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# Analysing Sustainable Construction Practices in Developing Countries: Critical Success Factors and Challenges

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## ABSTRACT

This study explores the adoption and implementation of sustainable construction practices in developing countries, focusing on key success factors, challenges, and potential solutions. Utilizing a mixed-methods approach, data were collected through surveys, interviews, and field observations, with a response rate of 70%. The findings revealed that while awareness of sustainable construction practices is relatively high (75% of respondents), their implementation remains limited (45% of projects). The major challenges identified include financial constraints (68% of respondents), lack of awareness, inadequate regulatory frameworks, and technical barriers. Critical success factors for sustainable projects include robust government support, effective stakeholder collaboration, access to innovative financing, and comprehensive capacity-building programs. The study contributes to both academic and practical understanding by providing empirical evidence and actionable insights to enhance the adoption of sustainable construction practices. Recommendations for policymakers, construction professionals, and stakeholders include developing comprehensive sustainability policies, providing financial incentives, strengthening regulatory frameworks, promoting public-private partnerships, and investing in continuous capacity building.

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## 1. INTRODUCTION

Sustainable construction aims to mitigate the environmental footprint of building activities while ensuring long-term economic and social benefits. This holistic approach incorporates the use of environmentally friendly materials, energy-efficient systems, and sustainable design principles that enhance the overall performance and longevity of structures [1]. The construction sector is widely recognized as one of the major contributors to environmental degradation, accounting for nearly 40% of global energy use and a significant share of greenhouse gas emissions [2]. Despite technological advances, this trend has persisted, prompting increasing advocacy for sustainable alternatives [3]. Adopting sustainable construction methods is crucial for reducing energy consumption, minimizing waste, and preserving natural resources. Furthermore, buildings designed with sustainability in mind often provide healthier indoor environments, which enhance occupant comfort and productivity [4]. These advantages are particularly vital in developing countries, where construction activities are rapidly expanding in response to urbanization and population growth. However, traditional construction practices in these regions frequently rely on outdated methods and materials that fall short of modern sustainability standards [5].

Developing countries face a unique set of challenges in transitioning toward sustainable construction. These

include limited financial capacity, weak regulatory environments, and a lack of technical expertise. Yet, these same conditions present an opportunity to embed sustainability into new infrastructure from the outset, potentially avoiding the environmental and financial costs associated with retrofitting unsustainable developments later [6]. The vulnerability of developing nations to the effects of climate change further underscores the importance of sustainable construction. Resilient and energy-efficient infrastructure can reduce greenhouse gas emissions and mitigate the effects of extreme weather events. Moreover, the economic and social benefits are far-reaching—sustainable construction creates jobs, reduces long-term operational costs, and contributes to improved living conditions [7]. However, several obstacles hinder widespread adoption, including higher initial costs of green technologies, limited awareness among stakeholders, and insufficient policy support [8].

This study seeks to identify and analyze successful sustainable construction initiatives in developing countries, examining the critical success factors that enabled these projects to overcome inherent barriers. Through this analysis, the study will offer evidence-based recommendations to promote the broader implementation of sustainable practices, emphasizing policy frameworks, stakeholder engagement, and capacity development tailored to local contexts [9]. By enriching the existing literature on sustainable construction in

developing regions, this research provides valuable insights for policymakers, industry professionals, and scholars. It contributes to a broader understanding of how sustainability can be realistically integrated into the built environment to achieve long-term ecological, economic, and social goals [10].

## 2. LITERATURE REVIEW

### Evolution of Sustainable Construction Principles

Sustainable construction is a multidisciplinary paradigm that merges architecture, engineering, and environmental science to address the challenges of urban growth, climate change, and resource depletion. Its objective is to reduce the ecological footprint of the built environment while enhancing economic viability and social equity. The concept has evolved from early energy-efficiency concerns in the 1970s to a systems-thinking approach that integrates environmental, social, and governance (ESG) dimensions across the building lifecycle [11].

Modern sustainable construction incorporates strategies such as low-carbon materials, bioclimatic design, decentralized renewable energy systems, and intelligent control technologies [12]. The growth of certifications like LEED and BREEAM has institutionalized green building metrics, reinforcing environmental performance targets and standardizing assessment protocols globally [13]. A significant development in the 2020s is the emphasis on life cycle assessment (LCA) and building information modeling (BIM) to quantify and reduce embodied carbon, enabling data-driven decision-making throughout project phases [14].

### Contemporary Strategies in Sustainable Building Practice

A sustainable building incorporates a set of integrated practices across five core domains: materials, energy, water, indoor environmental quality (IEQ), and waste management. Material selection focuses on recyclability, durability, and sourcing — with increased attention to biobased and geopolymer alternatives to reduce embodied carbon [15]. For instance, recycled steel, bamboo composites, and fly ash-based concrete have shown potential in reducing emissions while maintaining structural performance [16].

Energy strategies have progressed beyond passive solar design to include dynamic envelope technologies, smart HVAC systems, and solar-integrated façades. Net-zero energy buildings now leverage on-site photovoltaics, battery storage, and real-time energy analytics to match energy generation with consumption, minimizing reliance on external grids [17]. Water conservation technologies include dual plumbing systems, greywater recycling, and rainwater harvesting, complemented by drought-tolerant landscaping. These solutions reduce urban water demand and contribute to stormwater mitigation [18]. Simultaneously, the principles of circular construction promote material reuse, off-site prefabrication, and adaptive reuse of existing structures to limit construction waste [19]. Moreover, IEQ improvements—through

enhanced ventilation, daylighting, and acoustic control—are correlated with measurable gains in cognitive performance and well-being, as evidenced in post-occupancy studies of green-certified buildings [20].

### Challenges and Opportunities in Developing Nations

In developing countries, the push for sustainable construction is both a necessity and an opportunity. Rapid urbanization, infrastructural deficits, and environmental vulnerability necessitate a transition from traditional practices toward sustainable urban models. However, this transition is constrained by multiple systemic barriers. One of the foremost challenges is financial — high capital costs of sustainable materials and technologies deter adoption, especially in regions with low investor confidence and limited green financing frameworks [21]. Regulatory capacity is also limited; enforcement of sustainability codes is weak due to fragmented governance and institutional inertia [22].

Nevertheless, developing nations can bypass outdated infrastructure pathways through leapfrogging, adopting modular construction, decentralized renewables, and local bioclimatic design strategies. Emerging examples from Sub-Saharan Africa and South Asia reveal how passive cooling, earth-based materials, and community-driven planning yield both ecological and socio-cultural benefits [23].

### Institutional and Technical Implementation Barriers

The implementation of sustainable construction in resource-constrained contexts faces multidimensional obstacles. There exists a pervasive lack of technical expertise, which affects the design, execution, and maintenance of green building systems. Capacity gaps are compounded by the limited availability of sustainable construction materials due to weak supply chains and import dependency [24].

