

A Systematic Literature Review on the Role of Sustainable Building Materials in Enhancing Environmental Efficiency in Developing Countries

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ABSTRACT

A literature review is essential in academic research because it examines existing studies related to the topic and identifies gaps requiring further investigation. In the field of sustainable building materials, previous research emphasizes the environmental, economic, and social dimensions of sustainability, which are particularly important in developing countries. These regions often face resource limitations, rapid population growth, and infrastructure challenges, making sustainable construction both necessary and difficult to implement. Sustainable building materials offer notable technical and environmental advantages, including high durability, low thermal conductivity, strong insulation performance, recyclability, and ease of maintenance. Materials such as recycled concrete, sustainably sourced timber, and compressed clay bricks have shown effectiveness in reducing energy use and carbon emissions during construction and operation. Their adoption in developing countries can also lower long-term costs, improve indoor environmental quality, and support local economies. However, widespread use is hindered by high initial costs, limited technical expertise, low public awareness, and the absence of clear regulations. A major research gap remains: there is a lack of long-term applied studies evaluating the real-world performance and economic feasibility of sustainable materials in developing nations. Addressing this gap is crucial for guiding policies and promoting resilient and sustainable construction.

KEYWORDS

- 1- Sustainable Building Materials
- 2- Developing Countries Environmental
- 3- Sustainability
- 4- Material Performance
- 5- Green Construction



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1. Introduction

1.1 Research Background

Developing countries have experienced rapid and accelerating urbanization driven by population growth, rural urban migration, and the increasing need to expand infrastructure and public services [1]. Although urbanization supports economic and social development, it simultaneously places substantial pressure on natural resources and intensifies environmental challenges, particularly in regions with limited institutional capacity, weak regulatory frameworks, and constrained financial resources [1], [2]. Retrofitting cities to meet sustainability standards after construction is often difficult and costly, highlighting the need for early integration of sustainable principles during planning and design [2], [3]. Experiences from countries such as India, Indonesia, and Nigeria demonstrate that incorporating sustainable building materials offers a practical approach to balancing rapid development with environmental protection, particularly when local supply chains and climatic conditions are considered [4]. Traditional construction materials especially cement and steel remain major contributors to global CO₂ emissions due to their highly energy-intensive manufacturing processes [7], [8]. Cement production releases large amounts of CO₂ during clinker formation, while steel production depends heavily on fossil fuels. These processes significantly increase the life-cycle emissions of buildings and intensify environmental pressures in developing regions [7], [8]. In contrast, sustainable building materials have emerged as promising alternatives that offer lower embodied energy, enhanced thermal performance, and improved indoor environmental quality [9], [10]. Many are produced using recycled or locally available resources, reducing transportation emissions and supporting local economies [9]. Empirical studies have shown notable reductions in greenhouse-gas emissions and energy use when low-carbon materials replace conventional ones, especially when combined with green design strategies [11], [12]. Despite these advantages, adoption in developing countries remains limited. Barriers include high initial costs, weak market availability, insufficient awareness, limited technical expertise, and inadequate policy support [13], [14]. Studies consistently highlight limited incentives, lack of performance data, and weak institutional coordination as major challenges [15], [16], [17]. These issues underscore the need for integrated approaches that include regulatory reform, financial mechanisms, capacity-building programs, and locally adapted innovations.

Although sustainable materials offer environmental, economic, and social advantages, there is still a lack of comprehensive, context-specific research examining their performance in developing countries [18]–[24]. This study aims to address this gap by analyzing current practices, challenges, and opportunities, and by providing evidence-based recommendations for policy and implementation.

1.2 Research Problem

The global construction sector faces increasing environmental pressures related to climate change, accelerated resource depletion, pollution, and poor urban environmental quality [18], [19]. With construction responsible for nearly 40% of global energy use and one-third of greenhouse-gas emissions, the transition to sustainable building practices has become a global priority [20], [21]. Sustainable building materials offer lower embodied energy, greater recyclability, and better thermal and acoustic performance [21]. They help reduce construction waste, enhance indoor air quality, and support healthier and more resilient living environments [22], [23]. Their adoption is particularly important in developing countries experiencing rapid urbanization, rising housing demand, and limited capacity to implement conventional green technologies [22].

However, despite their potential, sustainable materials have not been widely adopted in developing contexts. Barriers include high upfront costs, insufficient financial incentives, inadequate technical expertise, weak institutional frameworks, limited awareness among stakeholders, and a lack of local research on material performance in specific climatic and

socioeconomic conditions [23], [24], [20]. Consequently, high-carbon conventional materials continue to dominate construction markets, further intensifying environmental and economic pressures.

Existing studies remain limited, often theoretical or restricted to laboratory settings, offering insufficient guidance for policymakers and practitioners [24]. There is a clear need for applied, field-based research that evaluates the environmental, social, and economic impacts of sustainable materials in real construction projects in developing countries [25]–[34].

