NAU Journal of Civil Engineering (NAUJCVE) January/February 2026
Nnamdi Azikiwe University Journal of Civil Engineering (NAUJCVE)

Volume-5, Issue-1, pp-99--109
www.naujcve.com
Research Paper Open Access

Integrating Sustainability in Construction Design, Execution and Cost Management

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ABSTRACT: *Sustainable construction requires an integrated approach that harmonizes design, execution, and cost management to achieve environmental, economic, and social objectives. This study critically reviews recent literature to examine the roles of civil engineers, builders, and quantity surveyors in promoting sustainability, emphasizing the interdependencies between material selection, construction methods, and financial planning. Evidence reveals that isolated interventions often fail to deliver measurable sustainability gains, whereas interdisciplinary collaboration, digital tools such as BIM and life-cycle assessment, and proactive cost optimization strategies enhance performance, reduce waste, and improve long-term economic outcomes. Key challenges include technical capacity gaps, resistance to change, and inconsistent policy enforcement, while opportunities lie in emerging technologies, circular economy practices, and structured decision-making frameworks. The findings underscore the necessity of context-sensitive, analytically driven approaches for operationalizing sustainable construction, and identify research gaps in standardized integration frameworks, performance metrics, and adoption pathways for digital solutions.*

KEYWORDS: *Sustainable construction, Integrated design, Construction execution, Cost management, Life-cycle analysis, green materials.*

Date of Submission: 19-01-2026 Date of acceptance: 29-01-2026

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1. Introduction

Sustainability in construction has moved beyond being a desirable attribute to an essential requirement due to the sector's significant contribution to global carbon emissions, material depletion, and energy consumption (Cheng et al., 2024). While numerous studies highlight individual strategies for sustainable design, execution, or cost management, the literature reveals a lack of critical integration across these domains, which undermines the overall effectiveness of sustainability interventions (Yang et al., 2025). Integrating design, construction processes, and cost considerations is not merely additive; it requires deliberate coordination and interdisciplinary decision-making to ensure that choices in one domain do not compromise outcomes in another. For instance, selecting low-carbon materials in design may reduce environmental impact but could increase construction complexity and cost if execution and procurement processes are not aligned. Therefore, this study emphasizes a holistic analytical approach, evaluating sustainability not as isolated practices but as interdependent processes where trade-offs must be critically assessed and optimized across all project phases (Sharma et al., 2025).

Sustainable construction is conceptually anchored in the triple-bottom-line framework, yet in practice, its application often reveals tensions between environmental objectives, economic feasibility, and social responsibility (Cheng et al., 2024). Environmental initiatives, such as carbon reduction and waste minimization, may conflict with cost constraints, particularly when life-cycle implications are inadequately analyzed. Similarly, social considerations, including labor safety and community well-being, often incur operational trade-offs that require careful evaluation within budgetary limits (Yang et al., 2025). Global standards like LEED, BREEAM, and ISO 14001 provide guidance but do not inherently resolve these conflicts, highlighting the need for integrated decision-making frameworks that critically assess design, execution, and cost in tandem (Sharma et al., 2025). Consequently, achieving true sustainability necessitates a critical understanding of interdependencies and systematic analysis, rather than merely applying prescriptive best practices, underscoring the rationale for interdisciplinary research and evaluation in construction projects.

A systematic literature search was conducted to support this review on sustainable construction, initially identifying 94 sources from peer-reviewed journals such as *Sustainability*, *Journal of Cleaner Production*, and *Buildings* using keywords including "sustainable construction," "BIM," "life cycle cost analysis," and "green building practices." Sources were screened for relevance, quality, recency (2020–2025), and peer-review status, with duplicates and non-verifiable materials excluded. Following this process, a final set of 45 references was selected, ensuring that the review is current, credible, and covers interdisciplinary integration, cost optimization, and emerging technologies in construction sustainability.