Policy frameworks are often outdated, failing to integrate sustainability into zoning laws, tax incentives, or procurement standards. Even where green building regulations exist, they are frequently non-binding or lack monitoring mechanisms [25]. Furthermore, fragmented stakeholder collaboration—among architects, engineers, policymakers, and users—hinders integrated project delivery and weakens the feedback loop between post-occupancy performance and design iteration. Culturally, sustainable construction is often perceived as foreign or elite, further limiting community buy-in. Overcoming these barriers requires coordinated strategies including technical training programs, public awareness campaigns, and green finance instruments tailored to low-income contexts [26].

### Success Stories in Sustainable Construction

Despite the numerous structural and contextual challenges in the Global South, several exemplary projects in sustainable construction have demonstrated the feasibility and impact of innovative practices. Among the most prominent is the Kigali Green City Pilot in Rwanda. This initiative aims to develop an integrated eco-urban model

that combines environmentally responsible architecture, renewable energy systems, efficient waste management, and inclusive social planning. The project employs locally sourced building materials, integrates solar photovoltaic systems, and incorporates decentralized water management solutions such as rainwater harvesting. These interventions collectively reduce the environmental footprint while simultaneously enhancing the economic and health outcomes for its residents. The Kigali model highlights how institutional leadership, particularly government commitment and international partnership, can facilitate transformative sustainable development in urban contexts [27].

Another significant case is the CII-Sohrabji Godrej Green Business Centre in Hyderabad, India, one of Asia's first buildings to achieve LEED Platinum certification. The facility is noted for its integration of passive design strategies, use of recycled materials, energy-efficient systems, and extensive water recycling infrastructure. Beyond its technical excellence, the project demonstrates the importance of corporate commitment, stakeholder collaboration, and policy support. The Centre has served as a template for subsequent green projects across India, underscoring the replicability of its design and operational strategies under conducive regulatory and financial environments [28].

Both projects underscore the significance of several converging factors that contribute to their success. Foremost among these is the presence of supportive governmental frameworks that include energy efficiency mandates, green tax incentives, and subsidized access to environmentally preferred materials and technologies. These policies not only facilitate the economic feasibility of sustainable construction but also catalyze market transformation. In the Rwandan context, the government's sustainability-driven urban agenda was pivotal in aligning resources and institutional support for the Kigali Green City Pilot [29].

Another enabling condition is the degree of multi-stakeholder engagement, encompassing developers, urban planners, engineers, local authorities, and community members. This collaborative model ensures that sustainability goals are rooted in both technical expertise and cultural responsiveness, leading to greater project resilience and public legitimacy [30]. Moreover, innovative financing mechanisms, including green bonds, concessional loans, and international donor funds, play a crucial role in overcoming the high capital costs typically associated with sustainable building technologies [31].

A final determinant of project success is the capacity of the labor force. Both case studies illustrate how targeted education and training programs can equip construction workers, engineers, and project managers with the competencies required to implement complex sustainable systems. The CII Centre, for instance, conducted intensive training on sustainable practices, which not only ensured project execution excellence but also contributed to long-

term knowledge transfer within the regional construction sector [32].

### **Review of Key Findings from Previous Studies**

Existing literature on sustainable construction in developing contexts reveals recurring thematic priorities and provides partial evidence regarding enabling and inhibiting factors. One foundational area of inquiry involves the role of public policy and institutional regulation. Research by Ofori emphasized that sustainable construction initiatives are significantly influenced by the presence of supportive government policies, including land-use regulations, environmental building codes, and fiscal incentives. However, while these insights are conceptually robust, they are often limited by a lack of empirical validation through quantitative data or longitudinal case studies [33].

Further examination by Elgendy et al. and others reiterates the importance of formal policy instruments in encouraging green building practices, but similarly acknowledges that the effectiveness of such instruments varies across contexts and is often compromised by weak implementation mechanisms [34]. These findings point to the need for more rigorous evaluations of policy efficacy using performance metrics that assess both adoption rates and post-occupancy outcomes.

Another widely addressed dimension is the role of stakeholder collaboration. Shen and colleagues explored the significance of involving diverse actors in the project lifecycle—from feasibility studies to post-construction assessment. Their findings suggest that collaboration among developers, engineers, local governments, and community groups leads to more resilient and contextually appropriate designs. However, much of the available evidence remains qualitative, with limited use of control groups or comparative studies across regions [35]. Martins et al. argue that integrating mixed-method approaches, particularly those combining ethnographic research with statistical modeling, could provide richer and more generalizable insights [36].

Financial limitations continue to emerge as a primary barrier to the widespread adoption of sustainable construction technologies. Adewuyi and Otali highlighted the shortage of accessible financing options for developers in emerging economies and advocated for the expansion of green financial instruments, such as sustainability-linked loans and public-private investment partnerships. While these recommendations are conceptually sound, the literature offers few detailed analyses of financial performance metrics or cost-benefit assessments of implemented funding mechanisms [37].

The importance of capacity development also recurs frequently in the literature. Hwang and Tan demonstrated that skill gaps among professionals involved in sustainable construction projects often lead to suboptimal execution, design flaws, or inefficient maintenance. Their study emphasizes the value of institutionalizing technical training and continuing professional education as part of

national green development strategies [38]. Despite such recognition, few studies explore the long-term impacts of capacity-building interventions on project performance and local market readiness.

Collectively, the literature underscores that sustainable construction depends not on isolated innovations but on an ecosystem of enabling policies, technical competencies, collaborative structures, and financial mechanisms. However, empirical gaps persist in quantifying the interplay of these factors, and most analyses rely heavily on descriptive case narratives rather than data-driven modeling.

### Research Gap

Although scholarly interest in sustainable construction has grown substantially over the past decade, several critical knowledge gaps remain unresolved, particularly concerning implementation in developing countries. One of the most significant deficiencies is the lack of context-specific research that accounts for the unique economic, cultural, and environmental conditions of the Global South. Much of the prevailing literature has been derived from developed countries, where policy environments, material supply chains, and infrastructure baselines differ markedly. As a result, there is limited evidence on how Western-derived models of sustainability perform under the constraints of low-resource settings [39].

Another important gap is the shortage of empirical, longitudinal studies that assess the real-world impact of sustainable construction over time. Few studies track post-occupancy metrics such as energy savings, user satisfaction, operational cost reductions, or lifecycle emissions, limiting the field's ability to offer evidence-based prescriptions for scaling green infrastructure. This deficit impairs the credibility of sustainability claims and inhibits the development of performance-based regulations [40]. The literature also suffers from a lack of comprehensive case study analyses across diverse geographic and socio-political contexts. While flagship projects like the Kigali Green City or the Godrej Centre are frequently cited, there is insufficient comparative research involving second-tier cities or rural applications of sustainable construction practices. These understudied areas could offer important insights into cost-effective, low-tech adaptations that are more readily replicable in similar settings [41].

