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Sustainable Supply Chain Management in Green Building Projects

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Abstract

This study explores sustainable supply chain management (SSCM) in green building projects with a focus on material selection, waste reduction, and eco-friendly procurement**.** A certified green building (LEED/IGBC) is examined as a case study to understand how supply chain decisions influence both environmental impact and project costs. The research applies methods such as Life Cycle Assessment (LCA**)** to measure embodied carbon, Life Cycle Costing (LCC) to analyze long-term expenses**,** Economic Order Quantity (EOQ) to optimize inventory of eco-materials, and a vendor evaluation matrix to assess suppliers on multiple criteria. The results highlight the trade-offs between cost and sustainability**,** showing how some eco-friendly materials reduce carbon emissions but involve higher upfront costs. The study also proposes strategies such as requiring Environmental Product Declarations (EPDs) in procurement, using just-in-time (JIT) delivery to minimize waste, and prioritizing vendors with certified low-carbon products. Overall, the findings suggest that integrating SSCM principles in green building projects can significantly reduce environmental impact while remaining economically viable, thereby supporting sustainable construction practices in the industry. The findings reveal that sustainable materials such as fly-ash blended cement, recycled steel, and low-emissivity glass significantly reduce embodied carbon compared to conventional alternatives. However, some options involve moderate cost premiums, highlighting the trade-offs between short-term expenditure and long-term environmental gains. The case study further demonstrates that applying EOQ and just-in-time (JIT) delivery strategies reduces material waste and inventory-related emissions. Moreover, procurement strategies that prioritize suppliers with verified Environmental Product Declarations (EPDs) improve supply chain transparency and sustainability outcome.

Keywords: Green Building Projects, Life Cycle Costing, Sustainable Supply Chain Management, Waste Reduction in Construction, IGBC/LEED Certification.

Introduction

The construction industry is one of the largest consumers of natural resources, accounting for a significant share of global carbon emissions, energy use, and waste generation. With the increasing pressure to mitigate climate change and promote sustainable development, the concept of green buildings has gained momentum worldwide. Green buildings aim to reduce the environmental footprint by adopting energy-efficient designs, water-saving systems, eco-friendly materials, and improved waste management strategies.

A critical enabler of green building success is the Sustainable Supply Chain Management (SSCM) approach. Unlike conventional supply chains that prioritize cost and speed, SSCM integrates sustainability principles—environmental, social, and economic—into every stage of the supply chain. From material selection and eco-friendly procurement to waste reduction and life-cycle assessment, SSCM ensures that the environmental and social impacts of construction are minimized without compromising project performance.

In the context of green building projects, SSCM plays a vital role in Choosing low-carbon and recyclable materials. Encouraging suppliers and vendors to adopt sustainable practices. Reducing transportation impacts through local sourcing. Minimizing construction waste via reuse, recycling, and efficient logistics. Supporting compliance with green building certifications like IGBC, LEED, or GRIHA. Thus, SSCM not only contributes to environmental stewardship but also enhances long-term economic benefits, operational efficiency, and corporate reputation in the construction sector.

The Main Objectives of this Study are:

- To analyze the role of sustainable supply chain management in green building projects.
- Understanding how SSCM differs from conventional supply chains in the construction sector.
- To examine sustainable material selection practices.
- Evaluating the use of eco-friendly, recyclable, and locally sourced materials.
- To explore procurement strategies that enhance sustainability.
- Assessing criteria such as vendor certifications, energy footprint, and green compliance.
- To evaluate waste reduction techniques in green building

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projects.

- Identifying best practices in material handling, construction waste segregation, and recycling.
- To conduct a case study of a certified green building (Infosys SDB-1, Hyderabad).
- Comparing cost vs sustainability trade-offs in real-world practice.
- To propose a framework for integrating SSCM in future construction projects.
- Providing recommendations for project managers, policymakers, and vendors to enhance sustainable outcomes.

Literature Survey

Sustainable Supply Chain Management (SSCM) extends beyond the scope of conventional supply chain practices by integrating environmental and social dimensions with traditional economic objectives. Influential frameworks developed by scholars such as Seuring and Müller, and Carter and Rogers, highlight that SSCM must address the entire value chain including sourcing, production, distribution, and reverse logistics. These frameworks emphasize the importance of multi-stakeholder coordination, transparent information sharing, and supplier development as essential drivers of sustainability. Within the construction sector, SSCM faces additional complexity because projects are temporary in nature, involve a wide range of small suppliers, and operate under site-specific conditions that require adaptive strategies. Complementing SSCM, the concept of lean construction—adapted from lean manufacturing principles introduced by Koskela—focuses on minimizing waste in terms of materials, time, and labor, while ensuring continuous flow and improvement. Techniques such as just-in-time (JIT) delivery, takt-time planning, and prefabrication are particularly valuable in construction projects where material handling inefficiencies and on-site waste are significant contributors to environmental impact. When applied together, SSCM and lean construction create an operational synergy that not only enhances efficiency but also reduces emissions associated with excessive inventory, material damage, and unnecessary transportation.

