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The Economics of Bamboo Construction: Cost-Effectiveness Vs. Traditional Materials

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Abstract- ***As the global construction sector seeks sustainable alternatives to environmentally intensive materials like concrete, steel, and timber, bamboo has emerged as a renewable, low-carbon option with growing interest. This study investigates the economic viability of bamboo construction by comparing cost-related perceptions and performance against conventional materials, while capturing real-world insights from key stakeholders. A structured questionnaire was administered to 60 respondents, including architects, engineers, builders, contractors, developers, and homeowners, all of whom had prior experience using bamboo in construction. Quantitative analysis revealed that 55% of respondents viewed bamboo as having lower long-term costs, while 70% considered it more durable than traditional materials. However, over 90% rated market acceptance as low, citing major barriers such as lack of awareness (70%), regulatory constraints (63%), and perceived durability issues (57%). Despite these challenges, 60% expressed willingness to reuse bamboo, underscoring a gap between personal confidence and broader industry skepticism. The study concludes that bamboo is economically promising, especially over the lifecycle of a building, but its widespread adoption hinges on policy reform, awareness-building, technical training, and investment in supply chain infrastructure. These findings contribute to bridging the gap between bamboo's environmental potential and its real-world economic competitiveness.***

Indexed Terms- ***Adoption Barriers, Bamboo Construction, Cost-Effectiveness, Durability, Sustainable Materials***

I. INTRODUCTION

The global construction industry stands as a colossal engine of economic growth, yet it simultaneously exerts immense pressure on the planet's finite resources and contributes significantly to environmental degradation. Traditional building materials, notably concrete, steel, and timber, form the backbone of modern infrastructure but carry substantial environmental burdens, including high carbon emissions, extensive energy consumption, resource depletion, and significant waste generation (Tiza, Imoni, Akande, Mogbo, Jiya & Onuzulike, 2024). As the urgency of climate action intensifies and the principles of sustainable development gain paramount importance, the search for viable, eco-friendly alternatives has become not just desirable, but imperative (Atiku, Jeremiah, Semente & Boateng, 2024). Bamboo, a rapidly renewable grass species with remarkable structural properties, has emerged as a frontrunner in this quest for sustainable construction solutions (Iroegbu & Ray, 2021). Celebrated for its fast growth rate (maturing in 3-5 years versus decades for timber), exceptional strength-to-weight ratio (comparable to mild steel in tension), carbon sequestration capabilities, and low embodied energy, bamboo presents a compelling ecological profile (Rusch, Wastowski, de Lira, Moreira & de Moraes Lúcio, 2023). Its historical and contemporary use in diverse regions, from traditional dwellings in Asia and Latin America to modern architectural marvels worldwide, demonstrates its inherent versatility and potential.

However, despite its significant environmental advantages and growing architectural interest, bamboo's widespread adoption in mainstream construction faces persistent hurdles (Bredenoord, 2024). A central debate revolves around its economic viability, particularly when directly compared to the entrenched dominance of concrete, steel, and conventional timber (Ahmed, 2021). While proponents highlight potential cost savings, especially in resource-rich regions, and long-term sustainability benefits (Mohan, Dash, Boby & Shetty, 2022), skepticism persists among key industry stakeholders. Concerns frequently cited include: Perceived High Initial Costs, Durability and Maintenance Apprehensions, Supply Chain and Scalability Issues and Lack of Standardized Cost Data (Amuah, Fei-Baffoe, Sackey, Douti & Kazapoe, 2022). Consequently, while the environmental case for bamboo is increasingly strong, its economic competitiveness remains ambiguous and a significant barrier to market penetration (Vitug & Alvarez, 2024). Traditional materials benefit from well-established industries, mature supply chains, standardized codes, and deeply ingrained familiarity among architects, engineers, builders, and developers (Dhurve, 2024). Their immediate financial predictability often overshadows long-term environmental costs, which are frequently externalized (Chilton, Kadivar & Hinkle, 2025). This research directly addresses this critical knowledge gap. This study aims to rigorously examine the economic viability of bamboo as a primary construction material by systematically comparing its cost-effectiveness with traditional materials (concrete, steel, timber) and analyzing the perceptions of key stakeholders who influence material selection. The primary research objective is: To assess whether bamboo construction offers genuine economic competitiveness against traditional materials, thereby determining its viability as a scalable and sustainable alternative within contemporary building practices.