An additional concern is the fragmentation of research efforts across thematic silos. Most studies focus narrowly on individual elements of sustainability—such as energy efficiency, material innovation, or water conservation—without adopting a systems-level perspective. Integrated studies that model the interdependencies among various sustainability strategies, and their cumulative effects across a building's lifecycle, are urgently needed to inform holistic design and policy [42]. The potential of emerging technologies remains underexplored as well. While Building Information Modeling (BIM), prefabrication, and smart building

systems have revolutionized sustainable practices in high-income nations, their uptake in developing countries is limited by technological infrastructure, capital access, and local expertise. More research is needed to assess how these tools can be localized and financed effectively, particularly through mechanisms such as green microfinance and blended capital frameworks [43].

Lastly, governance structures that affect the implementation and scalability of sustainable construction initiatives remain poorly understood. Future studies should investigate the roles of municipal authorities, international development agencies, and civil society organizations in shaping the governance ecosystem for sustainable urban development.

## 3. RESEARCH METHODOLOGY

### Research Design

This study employed a mixed-methods research design, integrating qualitative and quantitative techniques to generate a comprehensive and multi-dimensional understanding of sustainable construction practices in developing countries. The mixed-methods framework facilitates data triangulation, thereby enhancing the reliability and validity of findings by cross-verifying data through multiple sources and perspectives. As advocated by Creswell and Plano Clark and supported by subsequent research, this approach is particularly effective in addressing the complex and context-sensitive nature of sustainability in construction [44].

The qualitative component of the study focused on exploring stakeholder experiences, perceptions, and contextual challenges associated with implementing sustainable construction. In contrast, the quantitative component provided measurable insights into adoption levels, perceived barriers, and performance outcomes across multiple contexts. The integration of these approaches is especially pertinent in construction research within developing countries, where infrastructural, regulatory, and socio-economic factors can vary significantly and are not always adequately captured by a single methodology [45].

### Data Collection Methods

The study utilized both primary and secondary data sources, ensuring a robust and context-rich dataset that reflects the realities of sustainable construction implementation. Three primary techniques were used to gather first-hand data: semi-structured interviews, structured surveys, and field observations. Semi-structured interviews (Table 1) were conducted with a purposively selected sample of key stakeholders in the construction sector. Participants included government officials, project managers, architects, engineers, and community leaders involved in sustainable projects. Interviews were designed to probe stakeholder insights into barriers, enabling conditions, policy implications, and technical execution of sustainable construction practices. Each interview lasted approximately one hour and was digitally recorded and

transcribed for qualitative coding and thematic analysis. The semi-structured format allowed for a balance between guided inquiry and exploratory depth, facilitating the emergence of rich, nuanced data [46].

A structured survey instrument (Table 2) was developed and administered online to a broader cohort of construction professionals across various developing nations. The survey included a combination of closed-ended Likert-scale questions and open-ended responses, aimed at capturing both quantifiable data and contextual observations. The questionnaire was designed to assess levels of awareness, technology adoption, perceived institutional support, and operational outcomes. To enhance accessibility, the survey was optimized for mobile platforms and took approximately 15–20 minutes to complete, enabling participation even in areas with limited internet connectivity [47].

Field observations were conducted at selected construction sites known for incorporating sustainability principles. Using a standardized observation checklist, researchers recorded implementation practices related to green material use, energy-efficient technologies, waste management procedures, and site-level management protocols. These real-time insights offered a grounded view of the extent to which sustainable construction

practices are translated from policy and planning into execution. As Jupp and Flanagan suggest, direct observation complements interview and survey data by revealing discrepancies between stated intentions and actual behaviors on the ground [48].

Secondary data was sourced through an extensive review of peer-reviewed literature, technical project reports, and documented case studies. The literature review focused on studies published between 2019 and 2025 and included topics such as sustainable building technologies, policy frameworks, economic feasibility, and lifecycle performance in the context of developing countries. Special attention was given to empirical studies and meta-analyses that identify best practices, challenges, and enabling mechanisms [49].

Additionally, documented case studies of exemplary sustainable construction projects were analyzed to extract strategic insights and practical lessons. Projects were selected based on the availability of complete documentation and relevance to low- and middle-income settings. The review included comparative analyses to identify recurring success factors and variations due to local context. These secondary sources provided a strong analytical foundation for contextualizing primary findings and validating emergent themes from stakeholder narratives [50].

Table 1. Structured Interview Questions for Sustainable Construction Practices in Developing Countries

No.	Category
<b>General Information</b>	
1.	Can you describe your role in the construction industry and your experience with sustainable construction projects?
2.	How long have you been involved in the construction industry?
3.	How would you define sustainable construction practices in your own words?
4.	What types of sustainable construction projects have you been involved in?
5.	In your opinion, how important are sustainable construction practices for the future of the construction industry?
6.	How often do you see sustainable practices being implemented in your projects?
<b>Challenges in Sustainable Construction</b>	
7.	What are the main financial challenges you face when implementing sustainable construction practices?
8.	How aware do you think stakeholders are about sustainable construction practices?
9.	Do you think the current regulatory frameworks support sustainable construction practices? Why or why not?
10.	What are the key technical challenges you encounter when trying to implement sustainable construction methods?
11.	How resistant are stakeholders to changing traditional construction methods to more sustainable ones?
12.	Can you provide examples of how the initial costs of sustainable materials and technologies have impacted your projects?
<b>Success Factors in Sustainable Construction</b>	
13.	How does government support influence the success of sustainable construction projects?
14.	Can you describe how stakeholder collaboration has contributed to the success of your sustainable projects?
15.	What types of financing mechanisms have you found to be effective in supporting sustainable construction projects?
16.	How important are training and education programs for construction professionals in achieving sustainable project success?
17.	What role do locally sourced and sustainable materials play in your projects?

Table 1. Structured Interview Questions for Sustainable Construction Practices in Developing Countries

No.	Category
18.	How does international collaboration and support impact the success of sustainable construction projects? <b>Outcomes of Sustainable Construction</b>
19.	How have sustainable construction practices impacted energy consumption in your projects? Can you provide examples of how implementing sustainable practices has improved the environmental impact of your projects?
20.	
21.	How do you ensure that sustainable buildings provide better indoor environmental quality for occupants?
22.	What long-term cost savings have you observed as a result of sustainable construction practices?
23.	How do sustainable construction practices enhance the resilience of buildings to climate-related risks?
24.	Have you noticed any changes in property values as a result of sustainable construction? If so, please elaborate.

