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Evaluating Sustainability – Related KPIS in Public Construction Supply Chain : An Green SCOR – AHP- Based Analysis

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Abstract *- Public construction projects are increasingly required to integrate sustainability into supply chain performance, particularly in alignment with Sustainable Development Goal 12 on Responsible Consumption and Production. However, existing research often evaluates overall supply chain performance without prioritizing specific sustainability-related Key Performance Indicators (KPIs). This study addresses that gap by applying the Analytic Hierarchy Process (AHP) to assess the relative importance of sustainability indicators within a public construction project in Indonesia. Four KPIs were selected from the Green SCOR framework supplier sustainability compliance, percentage of recycled materials used, waste reduction in construction, and energy consumption per unit of construction—based on their prominence in literature and validation through a focus group discussion with experts. Data were collected from 66 stakeholders, including owners, contractors, consultants, and suppliers. The AHP results indicate that supplier sustainability compliance (0.401) is the most critical KPI, followed by recycled materials usage (0.268) and waste reduction (0.253), while energy consumption (0.077) ranked lowest. These findings reflect stakeholder emphasis on governance and circularity rather than technical efficiency, diverging from studies in developed countries where energy consumption is often prioritized. This study contributes by refining Green SCOR applications in public construction, demonstrating the use of AHP for KPI prioritization, and providing practical recommendations for policymakers and project managers to embed sustainability into procurement and monitoring systems.*

Keywords: *Supply Chain, Sustainability, AHP, Green SCOR, Public Construction, SDG 12.*

I. INTRODUCTION

The construction industry has long been recognized as one of the most resource-intensive sectors, responsible for a substantial share of global energy use, carbon emissions, and waste generation. Public construction projects, in particular, carry significant responsibility since they are often large in scale, publicly funded, and closely tied to national development priorities. In the era of global sustainability commitments, these projects are expected not only to deliver infrastructure efficiently but also to align with sustainable development objectives, especially the United Nations' Sustainable Development Goal 12 (responsible consumption and production). This dual expectation places increasing pressure on public sector supply chains to balance efficiency with environmental and social performance.

Although supply chain management (SCM) has become an essential component of construction project success, traditional performance evaluations tend to focus on cost, timeliness, and reliability. Such perspectives, while important, provide only a partial view of supply chain effectiveness. Growing environmental concerns demand that performance frameworks explicitly incorporate sustainability indicators such as energy efficiency, waste reduction, and material circularity. Failure to do so not only undermines long-term project outcomes but also weakens public trust in infrastructure delivery. Recent studies argue that without integrating sustainability into SCM, construction projects risk perpetuating inefficiencies and negative environmental externalities (e.g., excessive energy use, unsustainable supplier practices, and inadequate waste management).

The Green Supply Chain Operations Reference (Green SCOR) model provides a structured framework to embed sustainability into conventional SCM. By extending the original SCOR dimensions Plan, Source, Make, Deliver, and Return Green SCOR introduces environmental performance indicators such as emissions, energy use, and recycled content. However, despite its potential, the practical application of Green SCOR to public construction projects remains limited. Most empirical studies focus on private sector or manufacturing contexts, leaving a gap in understanding how sustainability-related Key Performance Indicators (KPIs) function within government-led infrastructure projects. Furthermore, existing research often considers sustainability in broad terms, without disaggregating and prioritizing specific KPIs that directly influence project outcomes.

This study addresses the above gap by concentrating on sustainability-related KPIs within the supply chain of a public construction project. From the broader Green SCOR framework, four indicators were selected to reflect core sustainability priorities: energy consumption per unit of construction, supplier sustainability compliance, waste reduction, and the percentage of recycled materials used. These KPIs collectively capture environmental efficiency, compliance, and resource circularity, which are critical dimensions for achieving sustainable project delivery. Evaluating their relative importance not only enriches theoretical understanding of sustainable supply chain management but also provides practical insights into how public sector construction projects can embed sustainability into procurement, operations, and monitoring systems.

The novelty of this research lies in its exclusive focus on sustainability-related KPIs within public construction projects. Unlike prior studies that examined overall supply chain performance or emphasized traditional dimensions such as cost and reliability, this study isolates sustainability indicators and applies the Analytic Hierarchy Process (AHP) to systematically prioritize them. This approach provides a unique contribution by highlighting which environmental KPIs are most critical to achieving sustainable outcomes in public infrastructure projects, particularly in developing country contexts where sustainability integration is still emerging.

The scope of this study is limited to a single public construction project in Indonesia, with data collected from 66 stakeholders representing owners, contractors, consultants, and suppliers. The findings are therefore context-specific and may not fully capture variations across different types of projects or geographical regions. Nevertheless, the methodological approach and insights generated can serve as a reference for future studies and as a foundation for comparative analyses across multiple projects.

The contributions of this research are threefold. First, it enriches the literature on sustainable supply chain management by offering empirical evidence from a public construction project in a developing country context. Second, it advances methodological practice by demonstrating how AHP can be effectively applied to prioritize sustainability-related KPIs in construction. Third, it provides actionable insights for policymakers and project managers, emphasizing the need to embed energy efficiency, supplier compliance audits, and circular economy principles into procurement and monitoring systems. By addressing these dimensions, the study supports the broader agenda of sustainable infrastructure development while offering a replicable framework for future research and practice.

