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Adoption of Waste and Sustainable Materials in the Built Environment Sector: A Stakeholder Perspective

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ABSTRACT

The use of waste and sustainable materials focuses on minimizing environmental impact and resource depletion by prioritizing waste reduction, reuse, and recycling. In the last few decades, reuse and recycling of waste and sustainable material have emerged as critical strategies for achieving resource efficiency and reducing environmental degradation, especially in the built environment sector worldwide. Globally, the built environment, with sub-sectors such as real estate and construction, consumes nearly half of all extracted materials and generates approximately 615 million tonnes of construction and demolition (C&D) waste annually, accounting for up to 40 percent of total solid waste streams. In developed economies such as USA, Australia & European Union, countries have implemented stringent regulations and mature infrastructure to recycle more than 60 percent of their C&D waste but developing economies show dismal figures, e.g. India - one of the world's fastest-growing construction markets, produces more than 150 million tonnes of C&D waste each year, yet recycles less than 1 percent of that volume, which is far less than developed countries' average. In this context, this study examined key academic literature and industry reports.

The researcher also conducted an in-depth study through a structured questionnaire to analyse the awareness, preferences, myths and imitating factors with respect to adoption of waste and sustainable materials by various stakeholders of the built environment sector. The collected opinion of 44 real estate and construction industry professionals and stakeholders revealed that 68.1 percent of industry respondents have moderate to high familiarity with circular-economy concepts, and 72.7 percent of organizations assign high priority to waste-reduction initiatives. While 61.4 percent respondents believe that the recycled materials are cost-competitive and 63.6 percent expect payback of extra cost within three to five years, yet operational barriers persist: 34.1 percent cite severe supply-chain uncertainties and 52.3 percent report significant technical challenges in material recovery documentation. Additionally, 72.8 percent of respondents believe that recycled materials are useful in the context of developing countries like India, and 65.9 percent consider international green certifications to be good value for money.

Keywords- Waste and sustainable materials, real estate & construction industry, built environment sector, recycling of construction materials, sustainability and climate change.

INTRODUCTION

The concept of circular economy has emerged as a revolutionary paradigm that challenges the traditional linear "take-make-dispose" model, advocating instead for a regenerative system where materials are kept in use for as long as possible through reuse, recycling, and upcycling. This approach is particularly relevant for the construction industry, where buildings and infrastructure account for half of all extracted materials, almost half of the total energy consumption, as well as about one-third of greenhouse gas emissions and waste flows at both European Union and global levels.

The urgency of addressing construction waste management is further emphasized by the staggering global statistics: every year, 615 million tonnes of construction and demolition waste is generated around the globe, with recycling rates varying dramatically across different countries. Developed nations like Australia achieve recycling rates of more than 60%, while developing countries face significant challenges, with India having the lowest recycling rate and China recycling only 5% of C&D waste. This disparity highlights the critical importance of understanding regional contexts and developing tailored approaches to sustainable material management. International frameworks emphasize sustainable construction: e.g. EU's Circular Economy Action Plan and Waste Framework Directive aims to increase the

proportion of recycled materials used in the economy from 11.7% in 2020 to 23.4% by 2030. Japan and South Korea employ advanced recycling technologies and strict enforcement to manage C&D waste (Menegaki & Damigos, 2022). Singapore's integrated approach combines policy incentives, technology, and public-private partnerships (Demirbas & Alamri, 2024). In many developing countries, limited enforcement capacity and competing priorities hamper regulatory effectiveness (Rajesh & Priya, 2017).

REVIEW OF LITERATURE

A. Global Context

The academic literature reveals a growing body of research focused on application of circular economy principles in construction and demolition waste (CDW) management. The construction industry ranks among the planet's most resource-intensive sectors, consuming roughly 40% of global materials and energy while generating substantial waste volumes (Gálvez-Martos et al., 2016). Its environmental footprint has intensified scrutiny on both waste management practices and the adoption of sustainable materials. This review examines the state of construction and demolition (C&D) waste management and sustainable material innovations worldwide, with a focused perspective on India. Construction activities contribute an estimated 30–40% of all solid waste globally, with the Asia-Pacific region alone producing over 1.5 billion tons annually (Mália et al., 2016). In the European Union, C&D waste comprises about 36% of all landfill deposits worldwide (Gálvez-Martos et al., 2016). Generation rates vary significantly: Mália et al. (2016) reported 28–121 tons of waste per US$ 1 million of construction work depending on national practices and infrastructure.