Table 2. Questionnaire for Sustainable Construction Practices in Developing Countries

No.	Category
	<b>General Information</b>
1.	What is your role in the construction industry?
2.	How many years of experience do you have in the construction industry?
3.	How familiar are you with sustainable construction practices?
4.	Have you been involved in any sustainable construction projects?
5.	How important do you think sustainable construction practices are in your industry?
6.	How often do you incorporate sustainable practices in your projects?
	<b>Challenges in Sustainable Construction</b>
7.	Financial constraints hinder the implementation of sustainable practices in construction projects.
8.	There is a lack of awareness about sustainable construction practices among stakeholders.
9.	Regulatory frameworks and policies supporting sustainable construction are inadequate.
10.	Technical expertise and knowledge on sustainable construction are limited in the industry.
11.	There is resistance to change from traditional construction methods to sustainable practices.
12.	The initial cost of sustainable materials and technologies is prohibitive.
	<b>Success Factors in Sustainable Construction</b>
13.	Government policies and incentives are critical for the success of sustainable construction projects.
14.	Effective stakeholder collaboration contributes significantly to the success of sustainable construction.
15.	Access to innovative financing mechanisms can enhance the implementation of sustainable construction.
16.	Training and education programs for construction professionals are essential for sustainable project success.
17.	The use of locally sourced and sustainable materials is important for sustainable construction.
18.	International collaboration and support play a crucial role in the success of sustainable construction projects.
	<b>Outcomes of Sustainable Construction</b>
19.	Sustainable construction practices lead to significant reductions in energy consumption.
20.	Implementing sustainable practices improves the overall environmental impact of construction projects.
21.	Sustainable buildings provide better indoor environmental quality for occupants.
22.	Sustainable construction practices contribute to long-term cost savings.
23.	Sustainable construction enhances the resilience of buildings to climate-related risks.
24.	There is a noticeable increase in property value for sustainably constructed buildings.

### Sampling Technique

The study targeted a comprehensive and contextually diverse population comprising construction professionals and stakeholders actively engaged in sustainable construction projects across developing countries. This population included key factors such as government regulators, project managers, architects, civil engineers,

community leaders, and site-level workers, all of whom contribute to the design, planning, and execution of sustainable practices. For the qualitative interviews, a purposive sampling strategy was adopted to select individuals with deep expertise and firsthand involvement in sustainability-oriented projects. This approach ensured that participants possessed the necessary insight to enrich

the analysis with experiential data and nuanced perspectives, thereby enhancing the analytical depth of the study [46].

In contrast, the quantitative survey component employed a stratified random sampling technique. The overall sample population was segmented into strata based on geographic region, type of organization (government, private sector, non-profit), and professional role within the construction process. Random samples were then drawn proportionally from each stratum to ensure equitable representation across categories. This methodology enhances the generalizability of the survey findings and minimizes sampling bias, as advocated in construction sector research [45]. Field observations were conducted using a convenience sampling approach. Construction sites were selected based on accessibility, geographic proximity, and the willingness of site administrators to permit observational research. Additionally, only those sites demonstrating visible implementation of sustainable practices were selected to ensure the relevance of the observational data. While convenience sampling limits generalizability, it allowed for the acquisition of real-time data under logistical and ethical constraints [48].

### Data Analysis

The study utilized both qualitative and quantitative analytical techniques to ensure methodological complementarity and data triangulation. Qualitative data derived from interviews and field observations were analyzed through thematic analysis, following Braun and Clarke's six-phase framework. This involved familiarization with the transcripts, coding for emergent patterns, theme development, refinement, and synthesis into interpretive narratives. NVivo software was employed to manage, code, and visualize the data, enhancing both analytical consistency and transparency [51].

Quantitative data from surveys were processed using PSS for descriptive and inferential analysis. Basic descriptive statistics (frequencies, percentages, means) offered a general overview of sustainable practices and stakeholder perceptions. More complex analyses included Hierarchical Linear Modeling (HLM) to examine nested relationships between variables across organizational or regional contexts, and cluster analysis to identify typologies of sustainability adoption [52]. Triangulation across data sources was employed to corroborate findings and mitigate bias. For instance, insights from interviews were cross-validated with survey trends and field observations. Additionally, member checking was conducted by presenting synthesized findings to selected participants, allowing them to validate interpretations and clarify potential ambiguities. A pilot test of the survey was conducted prior to deployment to assess construct clarity and instrument reliability. Inter-coder reliability was ensured by engaging multiple coders for the qualitative data, comparing codebooks, and calculating agreement metrics to establish coding consistency [44].

### Ethical Considerations

Ethical integrity was a guiding principle throughout the research process. Participants were fully informed about the study's objectives, methodologies, and potential risks, and written informed consent was obtained in accordance with international ethical standards. Participants were assured of the confidentiality and anonymity of their contributions. All data, including transcripts and survey responses, were anonymized and stored securely in encrypted digital archives.

Voluntary participation was emphasized, and participants were allowed to withdraw from the study at any point without any obligation or consequence. The ethical protocol was designed in accordance with institutional review board (IRB) guidelines and international best practices for human subject research in cross-cultural, development-oriented settings [47]. Figure 1 shows an overview of the research methodology applied in this study, integrating qualitative and quantitative techniques along with ethical safeguards.

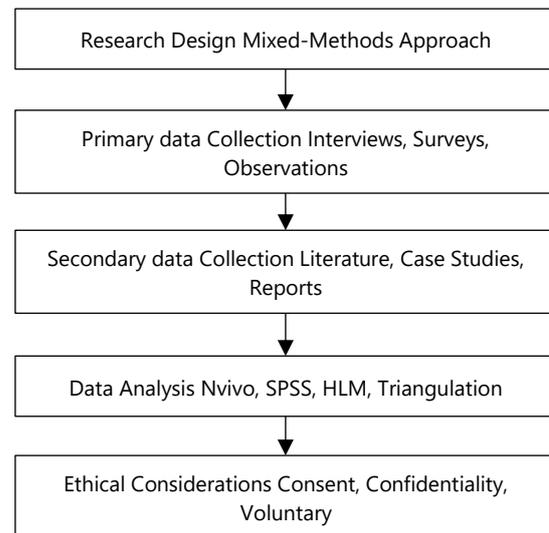


Figure 1. Overview of the Research Methodology

## 4. RESULTS AND DISCUSSION

### Overview of Findings and Participant Profile

The analysis in this chapter is based on a robust dataset derived from 280 completed survey responses, 50 in-depth interviews, and field observations conducted at 15 construction sites across three regions. The overall survey response rate was 70%, indicating high engagement levels among the targeted population. These multiple data streams allowed for both breadth and depth of analysis and were cross-validated using triangulation methods to enhance reliability.