2.1 Concept Of Sustainability In Construction

Sustainable construction extends beyond conventional environmentally friendly practices to critically balance environmental stewardship, economic efficiency, and social well-being, as emphasized in the triple-bottom-line framework (Alghamdi, 2025; Tiza, 2022). While many projects claim sustainability, evidence indicates that without systematic evaluation, such claims may overlook trade-offs between cost, performance, and environmental impact (Tiza, Okafor, & Agunwamba, 2025). Critical examination of materials, energy use, and construction methods reveals that prioritizing sustainability requires deliberate decision-making to reduce negative environmental impacts, optimize resource efficiency, and enhance long-term operational performance, rather than merely adopting isolated "green" strategies (Egbebike& Tiza, 2025).Fig. 1 illustrates sustainability in construction as the integration of environmental, economic, and social dimensions.

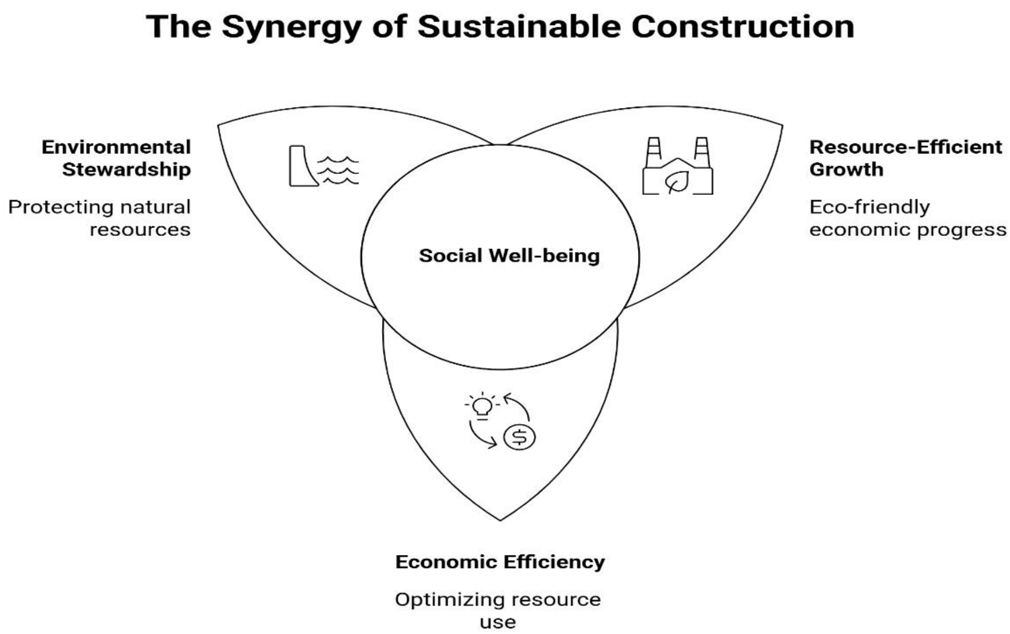

Fig. 1: The concept of sustainability in construction

Although environmental considerations dominate sustainability discourse, research highlights the necessity of analyzing interdependencies across all three dimensions. Environmental sustainability emphasizes reducing emissions, material waste, and energy intensity, yet these measures often interact with cost and social outcomes (Wen, 2025; Utsev et al., 2024). Economic sustainability focuses on life-cycle cost efficiency and value generation, where short-term expenditure may be justified by long-term savings or performance gains (Tiza, 2022). Social sustainability, encompassing worker safety, health, and community benefits, must be integrated into project planning to avoid unintended consequences such as labor exploitation or community disruption (Tiza, Jirgba, Sani, & Sesugh, 2022). Critically, the challenge lies in balancing these dimensions so that gains in one area do not compromise outcomes in others, demanding a systematic, analytical framework for sustainable project delivery.