Incorporating recycled concrete aggregates (RCA) into new concrete can maintain comparable mechanical properties while lowering environmental impact. Optimal replacement ratios of 20–30% RCA sustain structural integrity and reduce carbon footprint (Tam & Hao, 2021). Recycled brick powder used as a supplementary cementitious material at 10–20% replacement improves compressive strength (Das & Patel, 2024), and waste tire rubber has shown feasibility in specialized concrete applications (Agrawal & Waghe, 2024). Life cycle assessment (LCA) is essential for quantifying environmental benefits of sustainable materials. Studies reveal recycled building materials reduce greenhouse gas emissions and energy use across a building's lifecycle (Chen & Wu, 2024). Integrating LCA with Material Flow Analysis within circular economy frameworks supports evidence-based material selection (Ghisellini & Ulgiati, 2021). Bio-based composites, such as mycelium-bound composites (MBCs), have surged in research interest due to their renewable nature and low embodied energy (Smith & Jones, 2024). Wood-plastic composites (40–45% wood, 50–60% recycled plastic) offer closed-loop recycling with durable performance (Silva & Rodrigues, 2023).

B. Indian Context

India's construction sector, second only to agriculture in size, generated over 150 million metric tons of C&D waste in metropolitan areas in 2016, with medium-sized cities contributing roughly half (Bansal & Singh, 2020). The Construction and Demolition Waste Management Rules, 2016, represent a regulatory milestone, yet implementation remains uneven across states (Bansal & Singh, 2020). Key impediments include low awareness, inadequate processing infrastructure, and limited regulatory enforcement (Rajesh & Priya, 2017). Economic pressures favor short-term cost savings over long-term sustainability, with only 30% of C&D waste reused in India versus up to 90% in developed nations (Bansal & Singh, 2020). Contractors prioritize worker training for waste segregation, while engineers stress enforcement of illegal disposal penalties, highlighting divergent stakeholder priorities (Sharma & Patel, 2024).

Environmental management plans (EMPs) for construction sites have begun integrating waste minimization and recycling throughout project phases (Sharma & Patel, 2024). Circular economy principles are gaining traction, demonstrating benefits such as enhanced resource efficiency and environmental performance, although economic and policy barriers limit widespread adoption (Ghosh & Mondal, 2023). In a largely populated developing country like India, the biggest barrier to waste and sustainable materials are economic barriers which include high upfront costs for sustainable materials and recycling technologies, uncertain ROI, and limited incentives (Ghisellini & Ulgiati, 2021). Technical hurdles involve inconsistent quality of recycled materials and insufficient recycling infrastructure (Kowalski & Nowak, 2021). Social resistance to change and regulatory gaps further impede circular adoption (Ghosh & Mondal, 2023).

Other than economic barriers, some of the other researchers report the following as major barriers to adopt recycled sustainable materials in built environment sector:

- Awareness and Training: Limited technical knowledge among contractors impedes source-segregation practices (Sharma & Patel, 2024).
- Infrastructure Gaps: Only 2 percent of C&D waste is formally recycled due to scarcity of material recovery facilities (Rajesh & Priya, 2017).

- Policy Enforcement: Weak penalties and low monitoring capacity undermine compliance with segregation mandates (Ghosh & Mondal, 2023).

RESEARCH METHODOLOGY

This study employs a mixed-methods survey research design to investigate attitudes, practices, and barriers related to waste and sustainable materials in the real estate and construction sector. A structured questionnaire was developed based on an extensive literature review of circular economy, green building certifications, and construction waste management. The instrument includes 25 Likert-scale items across four domains: sustainability knowledge, organizational practices, economic perceptions, and developing-country contexts.

A non-probability purposive sampling strategy targeted real estate and construction professionals and other built environment stakeholders with decision-making influence over materials and waste management. Invitations were distributed via industry associations, professional networks, and LinkedIn. Data collection occurred over an eight-week period in May and June 2025, yielding 44 complete responses. Responses were downloaded from Google Forms and cleaned for consistency. Descriptive statistics—frequencies and percentages—summarized demographic profiles and item responses. Cross-tabulations examined relationships between experience levels, roles, and key sustainability attitudes.

ANALYSIS AND DISCUSSION

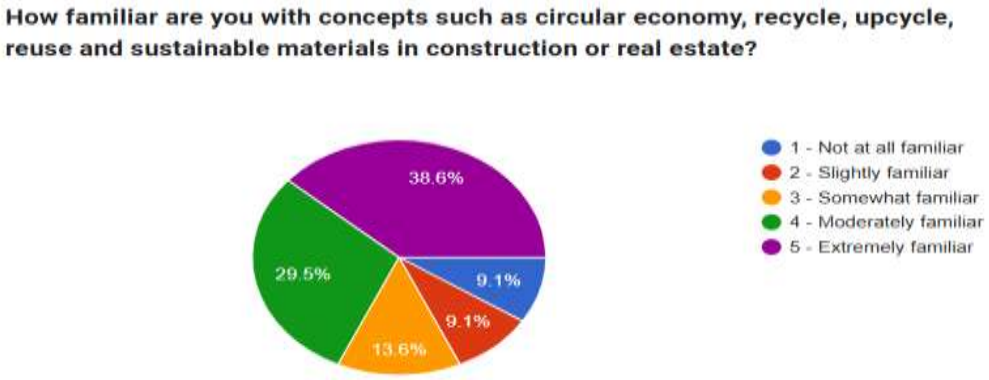
A. Respondent Demographics

The demographic composition of this survey on sustainable materials in the real estate and construction industry reveals a well-distributed sample of 44 professionals, though with notable patterns that significantly influence the survey findings and their broader applicability to the industry.