LITERATURE REVIEW AND HYPOTHESIS FORMULATION

The pursuit of sustainability has transformed from a voluntary commitment into a global imperative. Climate change, resource depletion, and increasing waste streams have pushed governments, industries, and international organizations to adopt sustainability frameworks at multiple levels. The United Nations' Sustainable Development Goals (SDGs), particularly Goal 12 on Responsible Consumption and Production, emphasize the integration of sustainability into production systems and supply chains. In this context, supply chain management (SCM) plays a pivotal role, as it governs the flow of materials, energy, and information across multiple stakeholders.

Globally, the construction sector stands out due to its substantial environmental footprint. Studies indicate that nearly 40% of global energy consumption and more than 30% of greenhouse gas emissions are directly linked to construction and building operations (Chen et al., 2020). In addition, 25–30% of urban solid waste is generated from construction activities, posing a serious challenge to waste management systems worldwide (Zhao et al., 2021). These statistics illustrate the urgency of rethinking construction supply chains, not only to deliver projects on time and within budget but also to minimize ecological impacts and promote sustainable resource use.

In supply chain literature, sustainability has evolved into a central dimension alongside efficiency, cost, and reliability. Sustainable supply chain management (SSCM) is defined as the integration of environmental, social, and economic considerations into conventional SCM practices (Govindan et al., 2018). While earlier supply chain studies were dominated by efficiency-driven objectives, contemporary research emphasizes the balance between operational effectiveness and environmental stewardship. This paradigm shift highlights the need for industries such as construction to adopt performance frameworks that explicitly measure sustainability outcomes, rather than treating them as secondary considerations.

Unlike manufacturing, where supply chains are relatively stable and repetitive, construction supply chains are characterized by their project-based and temporary nature. Each project involves a unique configuration of stakeholders owners, contractors, consultants, and suppliers whose coordination is critical for success. Vrijhoef and Koskela (2000) highlighted that construction supply chains suffer from fragmentation, limited standardization, and dependency on external environmental conditions. These characteristics create vulnerabilities that affect cost efficiency, schedule reliability, and ultimately sustainability.

Traditional performance evaluations in construction supply chains have emphasized efficiency metrics such as cost control, timeliness, and reliability (Arditi & Chotibhongs, 2005). While these metrics remain relevant, they are insufficient to capture the complex sustainability challenges embedded in construction projects. For instance, a project may achieve cost efficiency while simultaneously generating excessive waste or consuming disproportionate energy resources. This imbalance undermines long-term sustainability objectives and increases externalities borne by society and the environment.

Recent scholarship has argued that embedding sustainability into construction supply chains can generate multiple benefits. Li et al. (2022) demonstrated that applying sustainability metrics in construction projects enhances resource utilization, reduces energy inefficiencies, and aligns project performance with environmental policies. Similarly, Ghosh and Eriksson (2022) stressed the importance of integrating circular economy principles, such as recycling and material reuse, into infrastructure development to ensure long-term value creation. These insights suggest that the construction industry requires a paradigm shift in its approach to performance evaluation, moving beyond traditional efficiency-based measures toward comprehensive sustainability assessments.

The Supply Chain Operations Reference (SCOR) model, developed by the Supply Chain Council, provides a standardized framework for evaluating supply chain performance across five core processes: Plan, Source, Make, Deliver, and Return. While the SCOR model has been widely adopted in manufacturing and logistics, its adaptation to sustainability concerns resulted in the Green SCOR framework (SCC, 2017).

Green SCOR integrates environmental performance dimensions into the traditional SCOR structure. Indicators such as energy consumption, emissions, waste management, and recycled material usage are incorporated alongside conventional metrics. This extension allows organizations to assess not only operational efficiency but also environmental responsibility. Li et al. (2022) found that the application of Green SCOR in construction projects improved alignment between project outputs and sustainability objectives, particularly with regard to energy consumption and waste minimization. Similarly, Ghosh and Eriksson (2022) argued that Green SCOR provides a structured mechanism for embedding circular economy practices in public infrastructure projects.

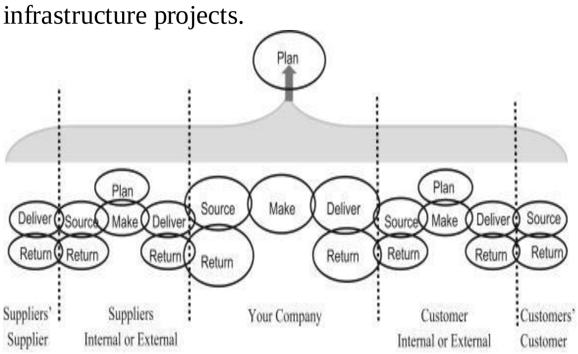

Figure 1. Supply Chain Operations Reference (SCOR) Model
Source: Supply Chain Council (SCC), 2012