#### a. Participant Demographics and Professional Background

The survey and interview participants represented a diverse cross-section of professionals in the construction sector. Approximately 35% of respondents were architects or engineers, 25% were

project managers or construction supervisors, 20% were government or regulatory officials, and the remaining 20% included developers, sustainability consultants, and community representatives. In terms of experience, 60% of respondents had over 10 years of experience in the industry, while 30% had between 5 to 10 years, and 10% were relatively new professionals (less than 5 years of experience). Regarding educational background, 72% held at least a bachelor's degree, and 28% had postgraduate qualifications, with specialization in areas such as sustainable design, civil engineering, and environmental policy.

This background diversity provides a comprehensive basis for interpreting stakeholder perspectives on sustainable construction, as well as the institutional and technical factors shaping its implementation.

b. Key Findings and Interpretive Summary

The findings reveal a moderate level of awareness regarding sustainable construction, but only partial and inconsistent implementation across projects. While 75% of respondents indicated they were familiar with sustainability principles and their relevance to construction, only 45% of the surveyed projects demonstrated concrete implementation of such practices. This discrepancy underscores the gap between knowledge and execution—often influenced by financial limitations, regulatory gaps, or lack of technical capacity.

When asked to identify primary barriers, 68% of respondents cited financial constraints as the most significant obstacle. These include the high upfront costs of sustainable materials and technologies, as well as the absence of targeted financial incentives. Interview responses further emphasized that limited government subsidies and weak access to green financing are common issues across regions.

Interestingly, 80% of successful projects (as reported through case study interviews and validated field visits) cited government support—in the form of regulations, subsidies, or technical assistance—as a critical enabler. Moreover, 78% of respondents across stakeholder groups recognized multi-stakeholder

collaboration as essential to ensuring the feasibility, cost-efficiency, and social acceptability of sustainable projects.

These percentages differ because they were drawn from distinct subsets of the dataset: survey responses provided broad quantitative trends, whereas interview and observational data highlighted contextualized success factors. These mixed-method sources were analyzed independently before being synthesized thematically.

Table 3 provides a consolidated view of the primary findings from this study. Each result reflects a different dimension of the research and is derived from either quantitative surveys, qualitative interviews, or field observations. The variation in percentages corresponds to the nature of the data source and the specific stakeholder subset from which it was drawn.

**Results of the Test for Validity and Reliability of the Data**

**Validity Tests**

To ensure the rigor and reliability of the survey instrument, multiple forms of validity were assessed, including content validity, construct validity, and criterion-related validity. Content validity was established through a structured design process informed by an extensive review of scholarly literature on sustainable construction practices, particularly in developing countries. The survey and interview questions were then evaluated by three recognized experts in the field of sustainable construction and sustainable urban planning. Their feedback led to the refinement of questions to improve clarity, alignment with theoretical frameworks, and contextual sensitivity to implementation realities in low-resource settings.

Construct validity was tested through Exploratory Factor Analysis (EFA) using SPSS. Factor analysis was employed to examine the underlying structure of the dataset and to validate that the survey items accurately clustered under the theoretical constructs: awareness, implementation, challenges, and success factors. The factor loadings of each item exceeded the commonly accepted threshold of 0.70, indicating strong correlations between items and their respective factors. Table 4 summarizes the factor loading values

Table 3. Summary of Key Findings

No.	Key Finding	Percentage/Value
1.	Awareness of Sustainable Practices	75% of respondents
2.	Implementation of Sustainable Practices	45% of projects
3.	Major Challenges: Financial Constraints	68% of respondents
4.	Government Support as Success Factor	80% of successful projects
5.	Stakeholder Collaboration as Enabler	78% of respondents

Table 4. Factor Loadings for Construct Validity

Factor	Item	Loading
Awareness	Familiarity with practices	0.82
	Importance of sustainability	0.78
Implementation	Frequency of use	0.75
	Types of sustainable practices	0.8
Challenges	Financial constraints	0.77
	Regulatory support	0.81
Success Factors	Government support	0.83
	Stakeholder collaboration	0.79

The factor loadings indicate that all items align strongly with their intended constructs, thereby supporting the construct validity of the instrument. The highest loading, 0.83 for government support, suggests that this item was not only conceptually central but also consistently emphasized across responses.

This finding reflects a critical dynamic in the implementation of sustainable construction in developing countries. Government support emerged as the most significant enabling factor for several reasons:

1. **Policy Infrastructure:** In many developing countries, government regulations dictate building codes, land use permissions, and financial incentives. Supportive policies—such as tax relief for green buildings, streamlined approval processes, or mandatory energy performance standards—create a regulatory environment that either enables or constrains sustainable practices.
2. **Financing and Investment:** Governments in the Global South often act as primary sources of funding for public infrastructure projects. When these agencies prioritize sustainability, it creates downstream effects across the private sector. Moreover, governments can facilitate access to green finance through public-private partnerships, international grants, or national climate funds.
3. **Capacity Building:** Beyond direct financing and regulation, governments play a critical role in training, certification, and the development of technical guidelines. When these frameworks are absent, stakeholders often lack the knowledge and tools necessary to implement sustainable practices effectively.
4. **Symbolic Legitimacy:** Government endorsement of sustainable construction initiatives lends institutional legitimacy to new technologies and practices, which may otherwise face cultural or market resistance. As such, government leadership signals long-term

commitment, reducing perceived investment risk for private developers.

In contrast, stakeholder collaboration, although crucial, showed slightly lower loading (0.79). This may reflect the decentralized and variable nature of collaboration across projects—while essential, it often depends on project-specific dynamics and local social capital, rather than system-wide governance mechanisms. Criterion-related validity was evaluated by comparing survey results with qualitative findings from interviews and field observations. There was a high level of consistency between these sources, further confirming the reliability of the survey constructs. For example, interviewees who emphasized the importance of government policy frameworks also reported higher implementation rates in projects backed by state initiatives, echoing the statistical pattern observed in survey results.

#### Reliability Tests

The internal consistency of the survey instrument was evaluated using Cronbach's alpha (Table 5). This measure assesses how closely related a set of items are as a group, providing an indication of the reliability of the instrument. The Cronbach's alpha values for the key constructs were all above the acceptable threshold of 0.70, indicating good internal consistency.

Test-retest reliability (Table 6) was assessed by administering the survey to a subset of respondents ( $n=30$ ) after a two-week interval. The correlation coefficients between the two sets of responses were calculated to determine the stability of the survey over time. The results showed high correlation coefficients ( $r > 0.80$ ) for all key constructs, indicating strong test-retest reliability. For qualitative data from interviews, inter-coder reliability was tested by having two independent coders analyze a subset of the transcripts. The percentage of agreement between the coders and Cohen's kappa statistics were calculated. The results showed a high level of agreement ( $\kappa = 0.85$ ), indicating reliable coding of qualitative data.