CATEGORY	DEMOGRAPHIC	Count	Percentage (%)
Role in Industry	Project Manager	12	27.3
	Architect	11	25.0
	Developer	7	15.9
	Contractor	7	15.9
	Others stakeholders	7	15.9
Years of Experience	More than 15 years	13	29.5
	6-10 years	12	27.3
	Less than 5 years	11	25.0
	11-15 years	8	18.2

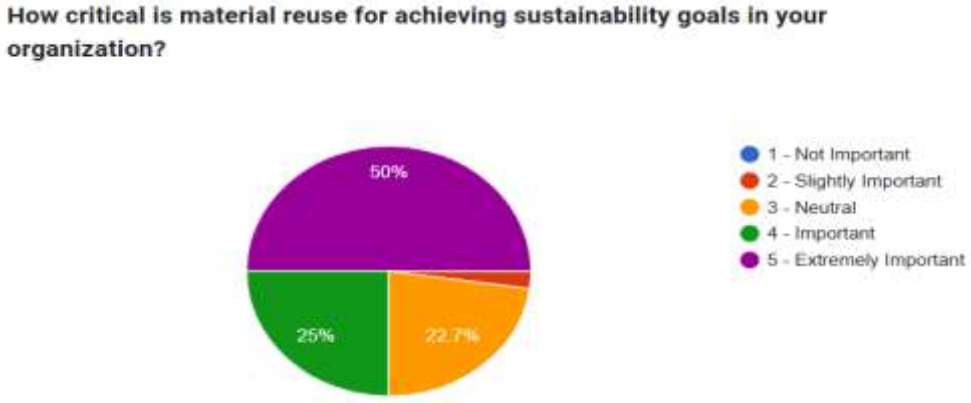
The survey captured responses from key decision-makers across the real estate and construction sector value chain, with Project Managers representing the largest group at 27.3% (12 respondents). This substantial representation is particularly valuable given that project managers typically oversee material selection decisions, budget allocations, and implementation strategies for sustainable practices. Architects comprise the second-largest group at 25.0% (11 respondents), which is crucial for this research focus. Architects play a fundamental role in specifying materials, designing for sustainability, and influencing client decisions about green building features. Developers and Contractors each represent 15.9% (7 respondents each), providing balanced perspectives from both the financial decision-making and construction implementation sides of the industry. The remaining 7 respondents belong to other stakeholders' categories such as attorney, consumer and company secretary.

The years of industry experience distribution reveals a mature professional sample with substantial industry knowledge. The most experienced group, with more than 15 years of experience, represents 29.5% (13 respondents), providing seasoned perspectives on industry evolution, long-term trends, and historical context for sustainable material adoption. This group's insights are particularly valuable for understanding how sustainability practices have evolved and what factors have driven or hindered adoption over time. Mid-career professionals with 6-10 years of experience comprise 27.3% (12 respondents), representing the current industry mainstream. Early-career professionals with less than 5 years of experience represent 25.0% (11 respondents), providing insights from the newest generation of industry professionals. The mid-senior group with 11-15 years of experience comprises 18.2% (8 respondents), the smallest segment but still providing valuable perspectives from professionals who have witnessed significant industry changes and technological developments during their careers.



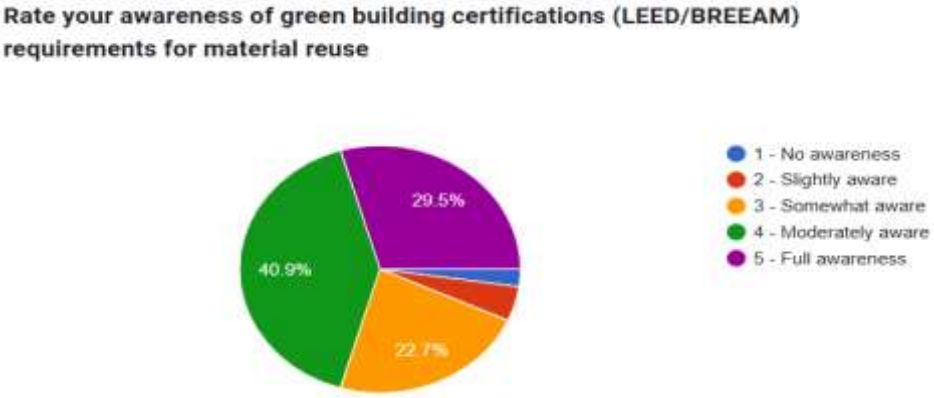
B. Familiarity with Circular Economy and Sustainable Materials

The survey indicates varying levels of familiarity with concepts such as circular economy, recycling, upcycling, reuse, and waste and sustainable materials. 38.6% of the respondents reported to be extremely familiar with the concepts and 29.5% of respondents were moderately familiar with these concepts. Still a significant number of respondents- 31.8% were somewhat familiar or completely unfamiliar with the understanding of such concepts. This disparity underscores the need for awareness campaigns and educational initiatives to bridge the knowledge gap. Familiarity with these concepts is crucial for driving the adoption of sustainable practices in the real estate and construction sector. Those who are extremely familiar are likely to be advocates for sustainability, while those who are unfamiliar may resist change due to a lack of understanding. The survey highlights the importance of providing accessible information and training to increase familiarity across all levels of the industry.