The findings of this study are anticipated to offer much-needed clarity in the ongoing debate. They have the potential to inform policymakers considering incentives for sustainable construction, guide builders and developers in material selection, influence architectural and engineering practices, and ultimately contribute to accelerating the adoption of bamboo as a key material in building a more sustainable and resilient future. This research bridges the critical gap between the recognized environmental promise of bamboo and the practical economic considerations that dictate real-world construction choices.

II. LITERATURE REVIEW

A. *Conceptual Review: Bamboo and Traditional Materials in the Construction Economy*

The conceptual landscape of this study revolves around the comparative economic analysis of construction materials, positioning bamboo against the entrenched dominance of concrete, steel, and timber. Bamboo is fundamentally conceptualized as a rapidly renewable biological resource with unique structural properties (high tensile strength, flexibility) and significant ecological advantages, including rapid carbon sequestration, low embodied energy, and minimal environmental degradation during cultivation (Iroegbu & Ray, 2021; Madhushan, Buddika, Bandara, Navaratnam & Abeysuriya, 2023). Its classification as a "non-timber forest product" (NTFP) with grass-like growth characteristics underpins its sustainability credentials. Conversely, traditional materials are characterized by high embedded energy (especially steel and concrete), significant carbon footprints, resource depletion concerns (timber), and often, linear economic models involving substantial waste (Ghobadi & Sepasgozar, 2023). The core economic concepts under scrutiny include initial cost (material acquisition, processing, labor, specialized design/engineering), life-cycle cost (maintenance, durability, repair, replacement, disposal), value engineering (optimizing function vs. cost), and externalities (environmental and social costs often excluded from traditional project accounting) (Chilton, Kadivar & Hinkle, 2025). The perceived tension lies in balancing bamboo's environmental capital (a positive externality) against potential economic premiums or risks (higher initial costs, uncertain longevity, specialized labor needs) compared to the established, albeit environmentally costly, efficiency and predictability of traditional material supply chains and construction practices (Dhurve, 2024).

B. Theoretical Review: Frameworks for Understanding Adoption and Competitiveness

Two primary theoretical frameworks provide a lens for analyzing bamboo's economic competitiveness and adoption barriers: Natural Resource-Based View (NRBV) of the Firm and Diffusion of Innovations Theory.

Natural Resource-Based View (NRBV) of the Firm (Hart, 1995): Hart's NRBV posits that sustainable competitive advantage can be built upon a firm's relationship with the natural environment. It outlines three strategic capabilities: pollution prevention, product stewardship, and sustainable development (Negrão, Gomes, Carvalho & Emmendoerfer, 2024). Applied to this study, NRBV suggests that bamboo's sustainability characteristics represent a potential source of strategic competitive advantage for construction firms, particularly as environmental regulations tighten and stakeholder (client, investor) demand for green building grows (Huang, 2021). The theory implies that firms recognizing bamboo's long-term value (reduced environmental liability, market differentiation, resource security) may be willing to overcome initial cost barriers or perceived risks. However, realizing this advantage requires capabilities in sourcing sustainable bamboo, developing efficient processing/construction techniques, and managing the knowledge gap, capabilities that are currently underdeveloped in mainstream construction compared to traditional materials. This study investigates whether stakeholders perceive and act upon this potential strategic advantage by evaluating bamboo's cost-effectiveness.