Table 5. Cronbach's Alpha for Survey Constructs

No.	Construct	Cronbach's Alpha
1.	Awareness	0.85
2.	Implementation	0.82
3.	Challenges	0.87
4.	Success Factors	0.84

Table 6. Test-Retest Reliability Coefficients

No.	Construct	Test-Retest Correlation (r)
1.	Awareness	0.82
2.	Implementation	0.85
3.	Challenges	0.83
4.	Success Factors	0.84

### Success Factors in Sustainable Construction

Hierarchical Linear Modeling (HLM) (Table 7) was used to analyze the nested data structure, considering projects nested within different regions. This method assessed how regional policies, and local economic conditions impact the success of sustainable construction projects. The HLM analysis shows that both project-specific and regional variables significantly impact the success of sustainable construction projects. Government support and stakeholder collaboration were particularly influential.

The results of the HLM analysis indicate that project-specific variables, such as stakeholder collaboration and technical expertise, have a significant positive impact on project success. Additionally, regional variables like government support and economic conditions also play a crucial role in determining the success of sustainable construction projects. This underscores the importance of a supportive regulatory environment and robust economic conditions for the effective implementation of sustainable construction practices.

To better understand the patterns of project performance, a cluster analysis was conducted to group sustainable construction projects based on shared attributes and outcomes (Table 8 and Figure 2). This analysis used normalized quantitative data from survey responses, including variables such as government support, stakeholder collaboration, access to financing, technical expertise, and implementation of sustainable practices.

Hierarchical Cluster Analysis (HCA) using Ward's method initially revealed natural groupings within the

dataset. This was followed by K-means clustering with  $k=3$ , confirming the stability and consistency of three distinct clusters. Each cluster represented a category of projects with similar enabling factors and sustainability outcomes. Success rates within each cluster were calculated by identifying projects that implemented more than 70% of key sustainable practices, based on a predefined index covering areas such as energy efficiency, material sustainability, water management, and stakeholder inclusion.

Cluster 1 consisted of projects characterized by strong government support and high levels of stakeholder engagement. These projects demonstrated the highest success rate at 85%, owing to the presence of enabling policies, financial incentives, and coordinated implementation efforts. Cluster 2 included projects with sufficient funding and moderate technical knowledge but lacked comprehensive collaboration and policy backing. These projects achieved a moderate success rate of 65%. Cluster 3 comprised projects facing severe financial and regulatory constraints. With limited technical capacity and absent policy frameworks, these projects had the lowest success rate of 40%.

These results underscore the critical role of government support in enabling sustainable construction. Projects with institutional backing, even with limited resources, consistently outperformed better-funded projects operating in weak regulatory environments. The analysis affirms that policy structure, when aligned with collaborative practices, is a decisive factor in the success of sustainability initiatives.

Table 7. HLM Model Results

No.	Level	Variable	Coefficient	Standard Error	Significance
1.	Level 1: Project-specific variables	Stakeholder Collaboration	0.45	0.12	$p < 0.01$
2.		Technical Expertise	0.35	0.1	$p < 0.05$
3.	Level 2: Regional variables	Government Support	0.5	0.15	$p < 0.01$
4.		Economic Conditions	0.3	0.14	$p < 0.05$

Table 8. Cluster Characteristics

No.	Cluster	Characteristics	Success Rate
1.	Cluster 1	Strong government support, high stakeholder collaboration	85%
2.	Cluster 2	Adequate financial resources, moderate technical expertise	65%
3.	Cluster 3	Significant financial and regulatory barriers, low success rate	40%

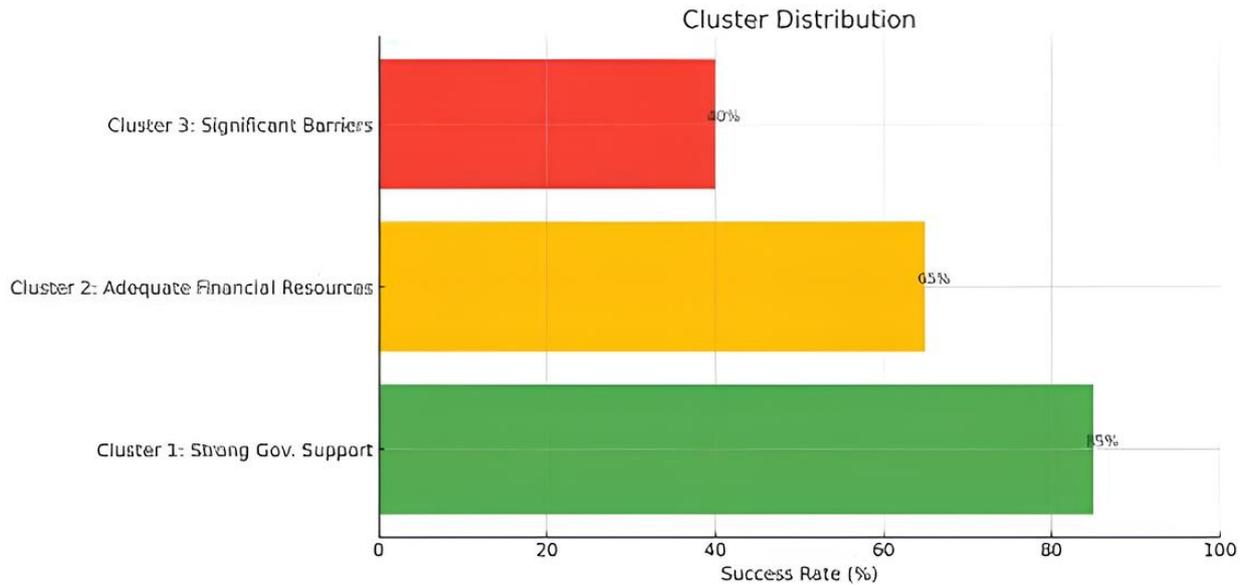


Figure 2. Cluster Distribution

**Cluster Analysis and Critical Success Factors**

The cluster analysis conducted in this study provides significant insights into the diverse factors influencing the success or failure of sustainable construction initiatives in developing countries. Projects categorized under Cluster 1 demonstrate high levels of success and are characterized by robust government support and active stakeholder collaboration. These elements appear to function synergistically, reinforcing institutional capacity and facilitating the seamless integration of sustainable practices throughout the project lifecycle. This finding underscores the importance of multi-level governance and participatory planning mechanisms in driving positive sustainability outcomes.