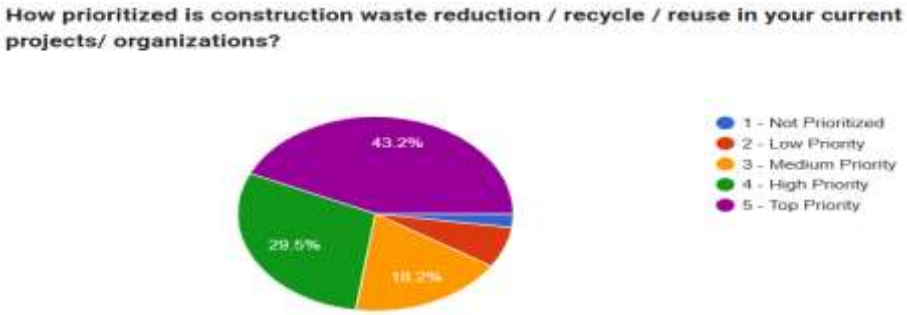
C. Criticality of Material Reuse for Sustainability Goals

The survey reveals favourable opinions on the importance of material reuse for achieving sustainability goals. While 50% of respondents considered it to be extremely important, 25% believed it is important. While 22.7% respondents felt neutral towards the importance of material reuse. This division suggests that material reuse is universally recognized as a critical component of sustainability. Those who view it as important are likely to be aware of the environmental benefits, such as reducing waste and conserving resources. On the other hand, those who consider it unimportant may prioritize other aspects of sustainability, such as energy efficiency or cost reduction. The survey highlights the need for targeted education and discussions to emphasize the role of material reuse in achieving broader sustainability goals.



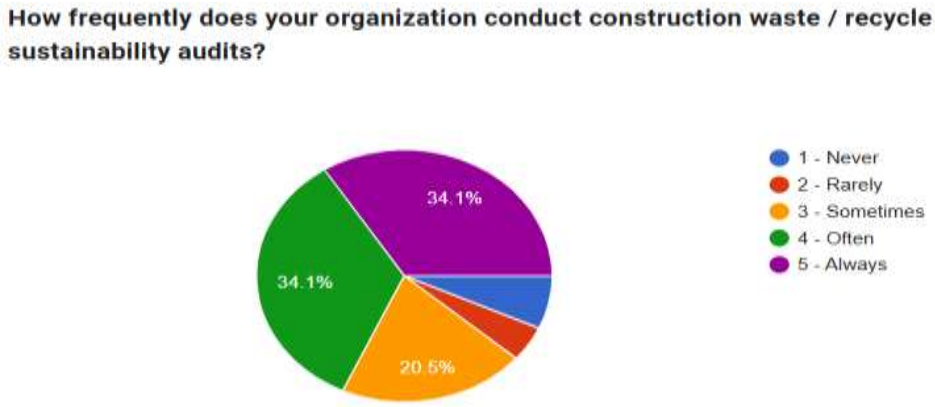
D. Awareness of Green Building Certifications

The survey indicates varying levels of awareness of green building certifications such as LEED and BREEAM. While 40.9% of respondents were moderately aware, 29.5% had full awareness, and 22.7% were somewhat aware. This suggests that while a majority of professionals are familiar with certification requirements, a significant portion still lacks understanding. Green building certifications play a crucial role in promoting sustainable practices by providing guidelines and benchmarks for material reuse and energy efficiency and hence there is need for targeted outreach programs.



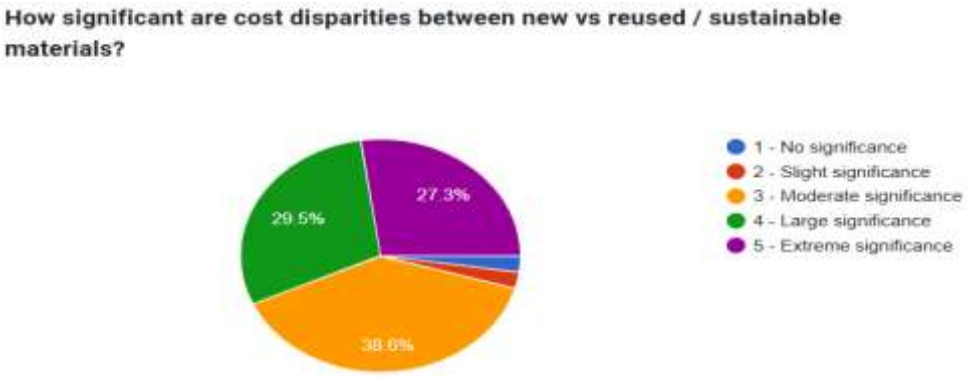
E. Prioritization of Waste Reduction in Projects