Diffusion of Innovations Theory (Rogers, 1962, 2003): Rogers' theory explains how, why, and at what rate new ideas and technologies spread through social systems (Kuo, McManus & Lee, 2021). Innovations are adopted based on perceived attributes: Relative Advantage (economic, social, etc.), Compatibility (with existing values, practices), Complexity (ease of use), Trialability (ability to experiment), and Observability (visibility of results) (Call & Herber, 2022). Bamboo construction, despite historical use, functions as an "innovation" in modern mainstream markets (Gunawarman, Pradnyaningrum, Murti, Utari & Kanaka, 2025). Its diffusion is likely hindered by perceptions of lower relative economic advantage (higher cost, risk), low compatibility with established building codes, practices, and supply chains, perceived complexity (specialized skills, design), limited trialability (few large-scale examples), and low observability of long-term performance. Stakeholder perceptions captured in this study directly relate to these key innovation attributes, explaining the slow adoption rate despite environmental benefits. The theory helps frame the analysis of why economic perceptions, even if inaccurate, act as significant barriers.

C. Empirical Review: Evidence on Costs, Perceptions, and Performance

Empirical research on the economics of bamboo construction presents a complex, sometimes contradictory picture, heavily influenced by geographical context and project scale:

Cost Comparisons: Studies often highlight bamboo's potential for lower initial costs in resource-rich regions where it is locally abundant and labor costs are moderate (Nguyen, 2024). Research on specific elements like scaffolding or low-cost housing supports this (Gebremariam, Amede & Hailemariam, 2024). However, other studies, particularly in contexts without established bamboo industries, report higher upfront costs due to processing (treatment, grading), specialized design/engineering, connection systems, and skilled labor scarcity (Reichelt, Holder & Maier, 2023). Life-cycle cost analyses (LCCA) are less common but increasingly suggest potential long-term savings for bamboo due to lower embodied energy, potential durability if properly maintained, and reduced end-of-life disposal costs compared to concrete or steel (Gan, Chen, Semple, Liu, Dai & Tu, 2022). However, the lack of standardized, long-term performance data makes robust LCCA challenging.

Stakeholder Perceptions: Empirical surveys consistently identify knowledge gaps and negative perceptions as major barriers. Architects and engineers often express concerns about structural reliability, code acceptance, and fire resistance (Davidson & Gales, 2021). Builders and contractors frequently cite lack of skilled labor, unfamiliar construction techniques, and perceived higher maintenance needs (Elegbede & Akinbile, 2024). Developers and homeowners express worries about durability, resale value, and pest susceptibility (Lyons, 2024). While environmental benefits are generally acknowledged, they rarely outweigh these economic and technical concerns in material selection decisions without strong incentives or proven cost parity.

Performance and Supply Chain: Research confirms that proper treatment (e.g., boron diffusion) significantly enhances bamboo's durability and resistance to insects and fungi, reducing long-term maintenance costs (Sain, Gaur, Khichad & Somani, 2024). However, access to reliable, high-quality treated bamboo remains a challenge in many regions, impacting both cost and performance consistency. Studies on supply chains highlight fragmentation, lack of standardization in grading and sizing, and underdeveloped market infrastructure as contributors to cost volatility and accessibility issues (Binfield, Nasir & Dai, 2024).

D. Research Gap

Despite the growing body of literature, significant gaps persist that this study aims to address:

i. Lack of Standardized Comparative Cost Metrics: There is a paucity of comprehensive, localized studies using consistent methodologies to compare the full cost spectrum (initial capital expenditure, maintenance, repair, replacement, lifecycle) of bamboo against concrete, steel, and timber for comparable building types and scales. Existing data is often project-specific, anecdotal, or regionally confined, making generalization difficult.

ii. Insufficient Focus on Integrated Stakeholder Perceptions: While some studies explore perceptions of specific groups (e.g., architects), there is a lack of holistic empirical research that simultaneously captures, compares, and analyzes the economic perceptions and decision-making drivers across the entire spectrum of key stakeholders (architects, engineers, builders, contractors, developers, homeowners) within a defined context. Understanding the alignment or divergence of these perceptions is crucial for identifying targeted interventions.

iii. Under-explored Link Between Perception and Objective Cost Data: The gap between perceived costs/risks and actual, verifiable economic performance (especially lifecycle costs) of bamboo construction is not sufficiently investigated. Research often treats perception studies and cost analysis in isolation, rather than explicitly contrasting stakeholder views with available empirical cost data to identify where misconceptions are the primary barrier.

iv. Context-Specific Economic Modeling: Generic cost-benefit analyses often fail to account for the high variability in bamboo economics based on local availability, processing infrastructure, labor skills, transportation costs, and regulatory environments. More granular, context-specific economic models are needed.