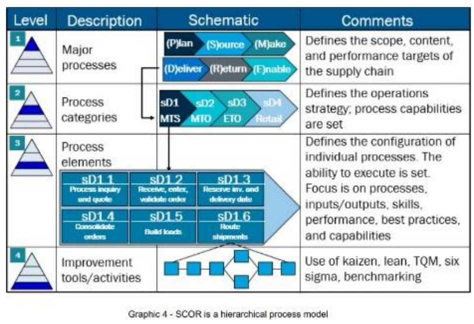

Figure 2. SCOR as a Hierarchical Process Model
Source: Supply Chain Council (SCC), 2012

However, one of the main challenges in applying the Green SCOR framework lies in the selection and prioritization of sustainability-related Key Performance Indicators (KPIs). Although the framework provides a broad range of indicators, not all are equally relevant or feasible in the context of public construction projects. For instance, while energy consumption per unit of construction directly affects both cost and environmental performance, other indicators may have limited applicability in temporary and fragmented project settings. As such, research that identifies and prioritizes the most critical sustainability KPIs is essential to operationalize Green SCOR effectively in the construction industry.

Building on prior literature, four KPIs emerge as particularly relevant for evaluating sustainability in construction supply chains. Energy consumption per unit of construction serves as a direct measure of resource efficiency, linking operational practices to environmental outcomes (Chen et al., 2020). Supplier sustainability compliance reflects the degree to which suppliers adhere to environmental standards and certifications, ensuring that sustainability principles are embedded throughout the supply chain (Govindan et al., 2018). Waste reduction has been widely recognized as a critical KPI given the substantial volume of construction waste and its negative impact on urban waste management systems (Zhao et al., 2021). Finally, the percentage of recycled materials used represents the extent to which circular economy practices are adopted in construction projects (Ghosh & Eriksson, 2022). Collectively, these KPIs provide a focused yet comprehensive framework for embedding sustainability into public construction supply chains, balancing operational efficiency with ecological responsibility.

Tabel 1 Category of Performance Indicators

No	Code	KPI Name	Definition	Unit	Formula
1	ESG.3.3	Energy Consumption per Unit of Construction	The total amount of energy used to complete one unit of construction.	kWh/unit	Total Energy Consumed / Total Completed Units
2	ESG.3.2	Waste Reduction in Construction	The reduction of waste generated during the construction process.	Percentage (%)	(Initial Waste – Final Waste) / Initial Waste × 100
3	ESG.2.5	Percentage of Recycled Materials Used	The proportion of recycled materials utilized in the construction project.	Percentage (%)	(Recycled Materials / Total Materials) × 100
4	RL.1.2	Supplier Sustainability Compliance	The proportion of suppliers that comply with sustainability standards.	Percentage (%)	(Number of Compliant Suppliers / Total Suppliers) × 100

Source: Adapted from Green SCOR framework and research instrument (2024).

By narrowing the scope to these four KPIs energy consumption, supplier sustainability compliance, waste reduction, and recycled materials use this study addresses dimensions that are both highly relevant and empirically measurable. While additional KPIs such as reverse logistics cost and return rate are also linked to sustainability, their implementation in construction contexts remains limited, and thus they are not the primary focus here.

Evaluating and prioritizing sustainability-related KPIs requires a methodological approach that can handle multiple criteria and stakeholder perspectives. The Analytic Hierarchy Process (AHP), introduced by Saaty (1980), has proven to be a robust decision-making tool in such contexts. AHP decomposes complex problems into hierarchical levels goals, criteria, sub-criteria, and alternatives and uses pairwise comparisons to derive relative weights.

In sustainable supply chain research, AHP has been widely used for supplier evaluation, green procurement, and sustainability assessment. Govindan et al. (2018) applied AHP to assess green supplier selection criteria, confirming its usefulness in prioritizing environmental considerations. Kannan et al. (2019) conducted a review of AHP applications in sustainability and concluded that the method is particularly effective for balancing qualitative judgments and quantitative analysis. In construction, Abdelgawad and Fayek (2010) used AHP to prioritize project risks, while Cheng et al. (2012) applied it to evaluate project performance across multiple criteria. These studies demonstrate that AHP is versatile and reliable for decision-making in complex environments, but its application to sustainability-related KPIs in public construction remains relatively unexplored.

The reviewed literature highlights the increasing importance of sustainability in global supply chain management, the distinctive challenges of construction supply chains, and the potential of frameworks such as Green SCOR and methodologies like AHP. However, empirical applications that focus explicitly on sustainability-related KPIs in public construction projects are still rare. Existing studies tend to either emphasize overall supply chain performance or focus on isolated sustainability initiatives without systematically prioritizing indicators.

This study seeks to address this limitation by exclusively focusing on four sustainability-related KPIs: energy consumption per unit of construction, supplier sustainability compliance, waste reduction, and recycled materials use. By applying AHP to prioritize these KPIs using data from stakeholders directly involved in a public construction project, the research aims to provide both theoretical insights and practical recommendations. The emphasis on public projects in a developing country context further strengthens the contribution, as these projects often face distinct challenges such as limited regulatory enforcement, resource constraints, and fragmented supply chains.