The survey reveals that waste reduction is a high priority for many organizations, with 43.2% of respondents indicating that it is a top priority. While 29.5% and 18.2% respondents reported it to be their projects' high or medium priority respectively, 9.1% indicated no or low priority. Organizations that do prioritize waste reduction are likely to benefit from cost savings, improved efficiency, and enhanced environmental performance. Even a miniscule lack of prioritization is a concerning factor for the real estate and construction sector , as waste reduction is a key component of sustainability. The survey hence highlights the need for targeted initiatives to emphasize the prioritization of waste reduction. But as a majority of survey respondents belong to large size organised sector projects, these findings may not be consistent with small/ medium size and unorganised sector projects.



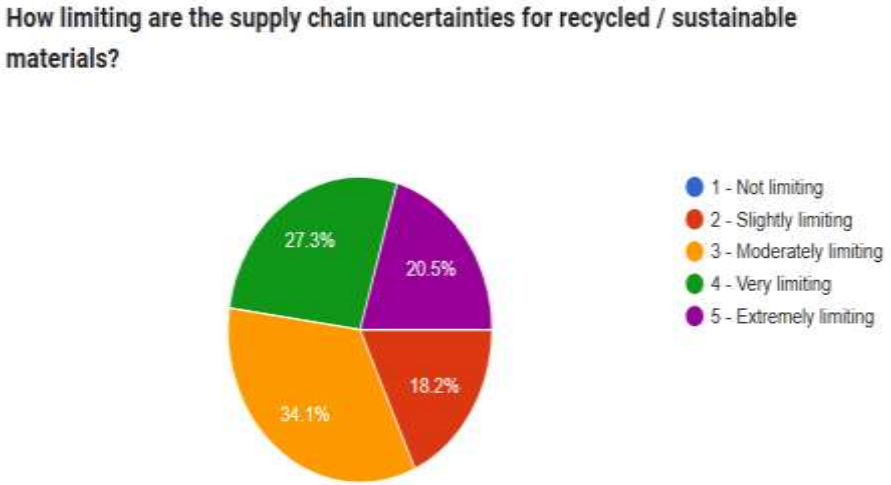
F. Frequency of Sustainability Audits

The survey indicates that sustainability audits are generally conducted, with around one-third of the respondents indicating that their organizations- sometimes, rarely or never conduct audits. This lack of regular monitoring may cause a barrier to achieving sustainability goals. Sustainability audits are essential for identifying areas for improvement and tracking progress toward sustainability targets. The survey highlights the need for all organizations to adopt regular audit practices to ensure that they are meeting their sustainability goals.



G. Cost Disparities Between New and Reused Materials

The survey reveals that cost disparities between new and reused materials are a major concern, with 27.3% of respondents indicating that the cost difference is extremely significant while another 29.5% opined to consider it largely significant. Still, a significant number of respondents- 43.2% mentioned it to be a moderate or not a significant factor at all. This perception or consideration is a major barrier to the adoption of reused materials, as cost is a key consideration for most organizations. Addressing this concern requires industry-wide efforts to reduce the cost of reused materials and demonstrate their long-term value.

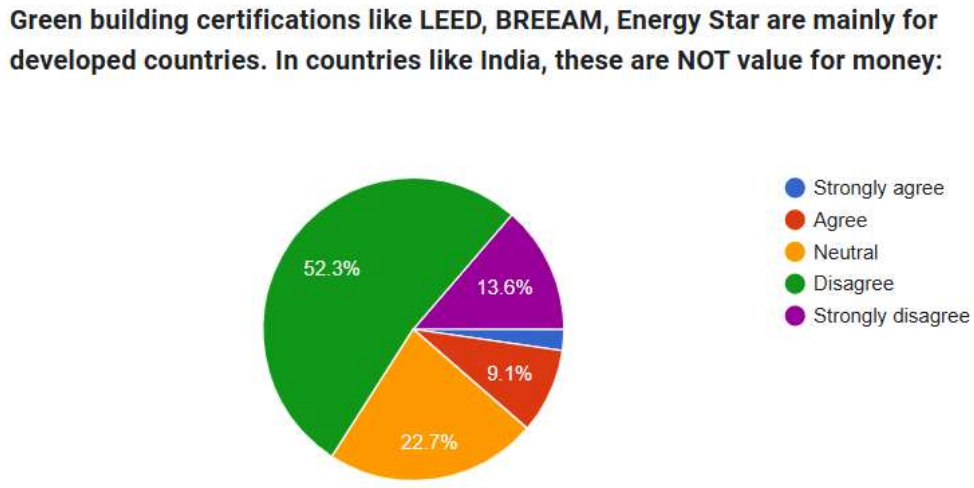


H. Supply Chain Uncertainties

The survey indicates that supply chain uncertainties are a significant barrier to the adoption of recycled and sustainable materials, with 47.8% of respondents indicating that these uncertainties are extremely or very limiting. Only 18.2% respondents do not perceive supply chain uncertainties to be a very significant barrier in the use of sustainable materials.