1.3 Aim and Research Objectives

1.3.1 Aim of the Research

This study aims to investigate the importance of sustainable building materials in promoting environmentally, socially, and economically integrated construction practices, particularly within developing countries [1]–[4]. It seeks to demonstrate how sustainable materials can enhance environmental performance, support social well-being, and strengthen economic resilience in rapidly growing urban contexts [9], [10].

1.3.2 Research Objectives

- To assess the significance of sustainable building materials as a strategic solution for construction in developing countries.
- To review the environmental, social, and economic benefits associated with sustainable building materials.
- To analyze key challenges hindering the adoption of sustainable building materials.
- To propose practical and evidence-based strategies to support their effective implementation.

2. Method

This study employs a systematic literature review (SLR) to evaluate the role, benefits, and challenges of sustainable building materials in developing countries. The method ensures transparency, rigor, and replicability while directly supporting the research objectives.

2.1. Literature Search and Data Retrieval

A structured search strategy was used to identify relevant publications from 2015 to 2024 across major databases including Google Scholar, Scopus, Web of Science, and institutional digital libraries. Search keywords included *sustainable building materials*, *eco-friendly materials*, *green construction*, *developing countries*, and *low-income countries*. Only peer-reviewed English and Arabic studies focusing on sustainable materials in developing contexts were included.

Table 1. Overview of Literature Search and Selection

Aspect	Key Information
Databases	Google Scholar, Scopus, Web of Science, digital libraries
Period Covered	2015–2024
Search Keywords	Sustainable building materials, eco-friendly materials, green construction, developing countries
Inclusion Filters	Peer-reviewed English/Arabic studies; focus on sustainable building materials
Outcome	Balanced dataset combining theoretical and applied studies

2.2. Screening and Selection Process

Titles and abstracts were screened to remove unrelated studies. Full-text articles were evaluated using predefined criteria:

1. relevance to sustainable building materials.
2. clarity of research objectives and methodology.
3. publication credibility.

When eligibility disagreements occurred, two reviewers discussed each case. If disagreement persisted, the academic supervisor made the final decision to ensure objectivity, as demonstrated in cases where energy-focused studies were excluded for insufficient relevance to building materials.

2.3. Data Extraction

A structured extraction form was used to record:

- Authors and publication year
- Research methodology
- Geographic context
- Material type analyzed
- Key environmental, economic, and social findings
- Reported challenges and limitations

This structured approach allowed consistent comparison across studies.

2.4. Analysis and Synthesis

Extracted data were grouped into three major analytical dimensions:

2.4.1. Environmental Performance

Includes energy efficiency, emission reduction, durability, waste minimization, and climate adaptability.

2.4.2. Economic Feasibility

Considers cost, long-term savings, maintenance, local production viability, and scalability.

2.4.3. Social Impact

Covers public awareness, cultural acceptance, health and comfort, local employment, and community benefits.

Comparative analysis was used to identify similarities, differences, and recurring patterns. The final synthesis combined narrative interpretation and tabular summaries to build a robust foundation for the study's recommendations.

2.5. Identification of Research Gaps

The systematic review revealed critical gaps including:

- Limited long-term and real-world field studies.
- Scarcity of cross-country comparative research.
- Weak integration of socio-economic and cultural factors.

These gaps highlight the need for applied research to guide policy and practice in developing countries.

3. Results and Discussion

This section presents the results of the research activities, analysis of sustainable building materials, the identified gaps in existing literature, the methodological framework developed for developing countries, and its practical implications.

3.1 Research Activities and Findings

The study employed a systematic literature review of 45 academic sources, including peer-reviewed articles, technical reports, and institutional publications. Keywords included “*sustainable building materials*”, “*recycled materials*”, and “*developing countries*”. The sources were screened for relevance, credibility, and methodological rigor. Selected studies were categorized into:

- Natural materials: bamboo, clay, stone
- Recycled materials: recycled concrete, fly ash
- Hybrid/innovative composites

Analysis focused on three dimensions: environmental benefits, economic feasibility, and practical challenges. Comparative case studies from developing countries were also examined to understand adoption practices, achieved benefits, and encountered barriers.

Table 1. Summary of Research Activities

Step	Description	Outcome
Data Collection	45 academic sources	Comprehensive dataset
Screening & Classification	Relevance and credibility check	Structured selection
Thematic Analysis	Environmental, economic, practical assessment	Identified key factors
Case Studies	Review of developing country cases	Practical insights
Synthesis	Consolidation of evidence	Gap identification

These steps ensured a systematic, transparent, and reliable foundation for the discussion and interpretation of results.

3.2 Discussion: Research Gap and Framework Development

3.2.1 Limitations of Previous Studies

Existing literature often focuses on isolated aspects of sustainability:

- Environmental and economic dimensions (Din and Ishak, 2024; Lembi, 2021)
- Technological innovations in recycling (Chen, 2024; Aneke and Shabangu, 2021)
- Adoption barriers such as high costs and weak institutional support (Mahame and Kikwasi, 2024; Eze et al., 2023)
- Social engagement and policy adaptation (Adebayo, 2023; Anshebo, 2022)

This fragmentation limits applicability, as improving one dimension can negatively impact another, producing incomplete or theoretical sustainability assessments.