This study directly targets these gaps by employing a structured survey methodology to gather primary data on stakeholder perceptions of bamboo's economic viability across the construction value chain within a specific (implied) context, while grounding the analysis in the conceptual understanding of material economics and theoretical frameworks of adoption and competitive advantage. It aims to provide a clearer, more nuanced picture of bamboo's true cost competitiveness and the perceptual barriers that must be overcome.

III. METHODOLOGY

This study employs a descriptive research design utilizing a cross-sectional survey approach to collect primary data on stakeholder perceptions and experiences regarding the economic viability of bamboo construction. The target population comprises key stakeholders involved in material selection and construction processes within Lagos State. This includes: Architects, Engineers, Builders, Contractors, Property Developers, and Homeowners (specifically those who have commissioned or been significantly involved in construction projects). A non-probability sampling approach is deemed most practical given the need to identify participants with relevant experience. Purposive sampling will be primarily used to target professionals known through industry networks, professional associations, and construction firms actively engaged in sustainable building or material sourcing. Convenience sampling will supplement this by leveraging snowballing techniques where initial participants refer others meeting the criteria. The target sample size is 60 respondents, aiming for a distribution across the identified stakeholder groups to ensure diverse perspectives. While not statistically generalizable to the entire population, this sample size provides sufficient breadth for meaningful descriptive and comparative analysis of stakeholder segments.

The primary data collection instrument is a structured questionnaire, designed based on the research objectives and gaps identified in the literature review. The questionnaire comprises four distinct sections: Section A: Respondent Profile, Section B: Cost Assessment, Section C: Durability and Maintenance, Section D: Perception and Adoption. Data analysis will employ both quantitative and qualitative techniques, primarily using Statistical Package for the Social Sciences (SPSS) software (Version 26) for Descriptive Statistics. Key ethical principles guiding this study include: Informed Consent, Confidentiality and Anonymity and Voluntary Participation. The study acknowledges several limitations: Sampling bias, perception-based nature, recall bias, geographic scope, lack of granular cost data.

IV. RESULTS AND DISCUSSION

A. Stakeholder Profile Analysis

Builders (25%) and architects (22%) lead responses, with 68% having 5–20 years of experience. All respondents have hands-on bamboo experience, with wall panels (80%) and roofing (50%) as primary uses. Bamboo is widely adopted for non-structural applications, but structural use remains limited (30%), indicating potential barriers in engineering acceptance.

Table 1: Profession (Q1) Frequency Distribution

Profession	Frequency	Percentage
Architect	13	21.67%
Engineer	8	13.33%
Builder	15	25.00%
Contractor	8	13.33%
Property Developer	8	13.33%
Homeowner	8	13.33%
Total	60	100%

Source: Author, 2025

Builders (25%) and architects (21.67%) dominate the respondent pool, indicating strong representation from design and construction professionals. Other groups (engineers, contractors, developers, homeowners) are evenly represented at ~13% each, ensuring diverse perspectives. The dominance of builders and architects in the respondent pool aligns with literature emphasizing their central role in material selection and construction decision-making, especially regarding sustainability and cost (Sain, Gaur, Khichad & Somani, 2024; Lyons, 2024). The relatively even distribution of other stakeholders enhances the validity of the findings by incorporating varied perspectives across the construction value chain, as recommended by stakeholder-inclusive research approaches (Elegbede & Akinbile, 2024; Davidson & Gales, 2021).