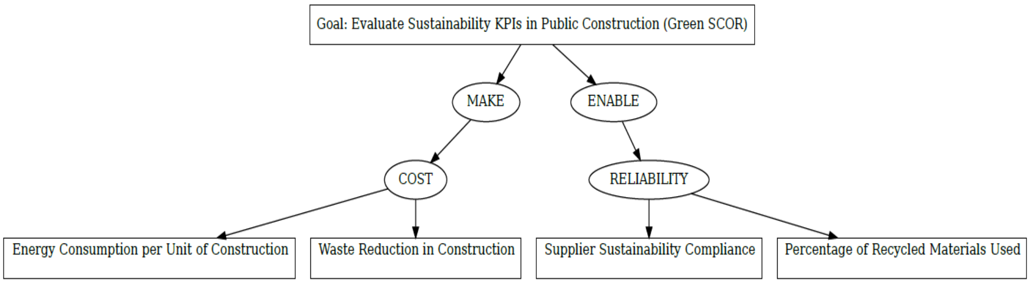

Figure 3. AHP Hierarchy of Sustainability-Related KPIs in Public Construction
Source: Adapted from Green SCOR Framework (SCC, 2017) and research data (2025).

This figure illustrates the hierarchical structure of the Analytic Hierarchy Process (AHP) used in this study, focusing on the Make and Enable processes of the Green SCOR framework. The sustainability-related KPIs evaluated are: energy consumption per unit of construction, waste reduction, supplier sustainability compliance, and percentage of recycled materials used.

II. METHOD

This study adopts a descriptive quantitative research design that integrates multi-criteria decision-making to evaluate sustainability-related performance indicators in public construction supply chains. The research framework was guided by the Analytic Hierarchy Process (AHP), a method widely used to prioritize complex and multidimensional criteria where both qualitative judgments and quantitative analysis are required. The selection of AHP is particularly relevant in this context, as construction supply chains involve diverse stakeholders with differing priorities, and sustainability considerations often require trade-offs between efficiency, compliance, and environmental responsibility. By decomposing the problem into hierarchical levels, AHP enables the systematic evaluation of sustainability-related Key Performance Indicators (KPIs), thereby producing structured insights that can inform both theory and practice.

The context of the research is a public construction project in Indonesia, which was chosen due to its relevance to government-led infrastructure development and its direct alignment with national sustainability commitments. Public projects carry unique challenges compared to private sector initiatives, including regulatory oversight, public accountability, and the necessity to demonstrate alignment with broader socio-environmental objectives. This makes the selection of sustainability KPIs particularly critical, as they reflect not only internal project performance but also compliance with international sustainability agendas such as the Sustainable Development Goals (SDGs).

The study involved 66 respondents representing owners, contractors, consultants, and suppliers. The respondents were selected purposively to ensure that participants had direct roles in decision-making and operational processes within the supply chain. Owners and contractors contributed perspectives on procurement policies and project execution, consultants provided expertise in project design and compliance, while suppliers offered insights into resource management and sustainability practices at the operational level. By including these groups, the study ensured a holistic representation of the supply chain ecosystem.

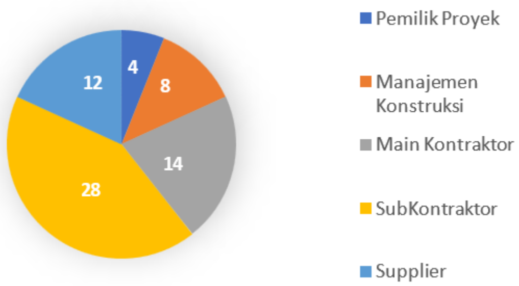

Figure 4. Distribution of Respondents by Stakeholder Group
Source: Research data (2025).

Data collection was carried out using a structured questionnaire specifically designed to capture judgments regarding the relative importance of sustainability-related KPIs. The development of the instrument was grounded in both the Green SCOR framework (SCC, 2017) and prior literature on sustainable construction supply chains (Chen et al., 2020; Li et al., 2022; Ghosh & Eriksson, 2022). From the broader set of indicators provided by Green SCOR, this study identified four core KPIs that are most directly relevant to environmental sustainability in public construction projects: (1) energy consumption per unit of construction, (2) supplier sustainability compliance, (3) waste reduction in construction, and (4) percentage of recycled materials used. These KPIs were selected not only for their prominence in academic literature and practical relevance in construction contexts, but also through validation in a Focus Group Discussion (FGD) with an expert panel and confirmation from project stakeholders, ensuring that the indicators reflect both theoretical foundations and real-world applicability.

The questionnaire consisted of pairwise comparison matrices, which required respondents to evaluate the relative importance of one KPI against another with respect to the overall goal of sustainable supply chain performance. Saaty's (1980) 1–9 scale was employed, where a score of 1 indicated equal importance, and a score of 9 indicated extreme importance of one indicator over another. This approach allowed respondents to make nuanced judgments by systematically comparing pairs of indicators rather than attempting to rank all criteria simultaneously. To minimize bias and ensure clarity, each KPI was accompanied by detailed definitions and examples contextualized within construction practice. For instance, energy consumption was described in terms of electricity and fuel use per square meter of construction output, while supplier compliance was explained as adherence to environmental certifications and contractual sustainability clauses.

Instrument development also incorporated a Focus Group Discussion (FGD) involving project managers, site engineers, logistics coordinators, and supplier representatives. The FGD served two primary purposes: first, to validate the relevance and clarity of the selected KPIs; and second, to refine the wording of the questionnaire to ensure accessibility to practitioners from diverse professional backgrounds. The experts confirmed that the four KPIs accurately represented sustainability dimensions in the supply chain and that the pairwise comparison method was suitable for eliciting informed judgments. By combining survey instruments with expert validation, the study strengthened the content validity of the research design.