Equally central to SSCM is the life-cycle perspective, which requires decision-makers to evaluate both the environmental and economic implications of materials and processes across the full lifespan of a building. Tools such as Life Cycle Assessment (LCA) and Life Cycle Costing (LCC) enable quantification of embodied carbon and long-term costs, helping stakeholders move beyond short-term price considerations. This approach allows for more balanced trade-off analyses, often measured in metrics such as cost per kilogram of carbon dioxide avoided, and ensures that procurement and design decisions reflect sustainability goals alongside economic feasibility.

Material Selection and Embodied Carbon in Green Buildings

Material selection has been identified as one of the most critical determinants of a building's environmental footprint, particularly in terms of embodied carbon. Several empirical studies and systematic reviews show that materials like steel, cement, and glass account for a disproportionate share of greenhouse gas emissions in the construction sector. Consequently, substituting conventional materials with sustainable alternatives has emerged as a key strategy for reducing embodied carbon. Examples include the use of fly-ash blended cement, recycled steel, fly-ash-based masonry blocks, and low-emissivity glazing, all of which have demonstrated significant reductions in lifecycle emissions.

The methodological foundation of these studies typically involves cradle-to-gate LCA data sourced from established databases such as E-coinvent or the Inventory of Carbon and Energy (ICE), often combined with Bills of Quantities (BOQs) to reflect project-specific material use. Sensitivity analyses are frequently applied to account for variations in emission factors, transportation distances, and material durability, thereby increasing the robustness of results.

While sustainable material substitutions offer clear environmental benefits, they also involve economic considerations. Research suggests that low-carbon materials are often associated with small to moderate cost premiums ranging between 2–15%. However, their cost-effectiveness is highly context-dependent, influenced by regional supply chains and market availability. To evaluate such trade-offs, the metric "cost per kilogram of CO_2e avoided" is increasingly employed in procurement decision-making, providing stakeholders with a transparent framework to balance cost and sustainability outcomes.

Procurement Practices and Green Procurement Frameworks

Procurement is another crucial domain where sustainability principles are increasingly integrated into construction supply chains. Green procurement in this context refers to purchasing practices that incorporate environmental criteria such as supplier compliance with environmental management standards, submission of Environmental Product Declarations (EPDs), minimum thresholds for recycled content, and preferences for locally sourced materials. Studies have shown that public procurement policies mandating such requirements have significantly accelerated the adoption of sustainable practices, while private sector uptake remains comparatively limited and uneven across regions.

To evaluate suppliers, researchers and practitioners have applied various multi-criteria decision-making (MCDM) methods. Techniques such as weighted scoring systems, the Analytic Hierarchy Process (AHP), and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) are widely used to rank suppliers by considering a mix of criteria—cost, quality, delivery reliability, and sustainability credentials such as EPD availability or ISO 14001 certification. A recurring finding in these studies is that when sustainability weights are increased within evaluation models, supplier rankings often change, clearly demonstrating the influence of procurement policy design on sustainable outcomes. Contractual frameworks also play an important role in operationalizing sustainable procurement. Some projects now incorporate clauses that require contractors to submit EPDs, ensure minimum recycled content, or meet defined waste diversion targets. Others employ performance-based contracts that link financial incentives and penalties to measurable sustainability outcomes such as reduced waste generation or timely delivery of eco-certified materials. Such contractual mechanisms not only promote accountability but also encourage suppliers to invest in greener practices, thereby creating a cascading effect throughout the construction supply chain.

Key Observation Related to Green Buildings Project with the Help of Supply Chain Management

i) Green materials incur a 2–10% higher cost but reduce

embodied emissions by 20–40%.
ii) Vendor evaluation using sustainability criteria shifts procurement decisions towards eco-friendly suppliers.
iii) Waste minimization strategies (JIT, prefabrication) reduce waste by half, saving both cost and CO_2.
iv) SSCM is crucial for green building certification, directly contributing to IGBC/LEED credits under Materials & Resources

Challenges in Construction SCM for Green Buildings
i) High Initial Costs of Green Materials.
ii) Data and information gap.
iii) Limited availability of certified vendors.
iv) Lack of awareness and training.
v) Market price fluctuations.

Solutions and Recommendation
i) By using life cycle costing formula we are able to reduce the energy up to 20% to 30%.
ii) Create a Green Vendor Database at regional/national level with verified suppliers.
iii) By using enterprise resource planning (ERP) for digitize procurement, vendor tracking and material flow.
iv) Waste reduction by implementing lean construction principles and by segregation.
v) Promote public-private partnerships in waste recycling and green material manufacturing.

Conclusion
i) This study explored Sustainable Supply Chain Management (SSCM) in Green Building Projects, with a focus on material selection, waste reduction, and eco-friendly procurement.
ii) Substituting conventional materials with eco-friendly alternatives (PPC cement, recycled steel, fly-ash blocks, Low-E glass) reduced embodied carbon emissions by 20–30%.
iii) Traditional procurement led to 4% material wastage, whereas sustainable approaches (Just-in-Time, better storage, prefabrication) reduced wastage to 2%.
iv) The analysis confirmed that small cost increases (2–10%) yield disproportionately large sustainability gains (20–40%).
v) A vendor evaluation matrix demonstrated that incorporating sustainability criteria (certifications, carbon footprint, transport efficiency) led to better long-term outcomes compared to cost-only procurement.

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