, this result bolsters the claim that, even in cases where initial capital costs are higher, sustainability-oriented procurement can eventually lower project costs. According to qualitative data, lower maintenance requirements, better energy performance, and decreased material waste were the main ways that cost efficiency gains were attained. A participant noted that *"At the beginning, some sustainable materials look expensive. But later, we spend less on repairs and energy, and that saves money in the long run."* The findings do, however, also demonstrate that improvements in cost efficiency were not automatic. Organizations found it difficult to measure long-term savings when life cycle cost analysis was not formally implemented, which exacerbated short-term cost concerns.

Table 4. Regression Results: Sustainable Procurement and Life cycle Cost Efficiency

Predictor	**β**	**p-value**
Sustainable procurement extent	0.37	<.001
Sustainable procurement adoption	0.88	<.001

Source: Author's findings

4.4 Impact of Sustainable Procurement on Environmental Performance

The findings from figure 3 show that sustainable procurement has a significant positive impact on environmental performance. Higher levels of sustainability integration were associated with better results in terms of waste reduction, resource efficiency, and emission reduction. From the standpoint of cleaner production, this validates the significance of proactive tactics used during the procurement phase as opposed to reactive environmental controls during construction. Compared to projects that only relied on post-award supervision, those that integrated environmental criteria into tender evaluation consistently improved the environment. This distinction was elucidated by one interview participant stating that *"If sustainability is considered when choosing contractors and materials, environmental performance improves naturally. If it comes later, we are only managing problems."*

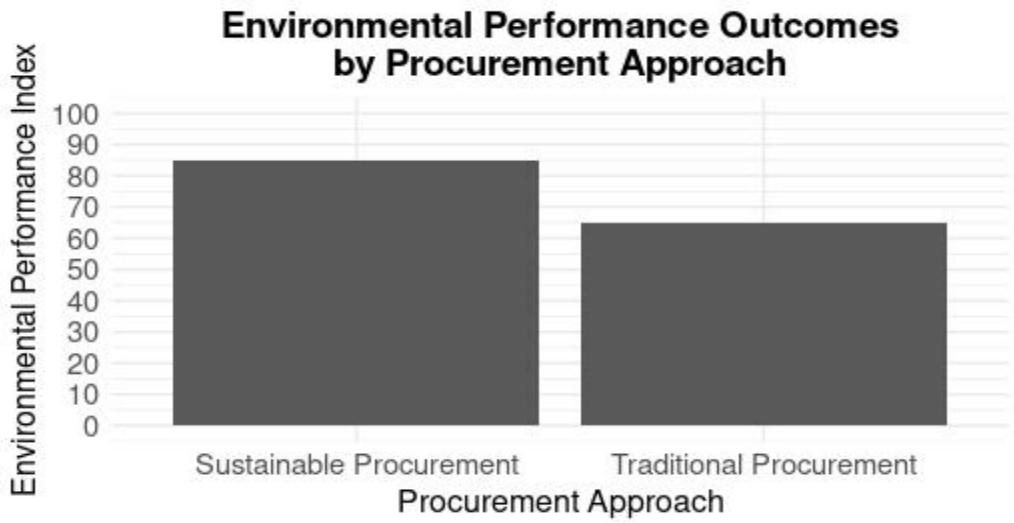

Figure 4. Environmental Performance Outcomes by Procurement Approach

4.5 Relationship Between Lifecycle Cost Efficiency and Environmental Performance

Life cycle cost efficiency and environmental performance were found to be strongly positively correlated as seen in Table 5, suggesting that projects that achieved better environmental outcomes also tended to perform better economically over the course of their life cycle. This finding challenges the long-held belief that environmental improvements inevitably result in higher costs, making it especially significant for the discourse surrounding cleaner production. Rather, the findings point to a mutually reinforcing relationship that is fueled by better resource utilization, decreased waste, and increased energy efficiency. This synergy was succinctly described a participant stating that *"When you reduce waste and energy use, you are automatically reducing cost. The two cannot really be separated."*

Table 5. Correlation Between Life cycle Cost Efficiency and Environmental Performance

Variables	r	p-value
Cost efficiency ↔ Environmental performance	0.71	<.001

4.6 Institutional and Implementation Insights

Respondents' responses from the interviews indicate that institutional limitations still prevent deeper sustainability integration, despite the favorable performance results. Rigid procurement regulations, a lack of technical capability, and risk-averse decision-making cultures were often mentioned by respondents as significant obstacles. For example, a respondent stated that *"Even*

when we know a sustainable option is better in the long run, approval is difficult because the system still rewards the lowest price". Despite their proven advantages, life cycle costing and circular economy concepts are still not widely applied, which can be explained by these limitations. Procurement frameworks must transition from price-based compliance models to performance- and life cycle-oriented decision systems to fully realize cleaner production.

5. Conclusion

This study examined how sustainable procurement methods affected environmental performance and life cycle cost efficiency in public construction projects in Abuja, Nigeria. The results, which were obtained using a mixed-methods approach, show that sustainable procurement greatly enhances economic and environmental outcomes over the course of a project. Compared to projects that were traditionally procured, those that incorporated sustainability criteria during the procurement process saw reduced waste, increased resource efficiency, and better long-term cost performance.

Crucially, the findings demonstrate that environmental performance and cost effectiveness are complementary rather than antagonistic goals. However, the study also shows that lifecycle costing and sophisticated sustainability tools are used sparingly, and sustainable procurement is primarily implemented at the compliance level. Deeper integration is still hampered by institutional rigidity, risk aversion, and capacity limitations. The results validate sustainable procurement as an essential upstream mechanism for promoting cleaner production in public construction, if it is integrated methodically rather than selectively.

6. Recommendations

The study suggests that public authorities formally incorporate life cycle cost analysis into procurement evaluation procedures to improve cleaner production outcomes in public construction. To move procurement beyond lowest-cost decision rules, sustainability criteria should be given explicit and quantifiable weighting during tender assessment. Initiatives to increase capacity are necessary to give project teams and procurement officers useful skills in sustainable material selection and life cycle assessment. Additionally, government-led programs should encourage the growth of regional markets for sustainable building materials, and procurement laws should be in line with the goals of the circular economy and cleaner production.

The results emphasize the necessity for public procurement authorities to implement life cycle-oriented procurement models that minimize environmental effects and provide long-term value for money. Through decreased waste, lower operating costs, and improved environmental compliance, sustainable procurement provides a route to better project performance for contractors and project managers. The study supports procurement as a strategic leverage point from the standpoint of cleaner production, showing that sustainability is most successfully attained when it is taken into consideration early in the project decision-making process. The

study's focus on public construction projects in Abuja limits its applicability to other areas or private-sector contexts. Furthermore, longer-term post-occupancy performance could not be fully captured, even though life cycle cost efficiency was evaluated using project and stakeholder data. In order to monitor life cycle outcomes over long periods of time and broaden comparative analysis across various regions and procurement regimes, future research should use longitudinal designs. To improve the empirical relationship between sustainable procurement and cleaner production outcomes, more research could incorporate quantitative carbon and energy performance metrics.

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