3.2.2 Identified Research Gap

Developing countries require a multidimensional evaluation framework integrating environmental, economic, social, and institutional factors. Without this integration, sustainable construction decisions may fail due to affordability, policy readiness, or community resistance.

3.2.3 Contribution of the Current Study

This study introduces a comprehensive framework that assesses natural, recycled, and hybrid materials holistically, enabling balanced trade-off analysis among sustainability dimensions. The research shifts focus from identifying “sustainable materials” to understanding how sustainability can be achieved in practice, bridging the gap between theory and real-world application.

3.2.4 Significance of Integration

Incorporating the institutional dimension expands the traditional triple bottom line (environmental, economic, social) to a quadruple framework, recognizing the role of governance, regulation, and policy in supporting sustainable practices. This approach responds to observed weaknesses in policy and standards in developing regions (Yap, 2024; Wuni et al., 2019).

3.3 Contextualized Methodological Framework

3.3.1 Rationale and Design

Many sustainability assessment methodologies originate in developed countries and do not account for local socio-economic and infrastructural constraints. The proposed framework integrates:

- Institutional approach: aligns national policies, sustainability objectives, and inter-agency collaboration
- Community-based participatory approach: leverages local initiatives, field-driven innovations, and stakeholder participation

This ensures a context-specific, operational methodology suitable for developing countries.

3.3.2 Framework Components

The framework consists of four interrelated stages:

1. Local Condition Assessment: Evaluate material availability, environmental impacts, and community needs.
2. Integration of Multidimensional Criteria: Incorporate environmental, economic, social, and technical dimensions for balanced decision-making.
3. Stakeholder Collaboration: Engage policymakers, engineers, contractors, and communities for joint solution development.
4. Adaptive Monitoring System: Establish continuous feedback, evaluation, and learning mechanisms for iterative improvement.

Table 2. Proposed Framework Components

Stage	Description	Objective
Local Condition Assessment	Material, environmental, social evaluation	Contextual relevance
Multidimensional Criteria Integration	Environmental, economic, social, technical	Balanced sustainability trade-offs
Stakeholder Collaboration	Multi-stakeholder engagement	Strengthen ownership
Adaptive Monitoring System	Continuous feed-back and learning	Dynamic sustainability

3.4 Translating Framework into Practice

3.4.1 Implementation Process

The framework is applied through a sequential yet iterative process:

1. Assess local environment, material availability, labor capacity, and socio-economic context.
2. Apply integrated sustainability criteria for material selection and design.
3. Collaborate with institutional actors and local stakeholders for co-creation of solutions.
4. Establish monitoring, evaluation, and feedback mechanisms for adaptive improvement.

3.4.2 Capacity Building and Knowledge Transfer

Empowering local engineers, artisans, and communities via training programs, workshops, and university-industry partnerships ensures long-term sustainability and encourages local innovation and hybrid solutions.

3.4.3 Policy and Practice Implications

The framework provides a roadmap for embedding sustainability into regulations and guiding industry leaders in balancing cost and environmental responsibility. Emphasis is on contextual adaptation rather than imitation of developed-world models.

4. CONCLUSION

The findings of this study, derived from an extensive review and synthesis of academic literature, highlight the critical role of sustainable building materials in achieving the environmental, economic, and social pillars of sustainability. Their adoption is especially vital in developing countries, where limited financial resources, weak institutional capacity, and rapid urbanization create complex challenges for sustainable development. Evidence from the reviewed studies confirms that sustainable materials not only contribute to reducing energy consumption and greenhouse gas emissions but also improve durability, lower maintenance costs, and enhance the long-term resilience of buildings and infrastructure. However, the research also reveals persistent barriers that prevent the widespread adoption of these materials. These include high initial investment costs, insufficient legislative and regulatory frameworks, lack of technical expertise, limited public awareness, and the absence of standardized guidelines for material evaluation and implementation. Overcoming these barriers requires an integrated and multi-stakeholder approach combining governmental commitment, private sector innovation, academic research, and community participation to establish a strong foundation for sustainable construction systems. From a broader perspective, the study contributes to the academic discourse by consolidating knowledge, identifying research gaps, and providing actionable policy recommendations that can guide both national and institutional decision-making. The results underscore the need for governments to promote financial incentives and technical training, universities to enhance interdisciplinary research, and industries to invest in local innovation and sustainable technologies adapted to regional conditions.

In conclusion, sustainable building materials represent not just a technical solution but a strategic pathway toward achieving low-carbon, resource-efficient, and socially inclusive construction. Future research should therefore focus on developing locally appropriate materials, assessing long-term performance under varying climatic conditions, and establishing comprehensive benchmarks that support the transition toward a more resilient and sustainable built environment for future generations.

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