Standards and certification frameworks such as LEED, BREEAM, and ISO 14001 provide structured benchmarks for evaluating sustainability performance, yet they are not exhaustive solutions (Shahid & Khan, 2025; Tiza, 2022). Analytical studies reveal that strict adherence to such guidelines does not automatically ensure optimal sustainability outcomes if material quality, construction practices, or cost implications are neglected (Tiza, Okafor, & Agunwamba, 2025). For instance, incorporating waste-derived materials and reclaimed asphalt pavement (RAP) can enhance environmental performance and reduce costs, but requires careful oxide composition and quality assessment to ensure structural integrity (Egbebike& Tiza, 2025; Tiza, Okafor, & Agunwamba, 2025). Consequently, sustainability standards should be applied critically and contextually, integrating local materials, construction practices, and life-cycle considerations to achieve truly sustainable construction outcomes (Utsev et al., 2024; Tiza, Jirgba, Sani, & Sesugh, 2022).Table 1 presents a comparative overview of global sustainability standards and guidelines in construction, highlighting their focus areas, strengths, and limitations.

Table 1: Comparative Overview of Global Sustainability Standards and Guidelines in Construction

Standard / Guideline	Focus / Scope	Insights / Limits
Leadership in Energy and Environmental Design	Environmental performance, resource efficiency	Effective benchmark, but not sufficient alone
Building Research Establishment Environmental Assessment Method	Environmental, economic, social sustainability	Holistic, but complex to implement
International Organization for Standardization 14001	Environmental management systems	Strong process focus, limited construction-specific guidance
Well Building Standard	Human health, indoor environmental quality	Health-centric, less lifecycle focus
German Sustainable Building Council Certification	Environmental, economic, social balance	Comprehensive, implementation intensive
Green Globes	Environmental performance, resilience, occupant health	Flexible, less rigorous verification
Passive House Standard	Energy efficiency, thermal comfort	Extremely low energy use, limited materials considerations
National Green Building Standard	Residential energy, water, materials, indoor quality	Adaptable for homes, limited for commercial buildings
Green Star	Regional energy, water, materials, innovation	Locally relevant, global comparison difficult
Comprehensive Assessment System for Building Environmental Efficiency	Planning to operation environmental assessment	Comprehensive, limited international adoption
National Australian Built Environment Rating System	Real-world building performance metrics	Focus on operations, limited embodied impact

3. Sustainable Design in Construction

Civil engineers play a pivotal role in sustainable construction by integrating environmental, economic, and social considerations into design decisions, including material selection, structural efficiency, and service life evaluation, to minimize long-term impacts (Tiza, 2022; Shahid & Khan, 2025). Neglecting sustainability early often leads to higher life-cycle costs and inefficiencies (Tiza, Jirgba, Sani, & Sesugh, 2022), requiring engineers to balance low-carbon materials with performance, cost, and availability in a context-specific, interdisciplinary process (Firoozi &Oyejobi, 2025). Innovative eco-friendly materials—such as bio-based composites, recycled aggregates, low-carbon concrete, and reclaimed asphalt pavement (RAP)—can substantially reduce embodied carbon and waste (Egbebike& Tiza, 2025; Tiza, Okafor, & Agunwamba, 2025), but their benefits must be verified against strength, durability, and life-cycle performance through rigorous testing (e.g., EDXRF) to avoid compromised quality or premature failure (Tiza, Okafor, & Agunwamba, 2025; Utsev et al., 2024). Energy-efficient strategies work best as integrated systems, combining passive measures (optimal orientation, daylighting, natural ventilation) with efficient HVAC and renewables to cut operational energy use, while accounting for climate and material thermal behavior (Shahid & Khan, 2025; Tiza, 2022; Tiza, Jirgba, Sani, & Sesugh, 2022). Case studies of projects using recycled/low-carbon materials, optimized passive design, and iterative assessment show significant reductions in embodied and operational carbon alongside improved economic and social outcomes, proving that success relies on continuous evaluation, feedback, and interdisciplinary alignment rather than isolated green technologies (Cheng et al., 2024; Utsev et al., 2024; Egbebike& Tiza, 2025; Tiza, 2022). Table 2 summarizes these interconnected elements—civil engineers' guiding role, innovative material selection, and energy-efficient strategies—in advancing sustainable construction.