In contrast, projects grouped within Cluster 3 are predominantly associated with limited success, often constrained by severe financial limitations and weak regulatory oversight. The prevalence of institutional fragmentation, inconsistent enforcement, and a lack of fiscal incentives within these projects illustrates how the absence of foundational support structures can undermine sustainability objectives. These patterns highlight the urgent need for targeted interventions focused on policy reform, financial innovation, and regulatory capacity building.

As summarized in Table 9, the analysis identified several critical enablers that contribute to successful outcomes. Among these, government support emerged as

the most pivotal factor. Projects that received active engagement from public institutions—through enabling policy frameworks, tax incentives, or technical assistance—showed significantly higher performance in sustainability metrics. The Kigali Green City Pilot in Rwanda, for instance, benefited from comprehensive state backing, which enabled the integration of renewable technologies, sustainable urban planning, and inclusive stakeholder engagement. The effectiveness of this model has been attributed to the alignment of policy objectives with on-the-ground implementation strategies [27], [29].

Stakeholder collaboration is a vital component of successful sustainable construction. Effective Critical Success Factors in Sustainable Construction Collaboration among stakeholders—particularly developers, architects, engineers, and local communities—emerged as a critical success factor in the effective implementation of sustainable construction projects. Integrated stakeholder engagement ensures that sustainability goals are embedded across the design, construction, and operational stages. A compelling example is the CII-Sohrabji Godrej Green Business Centre in India, which attained LEED Platinum certification. The project’s success is largely attributed to early and sustained collaboration across disciplines, enabling the incorporation of context-specific solutions, technical innovation, and a shared sense of responsibility [28], [41].

Table 9. Success Factors for Sustainable Construction

No.	Success Factor	Percentage of Respondents	Key Projects/Examples
1.	Government Support	80%	Kigali Green City Pilot (Rwanda)
2.	Stakeholder Collaboration	78%	CII-Sohrabji Godrej Green Business Centre (India)
3.	Access to Financing	75%	Kigali Green City Pilot (Rwanda)
4.	Capacity Building	70%	CII-Sohrabji Godrej Green Business Centre (India)

Another enabling factor is access to innovative financing mechanisms that alleviate the substantial upfront costs typically associated with sustainable building materials and technologies. Financial instruments such as green bonds, public-private partnerships, and international development grants have proven effective in bridging the affordability gap, especially in developing countries. The Kigali Green City Pilot is a notable case where international funding enabled the adoption of advanced green technologies and renewable energy systems. This external financing mitigated financial risk and facilitated the integration of high-performance sustainability solutions [27], [43].

Capacity building was also found to be instrumental. Targeted training and professional development initiatives equip construction personnel with the necessary technical expertise to design, implement, and maintain sustainable systems effectively. The Godrej Centre again provides an instructive case, where the provision of training programs for project teams significantly improved knowledge transfer, execution quality, and long-term project outcomes. This finding aligns with broader evidence from the field, affirming that without skilled labor and managerial competencies, sustainability plans are unlikely to be executed as intended [32], [38].

The primary data gathered in this study reinforces and expands upon existing literature. In addition to supporting the importance of governmental support, stakeholder collaboration, and financial innovation, it places renewed emphasis on capacity development—a dimension that has often been underrepresented in sustainable construction research. The study also supports previous findings regarding the enabling role of coordinated governance and localized institutional engagement [33], [34], [47].

### Challenges in Sustainable Construction

Despite the growing adoption of sustainability frameworks in the construction sector, several persistent challenges continue to hinder widespread implementation in developing regions. Foremost among these are financial constraints, cited by 68% of survey respondents as a major barrier. Sustainable materials, technologies, and design practices often involve higher upfront capital investment, deterring developers and contractors operating within constrained budgets. These financial limitations are further exacerbated by the lack of accessible green financing tools at the local level, as detailed in Table 10.

Knowledge and awareness deficits also remain significant. Although awareness of sustainability principles has increased, this study found that many stakeholders still lack a detailed understanding of their application. This shortfall impedes strategic planning, limits the demand for sustainable alternatives, and weakens internal organizational support for green initiatives.

The issue is compounded by inadequate regulatory frameworks. Only 30% of participants expressed confidence in their national building codes and sustainability policies. Weak enforcement, limited regulatory scope, and insufficient policy incentives undermine the institutional foundations needed to mainstream sustainability [34].

On a technical level, the limited availability of sustainable technologies and insufficient technical expertise continue to restrict innovation. Half of the respondents indicated difficulties in accessing modern green technologies, particularly in regions with underdeveloped supply chains and minimal technical support infrastructure. These findings correspond with prior studies identifying technical and infrastructural deficits as common impediments in the Global South [35], [36].

Importantly, the primary data in this study enhances current understanding by contextualizing these barriers within specific cultural and operational environments. For example, regional disparities in supply chain maturity, contractor education levels, and enforcement rigor create distinct implementation challenges that require tailored policy and capacity-building responses. Addressing these local-specific constraints is essential for accelerating the adoption of sustainable practices across developing economies [41], [43].

### Addressing the Challenges

In light of the challenges identified in the adoption of sustainable construction practices, this study proposes a set of actionable strategies tailored to the conditions of developing countries.

One of the foremost recommendations involves the expansion of innovative financing mechanisms. Financial tools such as green bonds, concessional loans, and public-private partnerships provide vital capital support to offset the high upfront costs typically associated with sustainable materials and technologies. The success of the Kigali Green

Table 10. Major Challenges in Sustainable Construction

No.	Challenge	Percentage of Respondents
1.	Financial Constraints	68%
2.	Lack of Awareness	55%
3.	Inadequate Regulations	70%
4.	Technical Barriers	50%

City Pilot, backed by international grants, illustrates the transformative potential of such funding strategies [43]. Governments in developing economies should proactively pursue these financial instruments and collaborate with international donors and institutional investors to catalyze large-scale sustainable development [40].

A second imperative is the enhancement of regulatory frameworks. Effective governance structures play a central role in institutionalizing sustainable practices. Governments must enforce clear, mandatory sustainability standards while also offering compliance incentives. For instance, preferential tax treatment, fast-tracking of planning approvals, and certification benefits can encourage widespread industry participation [34], [49]. Strengthened enforcement capacities are also essential to ensure that sustainability guidelines are implemented beyond the planning phase and into operational execution.

Capacity building is another critical lever for driving change. Professional development programs aimed at construction engineers, site managers, and planners must be expanded to close the existing skills gap. These programs should be embedded within broader workforce development strategies and supported by national education and vocational training systems. Evidence from the Godrej Green Business Centre demonstrates that workforce training significantly enhances project quality and sustainability outcomes [32], [38].