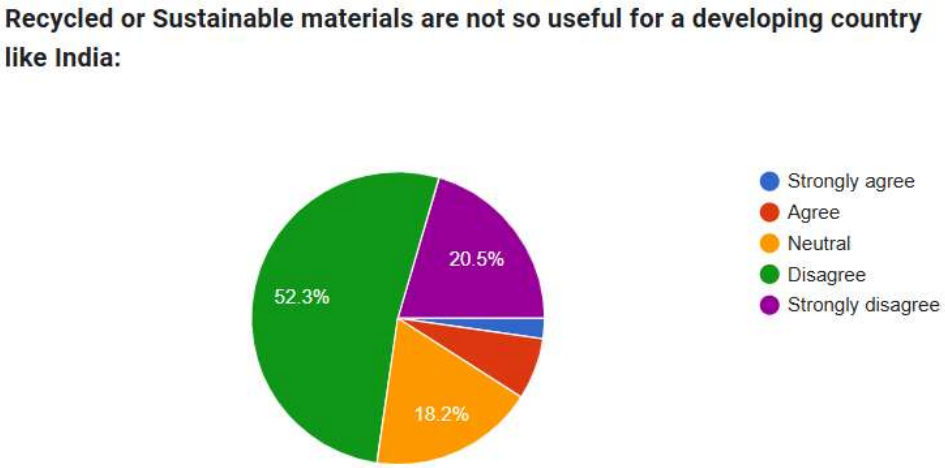
I. Common Myths and Misconceptions

Myth 1: Green Building Certifications are NOT Valuable in Developing Countries



One of the most persistent myths in sustainable construction is that green building certifications like LEED and BREEAM are not valuable in developing countries. The survey data reveals that 65.9% believe green certifications are value for money in India, with 34.1% being neutral or agreeing with this assertion. These findings indicate a strong positive value of green certifications. However, academic research presents a more nuanced picture. Several Indian studies indicate certifications are majorly popular among A grade buildings whereas the lower grade buildings in unorganised sector do not find it best value for excessive investment requirements. Literature on green building certification in developing countries shows that while challenges exist, including unavailability of approved materials, poor design of the buildings, and difficulties with the documentation process, these barriers can be overcome through commitment of the owners, top management support, and proper planning. Studies indicate that the development of national assessment tools is necessary for the developing world due to environmental, social, and economic issues, suggesting that adaptation rather than rejection of certification systems is the appropriate response.

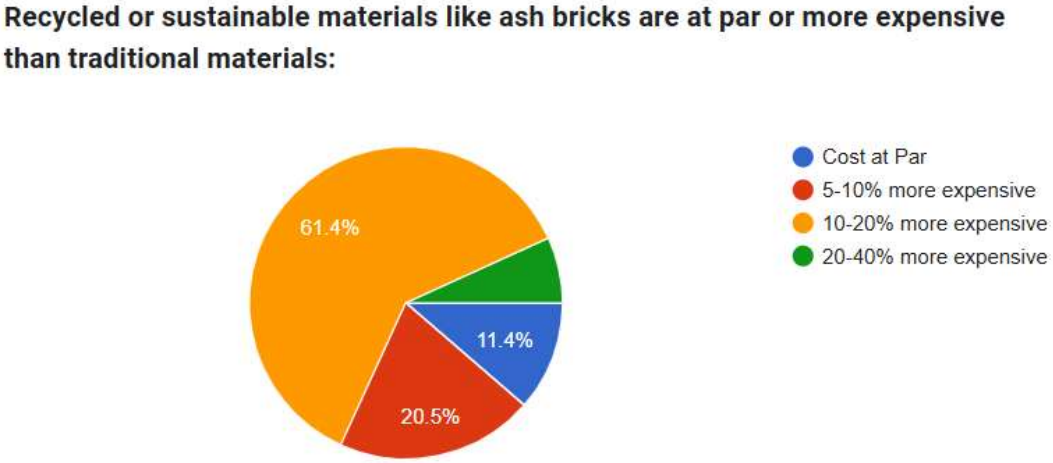
Myth 2: Recycled Materials are not useful for a developing country