Table 2: Analytical Overview of Sustainable Design Roles, Materials, and Strategies in Construction

Aspect	Key Roles / Actions	Analytical Insights
Civil Engineers' Role	Translate sustainability into design; evaluate materials, structure, service life	Neglecting sustainability in design → inefficiencies, higher life-cycle costs; trade-offs between low-carbon materials, cost, performance, and availability
Innovative Materials	Bio-based composites, recycled aggregates, low-carbon concrete, reclaimed asphalt	Environmental benefits must be weighed against structural integrity; EDXRF analysis ensures quality and durability
Energy-efficient Design	Passive strategies, building orientation, daylighting, natural ventilation; efficient HVAC; renewables	Energy strategies must consider climatic variability and material thermal performance; integrated systems outperform isolated features
Case Studies	Recycled/low-carbon materials, iterative performance assessment, optimized passive strategies	Success depends on iterative evaluation aligning environmental, structural, and cost objectives; interdisciplinary collaboration critical

4. Sustainable Construction Execution

Sustainable construction execution represents a pivotal phase in the project lifecycle where theoretical designs translate into tangible environmental benefits, yet it is fraught with operational complexities that demand critical scrutiny. While proponents highlight its potential for resource optimization and reduced ecological footprints, empirical evidence reveals inconsistencies in implementation efficacy, often undermined by systemic barriers and varying contextual factors. This section critically analyzes key methods, site practices, contractor roles, and adoption challenges, drawing on recent scholarly insights to evaluate their analytical implications for advancing sustainability in high-rise projects.

4.1 Construction Methods Promoting Sustainability (Modular Construction, Prefabrication, Waste Reduction)

Modular and prefabricated construction methods have been lauded for their capacity to mitigate environmental impacts, but their effectiveness hinges on precise integration and contextual adaptation, raising questions about scalability and long-term viability. Quantitative studies demonstrate that these approaches can achieve substantial waste reductions—ranging from 52% to 90% compared to traditional methods—through off-site fabrication that minimizes on-site material inefficiencies (Jaillon et al., 2009; Loizou et al., 2021). For instance, modular techniques reduce overall waste weight by up to 83.2%, with corresponding cost savings of 47.9% in large structures, by enabling controlled environments that limit errors and excess (Loizou et al., 2021; Quale et al., 2012). Prefabrication similarly accelerates schedules by 20-50% and minimizes site disturbances, such as soil erosion and habitat disruption, aligning with circular economy principles by promoting material reuse (Guerra et al., 2024; Jaillon& Poon, 2014).

However, this optimism must be tempered analytically: while waste reduction metrics are compelling, they often derive from case studies in controlled, high-resource settings, potentially overstating benefits in resource-constrained environments like developing regions (Hosseini et al., 2018). Critically, the level of prefabrication influences outcomes, with higher modular integration yielding greater reductions, yet this demands upfront investment in technology and supply chains that may exacerbate inequalities in global adoption (Lu et al., 2021). Moreover, while these methods promise eco-efficiency, unintended consequences—such as increased embodied carbon from transportation—underscore the need for lifecycle assessments to avoid greenwashing (Pan et al., 2024). Thus, rather than a panacea, modular and prefabricated approaches require adaptive frameworks to balance environmental gains against operational trade-offs.

4.2 Site Management Practices for Sustainability

Site management practices, including erosion control, waste segregation, and water recycling, are essential for operationalizing sustainability, yet their analytical evaluation reveals implementation gaps that compromise environmental outcomes. Erosion control techniques, such as silt fences and vegetative buffers, effectively reduce sediment runoff by 70-90%, preserving soil integrity and preventing waterbody pollution (Shajidha&Mortula, 2025). Waste segregation, integrated with lean principles, facilitates recycling rates of 70-90%, diverting materials from landfills and aligning with circular economy models (Kazancoglu et al., 2021; Low et al., 2020). Water recycling via greywater systems can slash freshwater demand by 45-60%, equivalent to 25-40 cubic meters saved per 1,000 m² of built area, particularly in arid contexts (Li et al., 2022).