Once data collection was completed, analysis followed the standard AHP procedure. The first step involved aggregating the pairwise comparison matrices from all 66 respondents. Because AHP requires a single consensus matrix for computation, the geometric mean was used to combine individual responses into a collective judgment matrix. This method is commonly recommended in AHP applications as it preserves the reciprocal properties of pairwise comparisons while mitigating the influence of outliers.

The second step involved calculating the priority weights for each KPI. The eigenvalue method was applied to derive normalized weights from the aggregated matrix. These weights represent the relative importance of each KPI in contributing to sustainable supply chain performance. For example, a higher weight for energy consumption would suggest that respondents collectively view energy efficiency as a more critical sustainability factor compared to recycled material usage.

The third step focused on assessing the consistency of respondent judgments. AHP provides a mechanism to evaluate the logical coherence of pairwise comparisons through the Consistency Index (CI) and the Consistency Ratio (CR). A CR value of less than or equal to 0.10 is generally considered acceptable (Saaty, 1980). In this study, all matrices achieved CR values below the threshold, confirming that the judgments provided by respondents were reliable and logically consistent. This check was crucial, as inconsistent judgments would undermine the validity of the derived weights and compromise the study's findings.

Following the consistency validation, the final step was to rank the four sustainability-related KPIs based on their normalized weights. The results indicate a distinct hierarchy, with energy consumption per unit of construction and supplier sustainability compliance emerging as the most critical indicators for assessing sustainability in public construction supply chains. In contrast, waste reduction and recycled materials usage were assigned relatively lower weights, yet they remain essential components of sustainable practices by reflecting efforts to minimize waste generation and promote circular resource utilization. Overall, these rankings capture stakeholder perceptions of which sustainability dimensions are considered most feasible and impactful in practice, thereby highlighting priority areas for embedding sustainability into public sector construction projects.

The analysis was conducted using Expert Choice™ software, a widely recognized decision-support tool for AHP applications. The software facilitated eigenvalue computation, consistency testing, and graphical representation of results, ensuring both accuracy and efficiency in the analytical process. By leveraging specialized software, the study enhanced the technical reliability of the findings while reducing the potential for human error in manual calculations.

In addition to quantitative analysis, qualitative insights were drawn from the FGD and respondent feedback. Several participants emphasized that energy efficiency is increasingly scrutinized due to rising fuel and electricity costs, as well as government regulations on emissions. Supplier compliance was highlighted as a growing concern, particularly in ensuring that contractors adhere to environmental certifications such as ISO 14001. Waste reduction and recycling were recognized as important but constrained by limited infrastructure for waste segregation and the lack of incentives for recycled material adoption. These insights provided a deeper contextual understanding of why certain KPIs were ranked higher than others, adding interpretive richness to the numerical results.

To ensure overall validity, the study adopted a triangulation approach. Content validity was established through literature-based KPI selection and expert review. Construct validity was reinforced by linking each KPI to sustainability constructs recognized in both academic and professional domains. Reliability was confirmed through the consistency ratio analysis in AHP. Ethical considerations were also observed: all respondents participated voluntarily, were informed about the study's objectives, and their identities were kept confidential.

The methodological framework employed in this study can be summarized as follows: sustainability-related KPIs were identified from literature and Green SCOR, validated by experts through FGD, and operationalized via pairwise comparisons in an AHP questionnaire distributed to 66 stakeholders. Responses were aggregated, analyzed using Expert Choice™, tested for consistency, and interpreted both quantitatively and qualitatively. This rigorous process ensures that the study not only yields robust empirical findings but also contributes methodologically by demonstrating how AHP can be applied to sustainability KPI prioritization in public construction supply chains.

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III. RESULT AND DISCUSSION

A. Result

The Analytic Hierarchy Process (AHP) was applied to synthesize expert judgements from 66 stakeholders including project owners, construction managers, main contractors, subcontractors, and suppliers regarding the relative importance of four sustainability-related KPIs in public construction supply chains. These indicators were derived from the Green SCOR framework, which extends the traditional SCOR model by integrating environmental dimensions into supply chain performance evaluation. The four KPIs selected energy consumption per unit of construction, supplier sustainability compliance, waste reduction in construction, and percentage of recycled materials used represent the core sustainability priorities most relevant to construction contexts. Stakeholder judgements were aggregated using the geometric mean method and processed in Expert Choice. The overall inconsistency ratio of the combined matrix was 0.08, which is below the 0.10 threshold, indicating that the pairwise comparisons were logically consistent and that the resulting priorities are reliable for interpretation.