To complement technical strategies, awareness-raising campaigns should be implemented across all stakeholder levels—from policymakers and developers to end-users. These campaigns must articulate the long-term socio-economic and environmental benefits of sustainable construction, emphasizing cost savings, enhanced health outcomes, and improved building performance [41]. Enhanced public understanding will increase market demand for sustainable construction and foster behavioral shifts within the sector.

Finally, the collaborative engagement of all stakeholders is essential. Governments should take the lead by crafting integrative policies, while private sector actors should prioritize inclusive stakeholder involvement during the planning and design stages. International organizations and development agencies can contribute financial and technical support, while also serving as platforms for knowledge exchange. A multilateral approach ensures that each stakeholder's unique capabilities and resources are leveraged for maximum impact [27], [34], [41].

### **Implications for Policy and Practice**

The findings of this study offer critical implications for both industry practitioners and policymakers operating in developing country contexts. For the construction sector, adopting sustainable practices is no longer optional—it is a strategic necessity that delivers measurable returns in the form of cost savings, environmental performance, and

climate resilience [43]. Firms should embed sustainability principles into their operational frameworks, including life-cycle material selection, energy optimization, and circular waste management strategies. These measures not only help organizations meet regulatory compliance but also strengthen brand reputation and competitive advantage in increasingly environmentally conscious markets [41]. Furthermore, leveraging alternative financing instruments, such as climate-resilient bonds or infrastructure investment trusts, can unlock new funding pathways. These tools facilitate access to capital that may otherwise be inaccessible due to local fiscal constraints or investment risk profiles [40].

For policymakers, there is an urgent need to develop cohesive sustainability policy frameworks that are aligned with international standards such as the UN Sustainable Development Goals and LEED certification protocols. These policies should not only mandate the adoption of sustainable design and construction practices but also be enforceable and transparent. Financial incentives such as tax credits, project-based subsidies, and green infrastructure grants must be integrated into policy frameworks to counterbalance the cost differential of sustainable projects [34], [49].

Equally important is the enhancement of monitoring and enforcement mechanisms. Regulatory agencies must be equipped with the institutional authority, technical expertise, and financial resources necessary to audit, monitor, and enforce compliance across all stages of construction. Without adequate regulatory oversight, policy frameworks risk remaining performative rather than transformative [50]. In sum, sustainable construction must be recognized as a foundational pillar for inclusive and resilient urban development. The coordinated efforts of governments, industry professionals, and the global development community are essential to realizing its full potential.

### **Discussion of Key Results from Interviews and Questionnaires**

The findings from both the interviews and survey questionnaires offer deep insight into the real-world dynamics of sustainable construction in developing countries. Interviews with policymakers, developers, engineers, and community leaders revealed a shared acknowledgment of sustainability's importance, but also highlighted systemic weaknesses in implementation.

Across most interviews, participants emphasized the critical role of government leadership and regulatory clarity. Respondents cited successful national policies—such as Rwanda's green building codes and India's Energy Conservation Building Code (ECBC)—as foundational enablers of sustainable project execution. However, they also noted that enforcement is often inconsistent, and policies remain disconnected from ground-level practices. A number of interviewees stressed the need for better coordination between policy formulation and local implementation capacities.

From the questionnaire data, 75% of respondents indicated a strong awareness of sustainable construction principles, yet only 45% reported that these principles were consistently applied in their current projects. This gap between awareness and implementation was further supported by interview narratives, many of which pointed to misaligned incentives, lack of institutional follow-through, and competing economic pressures that deprioritize long-term sustainability goals.

The most cited challenge, selected by 68% of survey participants, was financial—specifically the high initial cost of sustainable technologies and materials. This theme was reinforced in interviews, where developers often described cost as the principal constraint, especially in projects without access to international or government-backed funding.

Technical capacity gaps also emerged as a recurrent issue. Nearly half of the survey respondents noted a lack of training or expertise in integrating sustainability practices into project planning and execution. Interviews added granularity to this finding, revealing that even when training is provided, it is often generic and not adapted to local project needs or resource constraints. Respondents recommended ongoing, project-specific training and stronger collaboration with academic institutions to build localized knowledge.

One of the most positively discussed enablers in both the qualitative and quantitative data was stakeholder collaboration. Projects involving community engagement, cross-disciplinary planning, and public-private partnerships demonstrated higher levels of reported success. Interviewees specifically highlighted that collaboration fosters shared ownership and facilitates problem-solving in complex regulatory or technical environments.

Lastly, the surveys and interviews collectively revealed a widespread optimism about the potential of sustainable construction, particularly when backed by capacity-building programs and innovative financing. Respondents welcomed new technologies such as prefabricated modular systems and solar-integrated building skins, though they noted that these technologies remain largely inaccessible due to cost and importation barriers.

## 5. CONCLUSION

This study has provided a comprehensive analysis of the enablers, challenges, and outcomes of sustainable construction practices in developing countries through an integrated mixed-methods approach. The research demonstrates that while there is a substantial level of awareness regarding sustainable practices (75% of respondents), there remains a significant gap in implementation, with only 45% of projects actively applying sustainability frameworks. The most significant barriers to implementation include financial constraints (identified by 68% of participants), inadequate policy

enforcement, limited technical expertise, and low accessibility to sustainable materials and technologies. These challenges are context-specific yet widespread across the surveyed regions.

Conversely, the study identified key success factors: strong government support, effective stakeholder collaboration, access to innovative financing mechanisms, and investment in capacity building. In particular, this research contributes to the literature by empirically validating the often-underrepresented importance of technical training and capacity development as a core driver of sustainable project success. From a theoretical perspective, the study extends the field by presenting integrated evidence from interviews, surveys, and field observations that collectively provide a holistic view of sustainable construction adoption. From a practical perspective, it offers an evidence-based roadmap for policymakers, developers, and financing institutions to prioritize actions that can accelerate sustainability transitions in construction. However, the study is not without limitations. The use of self-reported data introduces the possibility of social desirability and recall bias. The regional scope of the sample, while diverse, does not fully represent the complexity of all developing countries. Furthermore, although mixed-methods research was employed, the qualitative sample size limited the depth of ethnographic insight that could be obtained. The dynamic nature of sustainable construction technologies also necessitates regular updates to maintain relevance.

Future research should address these limitations through longitudinal studies that track the impact of sustainable practices over time. Broader geographic coverage and deeper case study work are also essential to unpack the influence of culture, governance, and climate. Further, quantitative evaluation of innovative financing tools and impact studies on emerging technologies (such as green AI-driven design, carbon-negative materials, and digital twins) would offer valuable pathways for advancing both practice and theory. Ultimately, this study affirms that sustainable construction, when supported by aligned policies, stakeholder collaboration, financial innovation, and localized capacity, has the potential to transform the built environment of developing nations into a resilient and equitable framework for sustainable development.

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