Critically, however, these practices often falter in execution due to inconsistent enforcement and regional disparities; for example, developing nations face infrastructure deficits that limit recycling efficacy, leading to only 30-50% diversion rates without digital tools like BIM (Charef & Emmitt, 2021). Analytical scrutiny highlights a paradox: while technologies like AI-driven robotics enhance segregation precision, high costs and skill shortages perpetuate reliance on manual methods, undermining potential CO_2 reductions of 30-50% (Devaki & Shanmugapriya, 2022). This suggests that site management must evolve beyond descriptive protocols toward adaptive, data-informed strategies to address site-specific vulnerabilities and maximize ecological resilience.

4.3 Role of Builders/Contractors in Implementing Sustainable Processes

Contractors serve as linchpins in sustainable execution, yet their role is analytically contested, often limited by capability deficits that hinder transformative impact. As primary implementers, contractors influence sustainability through process selection, subcontractor management, and on-site protocol enforcement, potentially reducing waste by 64% via lean integration (Nahmens&Ikuma, 2012). They drive green capabilities by adopting technologies and fostering stakeholder collaboration, enhancing project outcomes in energy efficiency and material stewardship (Al Khalil et al., 2023).

However, critical analysis exposes vulnerabilities: contractors' self-perceived roles are often reactive rather than proactive, constrained by resistance to change and inadequate training in green practices (Enshassi et al., 2018; Pulaski & Horman, 2005). This leads to suboptimal implementation, where environmental concerns like waste control are sidelined for cost priorities, perpetuating inefficiencies (Zuo et al., 2021). Analytically, embedding sustainability in contracts via clauses for performance metrics could empower contractors, but without incentives, their role risks devolving into compliance rather than innovation, highlighting the need for systemic shifts in industry norms.

4.4 Challenges in Execution and Adoption of Green Methods

The adoption of green methods faces multifaceted challenges that analytically expose tensions between aspiration and feasibility, demanding targeted interventions for equitable progress. Primary barriers include high initial costs (ranked highest in multiple studies), lack of skilled labor, unfamiliarity with technologies, and regulatory voids, which collectively slow diffusion by 15-30% in developing contexts (Darko et al., 2017; Chan et al., 2018). Resistance to change and market inertia further exacerbate issues, with stakeholders prioritizing short-term economics over long-term benefits (Saleh & Al-Swidi, 2021).

Critically, these challenges are not uniform; in regions like Nigeria and Egypt, policy gaps and education deficits amplify disparities, contrasting with advanced economies where technical barriers dominate (Oke et al., 2019; Eshofonie& Oke, 2024).

Analytical implications suggest that solutions—such as incentives, training, and demonstration projects—must address root causes; for instance, capacity building could bridge skill gaps, but without enforcement, adoption remains fragmented (Agyekum et al., 2022). Ultimately, overcoming these requires a paradigm shift from barrier mitigation to proactive ecosystem redesign for resilient sustainability.Fig. 2 illustrates the key challenges in implementing green construction practices, including technical limitations, financial constraints, institutional barriers, resistance to change, and knowledge gaps.