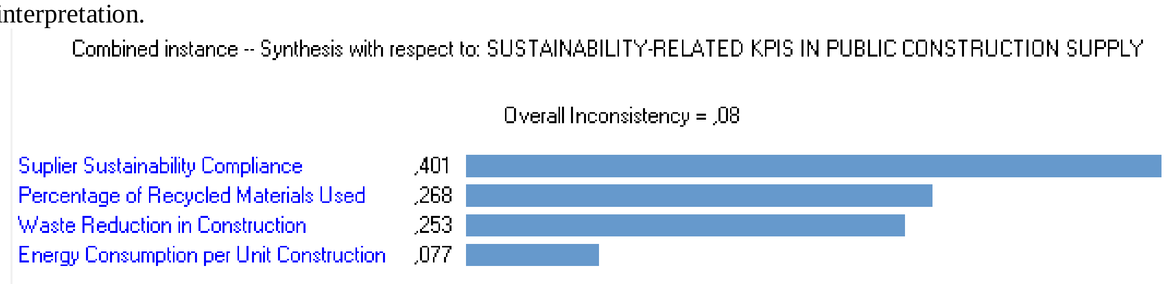

Figure 3. Expert Choice Output of AHP Synthesis for Sustainability-Related KPIs
Source: Expert Choice output, study data.(2025)

Ranking of Sustainability-Related KPIs

The AHP synthesis reveals a clear priority order among the four sustainability indicators (Table 2). Supplier Sustainability Compliance emerges as the most influential KPI with a global weight of 0.401, indicating that adherence to sustainability standards and certifications by upstream partners is perceived as the strongest driver of sustainable outcomes in public projects. Percentage of Recycled Materials Used ranks second (0.268), followed closely by Waste Reduction in Construction (0.253), reflecting growing, yet still developing, emphasis on circularity and on-site waste minimization. Energy Consumption per Unit of Construction receives the lowest priority (0.077), suggesting that, within the current project context, energy efficiency initiatives are recognized but not yet considered as critical as supplier governance and material circularity.

Table 2. Global Weights of Sustainability-Related KPIs (AHP Results)

KPI	Global Weight	Rank
Supplier Sustainability Compliance	0.401	1
Percentage of Recycled Materials Used	0.268	2
Waste Reduction in Construction	0.253	3
Energy Consumption per Unit of Construction	0.077	4

Notes: Priorities are normalized global weights from Expert Choice;
Overall inconsistency (CR) = 0.08.

Taken together, the priorities indicate that stakeholders assign the greatest practical leverage to upstream control mechanisms (compliance audits, contractual requirements, and verification of supplier practices), followed by measures that operationalize circular economy principles (use of recycled materials and systematic waste reduction). The comparatively lower weight for energy consumption suggests barriers to immediate implementation (e.g., technology availability, measurement practices, or cost pressures). These patterns guide where procurement criteria, monitoring, and managerial interventions should be concentrated in public construction supply chains.

B. Discussion

Discussion per KPI

Supplier Sustainability Compliance (0.401).

The analysis shows that supplier sustainability compliance emerged as the highest-ranked KPI. This reflects stakeholder recognition that upstream supplier behavior is decisive in shaping the sustainability outcomes of public construction projects. Compliance with environmental standards, certifications, and contractual obligations reduces the risk of unsustainable practices in the supply chain and strengthens the accountability of project delivery. The finding aligns with the increasing role of green procurement regulations in public projects, where supplier adherence becomes a prerequisite for contract eligibility. By emphasizing compliance, stakeholders seek to ensure that sustainability principles are embedded at the source of materials and services, rather than only at the project execution stage.

Percentage of Recycled Materials Used (0.268).

The second-ranked KPI highlights the growing, albeit still limited, attention to circular economy practices in public construction. The use of recycled materials directly reduces demand for virgin resources and lowers the environmental footprint of projects. The weight assigned indicates that while stakeholders view recycled content as relevant, implementation challenges—such as limited availability, quality variability, and lack of incentives—restrict its prioritization compared to supplier compliance. Nevertheless, the inclusion of this KPI in the upper half of the ranking demonstrates that resource circularity is no longer peripheral, but increasingly integrated into sustainability discourse in public projects.

Waste Reduction in Construction (0.253).

Waste reduction was ranked third and closely follows recycled materials in weight. This reflects the recognition that construction waste remains one of the most visible sustainability challenges, contributing significantly to urban solid waste streams. Stakeholders perceive waste minimization as critical for improving project efficiency and reducing disposal costs, yet barriers such as inadequate on-site segregation, lack of enforcement, and additional labor requirements reduce its practical emphasis. The findings suggest that while waste reduction is valued, it is often treated reactively rather than proactively, indicating the need for stronger regulations and management systems to institutionalize waste control measures in public construction supply chains.

Energy Consumption per Unit of Construction (0.077).

Energy consumption was assigned the lowest priority, which is noteworthy given that construction is among the largest energy-intensive sectors globally. This outcome suggests that, within the current project context, stakeholders prioritize supplier governance and material flows over energy efficiency. Possible explanations include the higher visibility of compliance and material management issues, as well as the absence of systematic energy monitoring practices at the project level. Although energy consumption directly influences both environmental and economic performance, it appears less salient for practitioners in developing country contexts where immediate procurement and waste concerns dominate. This finding underscores the need for policy and technological interventions to elevate the role of energy efficiency in future public projects.

The findings of this study both confirm and diverge from prior research on sustainable supply chain management. The prominence of supplier sustainability compliance supports the arguments of Govindan et al. (2018) and Kannan et al. (2019), who emphasize supplier accountability and certification as central to embedding sustainability in supply chains. Similarly, the moderate weight assigned to waste reduction resonates with Zhao et al. (2021), who identified construction waste management as a persistent global challenge that remains difficult to address despite its recognized importance.