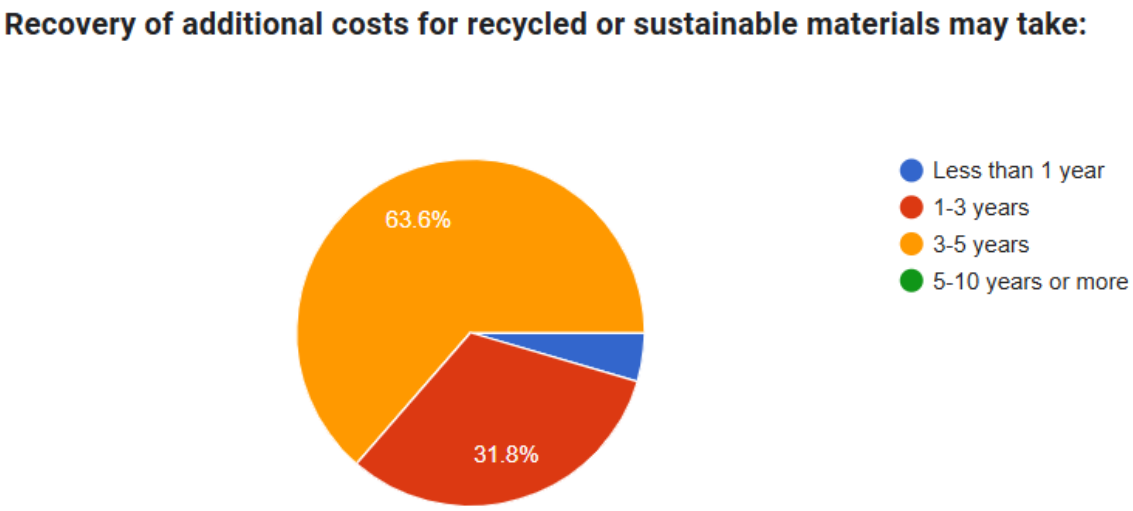


Another common misconception is that recycled construction materials are inherently not useful for a developing country. The survey data indicates mixed perceptions, with 72.8% believing that recycled materials are useful for a developing country. However, quality, aesthetic, and regulatory concerns might be having a negative impact on these positive perceptions. The survey also indicates that the majority of the usefulness of such sustainable materials is driven by environmental conscious investors and government push.

Academic research pertaining to this issue demonstrates that recycled materials can achieve comparable or superior performance to conventional materials. However, developing countries generally do not find them useful due to processing costs, supply chain and technological issues.

Myth 3: Sustainable Construction is far more expensive and not easy to recover its costs



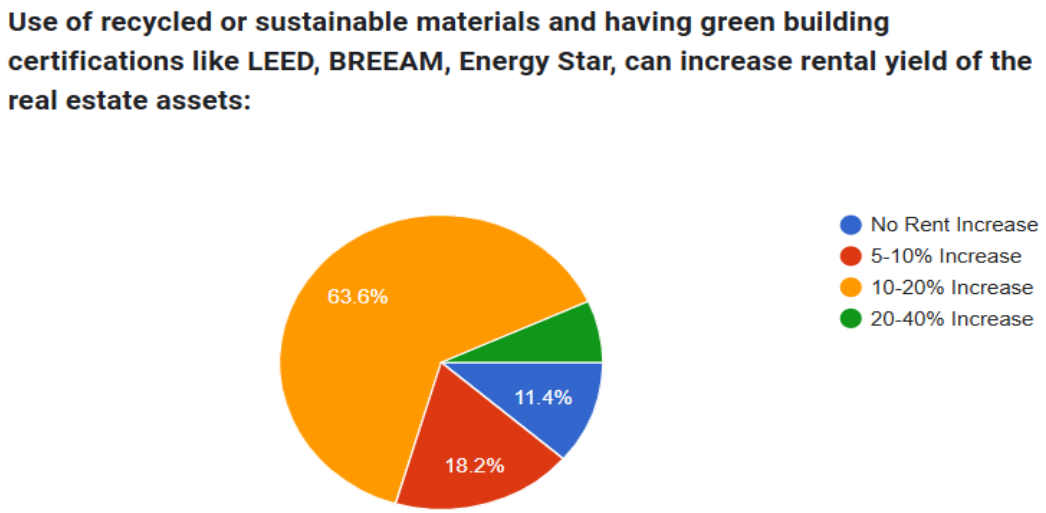


The belief that sustainable construction inevitably costs more is widespread but not supported by comprehensive research. Survey data reveals that the majority of the respondents- 61.4% believed recycled materials are 10-20% costlier than traditional materials, while 63.6% respondents opined that the cost recovery will take 3-5 years.

Academic research findings suggest that overall cost to the extent of 42% can be saved through the use of waste and sustainable materials like carbon-neutral soil-cement fly ash blocks.

Research on economic benefits demonstrates that fly-ash bricks are cost-effective, strong, crack resistance, low maintenance, durable and eco-friendly. Life cycle assessment studies show that sustainable construction systems save energy, leading to long-term economic and environmental benefits.