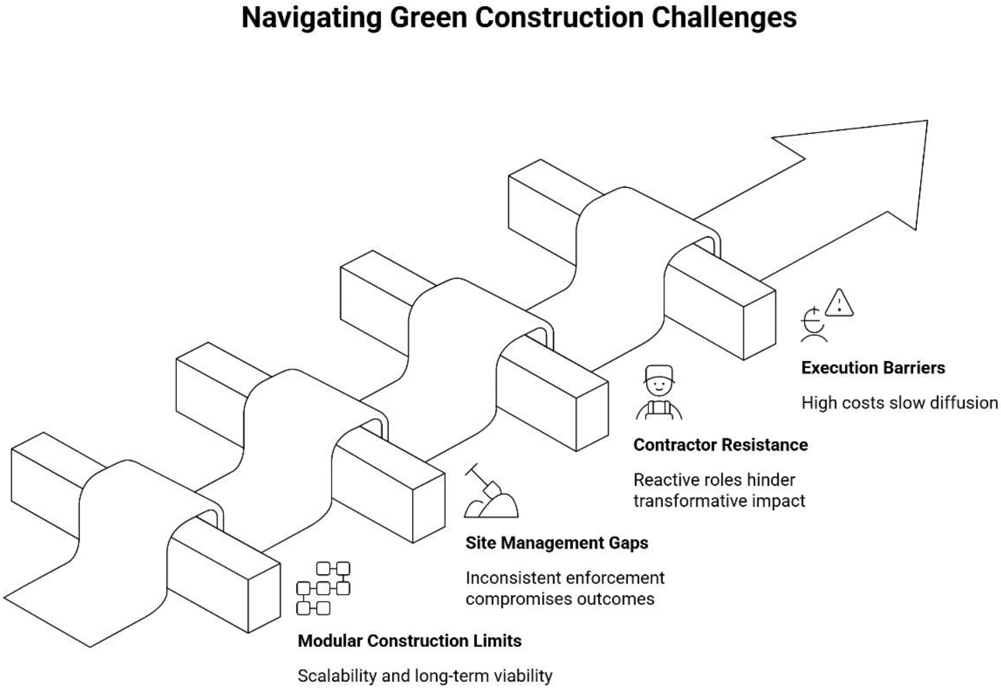

Fig. 2: Navigating Green Construction Challenges

5.1 Role of quantity surveyors in budgeting sustainable projects

Quantity surveyors play a strategic role in embedding sustainability into construction budgeting by critically evaluating both traditional cost drivers and emerging sustainability costs. Beyond routine cost planning, quantity surveyors must navigate complex decisions involving materials with lower environmental impacts, technologies that reduce operational emissions, and projections that balance upfront investment with long- term value (Kim et al., 2022; Dasović &Klanšek, 2021). Their decisions influence whether a project can realistically achieve sustainable outcomes without compromising economic viability, particularly in light of dynamic cost behaviors and the escalating complexity of green technologies. For example, integrating mixed- integer nonlinear programming with project management tools supports cost- optimal sustainable scheduling, illustrating how advanced quantitative methods improve the precision of budgeting and resource allocation (Dasović &Klanšek, 2021). These analytical roles underscore that quantity surveyors are central to sustainable construction, not merely as cost trackers but as financial strategists who ensure that sustainability criteria are integrated throughout the project lifecycle.

5.2 Life cycle cost analysis and ROI of green construction

Life cycle cost analysis (LCCA) is essential for evaluating the full economic implications of sustainable construction practices, as it moves beyond first costs to include maintenance, operational energy use, and eventual disposal or recycling costs (Zoghi& Kim, 2020; Sutikno et al., 2025). By adopting LCCA, practitioners gain a holistic perspective on how sustainability interventions influence the total cost of ownership, enabling more informed decisions about investments such as energy- efficient systems or waste- reducing strategies. Studies show that when quantified appropriately, LCCA demonstrates significant life cycle savings and stronger return on investment (ROI), countering the common misconception that sustainability is prohibitively expensive (Sutikno et al., 2025). For instance, analysis of BIM-based waste management revealed potential cost reductions of up to 57% over conventional methods, highlighting that advanced digital integration in cost modeling can uncover hidden financial benefits of sustainable construction (Zoghi& Kim, 2020). Consequently, LCCA is not only an evaluation tool but a decision-support mechanism that enables stakeholders to justify sustainable investments with robust economic data.