However, the results diverge from studies that prioritize energy efficiency as a key sustainability indicator. For instance, Chen et al. (2020) demonstrated that energy consumption is often considered a dominant KPI in global construction sustainability assessments, whereas in this study it was ranked lowest. This divergence reflects contextual differences: in developed economies, energy performance is strictly regulated and closely monitored, while in developing country contexts such as Indonesia, supplier governance and material circularity take precedence due to regulatory and infrastructural constraints.

The relative importance of recycled materials use also provides a nuanced perspective. While Ghosh and Eriksson (2022) reported high emphasis on circular economy adoption in public infrastructure projects in Europe, this study found that recycled materials ranked second but with moderate weight, highlighting both growing interest and the practical barriers of implementation in emerging markets. These comparisons demonstrate that sustainability priorities are highly context-dependent, shaped by local regulatory frameworks, market conditions, and stakeholder expectations.

Collectively, the findings extend the existing literature by providing empirical evidence from a developing country context. They suggest that while some sustainability KPIs (such as supplier compliance) show universal importance across contexts, others (such as energy consumption and recycled materials use) display significant variation. This highlights the need for adaptive frameworks that recognize contextual differences when operationalizing Green SCOR in construction supply chains.

From a theoretical perspective, this study advances the application of the Green SCOR framework by isolating and prioritizing sustainability-related KPIs specifically within public construction supply chains. Prior research has tended to evaluate Green SCOR holistically, often considering the entire spectrum of indicators without differentiating their relative importance. By narrowing the focus to four critical KPIs—supplier sustainability compliance, recycled materials use, waste reduction, and energy consumption—the study provides sharper insights into which sustainability dimensions stakeholders perceive as most impactful. This selective application of Green SCOR demonstrates that sustainability within public projects is not monolithic; instead, it is shaped by contextual realities and stakeholder priorities. Furthermore, by integrating the Analytic Hierarchy Process (AHP), the study contributes methodologically by illustrating how multi-criteria decision-making tools can be leveraged to operationalize sustainability indicators in a systematic and transparent manner.

On the practical side, the findings have direct implications for policymakers, contractors, and project managers. The high priority placed on supplier sustainability compliance underscores the necessity of embedding sustainability requirements into procurement documents, supplier contracts, and monitoring systems. Public sector agencies can leverage compliance audits and certification schemes as levers to enforce sustainability standards throughout the supply chain. Similarly, the relatively strong emphasis on recycled materials and waste reduction indicates growing awareness of circular economy principles, suggesting that incentive programs, regulatory mandates, and training initiatives can accelerate adoption. These interventions would not only reduce environmental impacts but also improve resource efficiency and cost management in public projects.

For practitioners, the relatively low emphasis on energy consumption highlights a critical gap that requires attention. Although energy efficiency is widely recognized as a global sustainability priority, the limited weight assigned by stakeholders in this study suggests that it has not yet been institutionalized within project practices in Indonesia. Addressing this gap may require investments in monitoring technologies, capacity-building for project teams, and integration of energy performance metrics into tender evaluations. Bridging this gap could align domestic practices with international benchmarks while also reducing long-term operational costs.

Finally, the findings provide a basis for developing adaptive sustainability frameworks tailored to developing country contexts. The study shows that while supplier compliance emerges as a universal priority, other indicators such as recycled materials and energy consumption—vary significantly across regions due to differences in regulation, infrastructure, and market readiness. This implies that policymakers and researchers should avoid "one-size-fits-all" approaches and instead design sustainability assessment frameworks that are context-sensitive. By doing so, they can ensure that sustainability objectives are both ambitious and realistically achievable in the environments where they are implemented.

This study applied the Analytic Hierarchy Process (AHP) to prioritize four sustainability-related KPIs in public construction supply chains, derived from the Green SCOR framework. The results show a clear hierarchy of priorities, with supplier sustainability compliance (0.401) emerging as the most influential KPI, followed by percentage of recycled materials used (0.268), waste reduction in construction (0.253), and energy consumption per unit of construction (0.077). The consistency ratio of 0.08 confirms the reliability of the stakeholder judgements and the robustness of the findings.

The findings explicitly answer the research question by identifying which sustainability KPIs hold the greatest practical relevance in public construction contexts. They indicate that stakeholders prioritize governance and supplier accountability above technical efficiency measures, reflecting the regulatory and market realities of developing country settings. At the same time, the results demonstrate growing awareness of circular economy principles, even if their practical implementation remains limited.

In summary, this research provides empirical evidence that sustainability priorities in public construction supply chains are both context-specific and evolving. The results extend existing literature by highlighting differences between developing and developed contexts, contribute methodologically by applying AHP to KPI prioritization, and generate practical recommendations for embedding sustainability into public sector procurement and project delivery. These contributions collectively strengthen the theoretical foundation of sustainable supply chain management while offering actionable strategies for practitioners and policymakers.