Myth 4: There Is No Market Demand for Sustainable Buildings

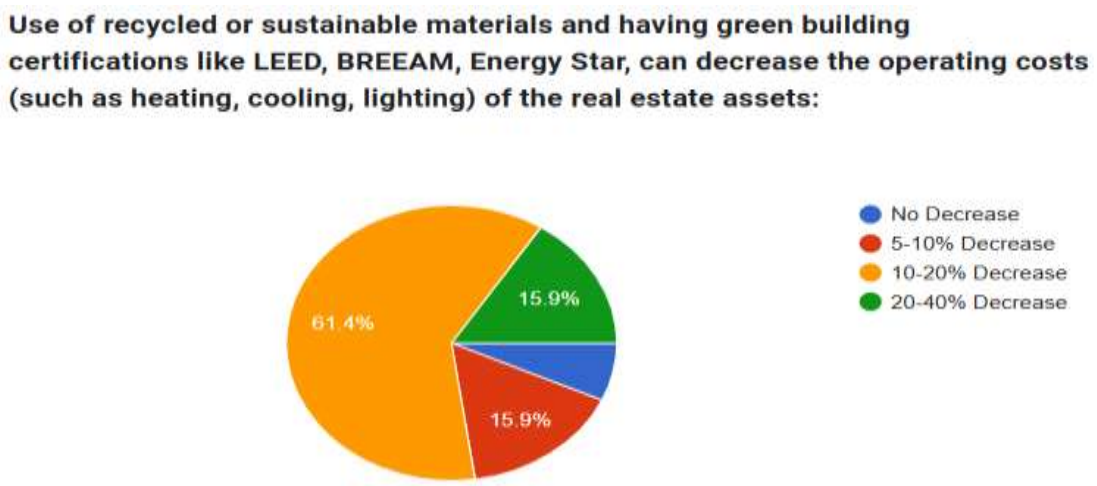


Another persistent myth is that market demand for sustainable buildings is insufficient to justify investment. Survey data shows that 63.6% respondents expect higher rents (10% - 20% increase) from sustainable features while only 11.4% respondents believed it to have no impact on rental yields.

The survey also indicated that the major demand for waste and sustainable materials is generated by green investors and large corporate clients. However, tenants who require real estate for residential purposes majorly consider cost & benefit analysis of traditional materials vs waste / sustainable materials. For certain projects, a push from government regulators is also a dominating factor to adopt sustainable materials over traditional alternatives.

Academic research reveals that the market for green buildings is growing as the green buildings bring multiple benefits and drive economic growth around the world, especially in developed countries. Developing countries, on the other hand, struggle to achieve similar growth and benefits from green buildings.

Myth 5: Waste-to-Resource Business Models Are Not Economically Viable



The survey data reveals that a majority of stakeholders believed that the use of recycled or sustainable materials and having green building certifications like LEED, BREEAM, Energy Star, can decrease the operating costs (such as heating, cooling, lighting) by 10-20%. While 15.9% believed that the savings can go up to 20-40% of operating costs. This indicates a high economic viability of green buildings from a developing country perspective.
However, academic literature suggests that due to processing costs, supply chain and technological issues, use of waste and sustainable materials is not economically viable in most developing countries.

CONCLUSION

The survey reveals a mix of optimism and challenges with regard to the adoption of sustainable materials and practices in the real estate and construction sector. Key barriers include limited familiarity, cost disparities, supply chain uncertainties, and lack of prioritization for waste reduction. However, the positive impact on asset value, rental yield, and operating costs, along with growing tenant demand and ESG investor interest, suggests significant potential for sustainability to become a mainstream priority in the industry. Addressing knowledge gaps, improving supply chains, and reducing cost disparities will be critical for driving widespread adoption.

LIMITATIONS AND FUTURE DIRECTIONS

While this study provides valuable insights into sustainable materials attitudes within the built environment sector, several limitations may affect the generalizability and interpretation of findings:

Sampling Bias and Representativeness: The use of purposive, non-probability sampling limits the ability to generalize results to the broader population of real estate industry professionals. The sample (N=44) may over-represent individuals already interested in sustainability, given distribution through professional networks and industry associations. Moreover, in the Indian context, a large proportion of real estate and construction operates in the unorganised sector which is not sufficiently represented in the survey. Also, the roles such as that of Policy Makers were under-represented, constraining analysis across all stakeholder groups.

Sample Size: With only 44 respondents, statistical power for subgroup analyses (e.g., comparing architects versus contractors) is limited. Small cell sizes in cross-tabulations may produce unstable percentage estimates and prevent robust inferential testing.

Self-Report and Social Desirability Bias: All data were collected via self-administered questionnaires, which may be subject to self-report bias. Participants may overstate their familiarity with sustainability concepts or organizational practices to align with perceived social expectations, inflating positive responses.

Cross-Sectional Design: Data were collected at a single point in time, precluding analysis of changes in attitudes or practices over time. Situational factors—such as recent regulatory changes or market events—may have influenced responses and cannot be disentangled in a cross-sectional framework.

FUTURE RESEARCH DIRECTIONS

To mitigate these limitations, future studies should employ larger, stratified random samples across multiple regions, incorporate longitudinal designs to track temporal changes, and integrate objective performance data (audit logs, certification records). Qualitative interviews and case studies could also deepen understanding of organizational decision-making processes, particularly in under-represented roles and geographic contexts.

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