5.3 Cost-benefit analysis of sustainable materials and techniques

Cost-benefit analysis (CBA) provides a framework for comparing short-term expenditures with anticipated long-term returns, particularly for sustainable materials and construction techniques whose benefits accumulate over time. Although upfront costs for green materials and advanced systems can exceed those of traditional alternatives, evidence suggests that long-term benefits—such as reduced energy consumption, lower maintenance costs, and improved building performance—frequently justify the initial investment (Kim et al., 2022; Dasović &Klanšek, 2021). For example, cost models that integrate sustainable indicators with schedule optimization demonstrate that strategic sequencing and technology adoption can reduce both waste and project duration, yielding financial advantages that are not apparent from initial cost estimates alone (Kim et al., 2022). Additionally, the use of systematic reviews on time-cost optimization reinforces the importance of trade-off analysis, highlighting methodological approaches to reconcile short-term cost increases with long-term sustainability gains (ElSahly et al., 2023). Therefore, CBA demands not only numeric comparison but also contextual interpretation, as cost outcomes are influenced by market conditions, regulatory incentives, and lifecycle performance requirements.

5.4 Examples of cost optimization in sustainable projects

Real-world applications demonstrate that early integration of sustainability criteria into cost planning consistently yields measurable cost optimization across the project life cycle. A study on cost-effective building models based on GREENSHIP rating assessment found that combining value engineering with LCCA methods significantly improved both sustainability performance and cost outcomes (Sutikno et al., 2025). Similarly, integrating cost-optimal scheduling models into project management tools helps align construction timelines with sustainable goals, reducing inefficiencies and enabling better allocation of resources (Dasović &Klanšek, 2021). These examples illustrate that cost optimization is not an emergent property of sustainability adoption but a result of deliberate analytical strategies, including advanced modeling, iterative budgeting, and digital support systems. The evidence underscores that sustainable construction can achieve financial benefits when cost management is proactive, data-driven, and aligned with environmental and social performance metrics.

6. Integration of Design, Execution, and Cost

6.1 Interdisciplinary approaches for sustainable construction

Sustainability in construction is inherently multidisciplinary, requiring civil engineers, builders, and quantity surveyors to coordinate decisions throughout the project life cycle. Empirical studies demonstrate that projects with structured interdisciplinary collaboration achieve better alignment between technical, environmental, and financial objectives, minimizing conflicts and project delays (Kim et al., 2022; Dasović &Klanšek, 2021). Critically, such collaboration extends beyond informal communication—it involves shared platforms, joint risk assessment, and co-optimization of design and execution strategies to ensure sustainability goals are realistically achievable and measurable.

6.2 Decision-making frameworks combining technical feasibility, cost, and environmental impact

Decision-making in sustainable construction requires frameworks that systematically integrate technical, financial, and environmental criteria. Multi-criteria decision analysis (MCDA) and life-cycle assessment (LCA) provide structured methods for evaluating trade-offs, highlighting potential conflicts between cost and environmental performance (Zoghi& Kim, 2020; ElSahly et al., 2023). Studies show that frameworks combining these analytical tools with BIM-based simulations improve the accuracy of planning, enhance resource efficiency, and prevent suboptimal material or technology choices that could undermine sustainability objectives (Sutikno et al., 2025).

6.3 Collaborative models among engineers, builders, and quantity surveyors

Collaborative models such as Integrated Project Delivery (IPD) and design-build approaches formalize shared accountability, aligning incentives and distributing risks among stakeholders (Kim et al., 2022). Evidence indicates that projects adopting IPD report improved adoption of green construction practices and optimized cost and schedule outcomes. Critical analysis shows that the success of these models depends on organizational culture, transparent communication, and early stakeholder engagement, emphasizing that collaboration is not automatic but must be deliberately structured and monitored (Dasović &Klanšek, 2021).

6.4 Tools and software supporting integration (BIM, LCA tools, project management software)

Digital tools are essential for operationalizing integrated sustainable construction. BIM enables real-time coordination across disciplines, supports visualization of material performance, and simulates environmental impacts, while LCA tools quantify embodied energy, carbon footprint, and life-cycle costs (Zoghi& Kim, 2020; Sutikno et al., 2025). Critically, these tools amplify the effectiveness of collaboration but require trained personnel to interpret results correctly; otherwise, they risk misinforming decision-making. Integration of project management software further enhances scheduling, resource allocation, and cost optimization, linking execution with both design and financial planning in a continuous feedback loop.