IV. CONCLUSION

This study examined the prioritization of sustainability-related Key Performance Indicators (KPIs) within public construction supply chains by applying the Analytic Hierarchy Process (AHP). Four KPIs derived from the Green SCOR framework were evaluated: energy consumption per unit of construction, supplier sustainability compliance, waste reduction in construction, and percentage of recycled materials used. Data were obtained from 66 stakeholders representing owners, contractors, consultants, and suppliers. The results revealed a clear hierarchy of priorities, with supplier sustainability compliance and recycled materials use ranked highest, followed by waste reduction, and energy consumption ranked lowest. The consistency ratio of 0.08 confirmed the reliability of the judgments, indicating that the findings are robust and logically consistent.

Research Conclusions

The findings explicitly address the research problem by identifying which sustainability dimensions stakeholders perceive as most critical in the context of public construction projects. First, supplier sustainability compliance emerged as the dominant factor, emphasizing that governance mechanisms and supplier accountability form the backbone of sustainable supply chain practices. Second, the significant weight assigned to recycled materials use highlights the gradual adoption of circular economy practices in construction, though challenges of supply availability and quality remain. Third, waste reduction was considered moderately important, reflecting awareness of its environmental impact yet persistent barriers in implementation. Finally, energy consumption per unit of construction was ranked lowest, suggesting that energy efficiency has not yet become a primary concern in developing country contexts where procurement and compliance issues are more pressing.

These conclusions highlight the contextual nature of sustainability priorities. While global literature often places energy efficiency at the forefront, this study shows that in Indonesia's public construction projects, regulatory compliance and material circularity are more influential. This divergence provides a novel contribution to the literature by demonstrating that sustainability priorities are not uniform across contexts but are shaped by local regulatory frameworks, market conditions, and stakeholder expectations.

Practical Implications

The findings of this study provide several important implications for policymakers, project owners, contractors, and suppliers engaged in public construction projects. The strong emphasis on supplier sustainability compliance demonstrates the critical need to embed sustainability requirements directly into procurement processes, contractual agreements, and monitoring systems. By ensuring that suppliers adhere to environmental standards and certifications, project owners can safeguard against unsustainable practices across the supply chain. The prioritization of recycled materials and waste reduction further highlights the growing importance of circular economy principles in construction. These findings suggest that public sector agencies should consider introducing regulatory mandates, incentive schemes, and training programs that encourage greater use of recycled materials and effective waste management practices on site. Although energy consumption received the lowest weight, it remains an essential dimension of sustainability in the long term. The low priority reflects contextual challenges rather than irrelevance, and thus practical steps such as investment in monitoring technologies, integration of energy metrics in tender evaluations, and capacity-building for project teams remain necessary. Collectively, these implications suggest that sustainability in public construction supply chains should be pursued not only through compliance mechanisms but also by fostering a culture of innovation, efficiency, and accountability that supports the broader achievement of Sustainable Development Goal 12.

Limitations of the Study

Despite its contributions, this study is not without limitations. First, the analysis was based on a single public construction project in Indonesia, which may limit the generalizability of the findings to other projects or regions with different regulatory frameworks and market conditions. Second, the scope of sustainability KPIs was deliberately restricted to four indicators energy consumption, supplier sustainability compliance, waste reduction, and recycled materials usage which, while highly relevant, do not capture the full spectrum of environmental, social, and economic sustainability dimensions. Third, the use of the Analytic Hierarchy Process (AHP) provided robust prioritization results but does not allow for the exploration of causal relationships or dynamic interactions among KPIs. Advanced methods such as Structural Equation Modeling (SEM) or system dynamics could yield richer insights. Finally, although 66 respondents were included and represented diverse stakeholder groups, the sample may not fully reflect perspectives from regulators, policymakers, or end-users. These limitations do not diminish the value of the findings but highlight areas where future research can extend and deepen the current study.

Suggestions for Future Research

Building on these limitations, several directions for future research are recommended. Future studies should examine sustainability KPI priorities across multiple projects and regions to identify patterns and contextual variations, particularly comparing developing and developed countries. Expanding the framework of analysis to include additional KPIs that capture social and economic dimensions would also provide a more holistic understanding of sustainability in construction supply chains. Methodologically, combining AHP with advanced techniques such as SEM, fuzzy logic, or machine learning could offer insights into causal relationships and predictive models that go beyond simple prioritization. Further, future research would benefit from incorporating a broader range of stakeholders, including regulators, policymakers, and community representatives, to ensure that diverse perspectives are captured. Finally, longitudinal studies that track changes in KPI prioritization over time would provide valuable evidence on how sustainability perceptions evolve in response to regulatory shifts, technological advancements, and market developments. Such extensions would not only strengthen theoretical understanding but also generate actionable guidance for practitioners seeking to align construction projects more effectively with sustainability goals.

In conclusion, this research demonstrates that sustainability in public construction supply chains is shaped by both universal and context-specific factors. Supplier compliance stands out as a universal driver, while material recycling and waste reduction reflect emerging practices, and energy efficiency highlights a gap yet to be bridged. By providing empirical evidence from Indonesia, the study enriches the literature on sustainable supply chain management and offers actionable guidance for practitioners and policymakers. Ultimately, the findings emphasize that sustainable development in the construction sector requires adaptive frameworks that respond to local realities while aligning with global sustainability goals

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