7. Challenges and Barriers

Despite advances in tools and collaborative models, projects face substantial barriers. Limited technical expertise, insufficient funding, and weak regulatory enforcement often constrain the adoption of integrated sustainable practices (ElSahly et al., 2023; Kim et al., 2022). Analytically, these barriers are not merely operational but structural, reflecting systemic underinvestment in workforce training, lack of incentives for innovation, and fragmented institutional oversight.

Construction firms frequently exhibit inertia due to risk aversion, adherence to traditional practices, and skepticism regarding the cost-effectiveness of green technologies (Sutikno et al., 2025). Evidence suggests that resistance persists even when sustainability measures demonstrate long-term savings, highlighting that behavioral and organizational change is as critical as technical innovation in promoting green construction adoption.

There is a pronounced need for capacity building in sustainable construction. Professionals require training in digital modeling, environmental assessment, and interdisciplinary collaboration to manage increasingly complex projects (Zoghi& Kim, 2020; Dasović &Klanšek, 2021). Without targeted upskilling, tools such as BIM and LCA cannot achieve their potential, and sustainability objectives risk remaining theoretical rather than actionable.

8. Opportunities and Future Directions

Emerging trends include circular economy principles, modular construction, and resilient design approaches that enhance environmental performance and resource efficiency (Kim et al., 2022). Critically, these innovations shift the focus from short-term cost reduction to long-term value creation, demonstrating that sustainability is not merely a regulatory requirement but a strategic advantage.

AI, sensors, IoT, and real-time monitoring enable proactive management of energy consumption, waste, and cost, creating opportunities for data-driven optimization across design, execution, and financial dimensions (Zoghi& Kim, 2020). Analytically, these technologies allow dynamic feedback loops, reducing inefficiencies and enabling predictive maintenance, thereby linking operational performance directly with sustainable outcomes.

Government policies, building codes, and financial incentives significantly influence the adoption of sustainable construction practices (ElSahly et al., 2023). Critical evaluation shows that policy support alone is insufficient; it must be complemented by enforcement mechanisms, standardized metrics, and stakeholder education to achieve measurable sustainability gains.

To sustain integrated practice, formalized shared objectives, cross-functional training, and collaborative contractual models are essential (Dasović &Klanšek, 2021; Sutikno et al., 2025). Analytical evidence suggests that such approaches reduce siloed decision-making, enhance project outcomes, and align cost, performance, and environmental goals, reinforcing the necessity of structured collaboration in sustainable construction.

9. Conclusion

This review demonstrates that sustainable construction cannot be achieved through isolated interventions; it requires a coherent and unified framework that integrates design, execution, and cost management. Evidence from recent studies indicates that such integration not only reduces material and energy waste but also enhances structural performance and ensures favorable long-term economic outcomes (Kim et al., 2022; Zoghi& Kim, 2020; Dasović &Klanšek, 2021). Critically, the findings highlight that sustainability is both a technical and managerial challenge, demanding coordinated strategies across multiple stakeholders rather than solely relying on innovative materials or processes.

The analysis underscores that siloed or fragmented approaches significantly compromise sustainability objectives. Interdisciplinary collaboration among civil engineers, builders, and quantity surveyors, supported by digital integration tools such as BIM and LCA software, is essential for aligning technical feasibility, environmental performance, and economic efficiency (Sutikno et al., 2025; ElSahly et al., 2023). By fostering shared decision-making and real-time coordination, such integration enables a proactive, rather than reactive, approach to sustainable construction, ensuring that sustainability considerations are embedded throughout the project lifecycle.

Despite advances in integrated methodologies, gaps remain in standardized frameworks that operationalize collaboration, quantify performance metrics, and guide the adoption of emerging digital solutions in diverse construction contexts. Future research should focus on developing universally applicable integration models, evaluating measurable sustainability outcomes across disciplines, and identifying practical pathways for implementing digital tools in real-world projects. Addressing these gaps will be crucial for transforming theoretical sustainability concepts into actionable strategies that are both economically viable and environmentally responsible.

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