Table 2: Years of Experience (Q2) Frequency Distribution

Experience	Frequency	Percentage
Less than 5 years	7	11.67%
5–10 years	24	40.00%
11–20 years	17	28.33%
More than 20 years	12	20.00%
Total	60	100%

Source: Author, 2025

The majority (40%) have 5–10 years of experience, suggesting mid-career professionals form the core respondent group. Combined with 28.33% having 11–20 years, this reflects substantial industry exposure, lending credibility to cost/durability assessments. The concentration of mid- to senior-level professionals aligns with literature suggesting that practitioners with 5–20 years of experience possess both practical field knowledge and decision-making influence, which enhances the reliability of their assessments (Gan, Chen, Semple, Liu, Dai & Tu, 2022). Their substantial industry exposure is critical in evaluating alternative materials like bamboo, as experienced professionals are more attuned to long-term performance and cost-efficiency considerations (Reichelt, Holder & Maier, 2023).

Table 3: Bamboo Usage (Q3) Frequency Distribution

Bamboo Used?	Frequency	Percentage
Yes	60	100%
No	0	0%
Total	60	100%

Source: Author, 2025

All respondents have used bamboo in construction, eliminating non-user bias. This ensures feedback is grounded in practical experience rather than theoretical perceptions. The inclusion of only respondents with direct experience using bamboo aligns with best practices in material evaluation studies, where firsthand usage reduces speculative bias and enhances data validity (Gebremariam, Amede & Hailemariam, 2024). As noted by Nguyen (2024), practitioner insights drawn from actual implementation are crucial for accurately assessing the performance, cost, and feasibility of alternative construction materials like bamboo.

Table 4: Bamboo Application (Q4) Frequency Distribution (Multiple responses allowed)

Application	Frequency	Percentage
Wall panels	48	80.00%
Roofing	30	50.00%
Decorative elements	28	46.67%
Flooring	22	36.67%
Structural framework	18	30.00%

Source: Author, 2025

Wall panels (80%) and roofing (50%) are the most common applications, highlighting bamboo's role in non-structural elements. Structural use (30%) is less frequent, suggesting hesitancy or niche adoption for load-bearing purposes. The preference for using bamboo in non-structural elements like wall panels and roofing aligns with literature noting that bamboo is often favored for its aesthetic appeal and ease of installation rather than for structural roles (Gunawarman, Pradnyaningrum, Murti, Utari & Kanaka, 2025). The limited structural use reflects ongoing concerns about standardization, strength variability, and regulatory acceptance, which have been identified as key barriers to its broader adoption in load-bearing applications (Binfield, Nasir & Dai, 2024).

B. Initial and Long-Term Cost Evaluation

Respondents perceive bamboo's long-term cost savings more favorably than its initial cost, suggesting that despite higher upfront investments for some, lifecycle economics are viewed positively. The 2.37 average for (closer to "Slightly Lower") reinforces bamboo's operational cost advantage.

Initial Cost: Much cheaper=1, Slightly cheaper=2, About the same=3, Slightly more expensive=4, Much more expensive=5

Long-Term Cost: Much lower=1, Slightly lower=2, About the same=3, Slightly higher=4, Much higher=5

Cost-Effectiveness: Strongly agree=1, Agree=2, Neutral=3, Disagree=4, Strongly disagree=5

Table 5: Cost Perception Analysis

Metric	1	2	3	4	5	Weighted Average
Initial Cost	16 (26.7%)	8 (13.3%)	22 (36.7%)	10 (16.7%)	4 (6.7%)	2.63
Long-Term Cost	10 (16.7%)	23 (38.3%)	22 (36.7%)	5 (8.3%)	0 (0%)	2.37
Agreement on Cost-Effectiveness	12 (20.0%)	18 (30.0%)	20 (33.3%)	8 (13.3%)	2 (3.3%)	2.50

Source: Author, 2025

Initial Cost has a neutral-leaning-positive average (2.63), with 40% perceiving bamboo as cheaper (scores 1-2), but 23.4% see it as more expensive (scores 4-5). Long-Term Cost shows stronger optimism (weighted avg 2.37), with 55% expecting lower maintenance costs (scores 1-2) versus only 8.3% anticipating higher costs. Cost-Effectiveness aligns with (avg 2.50), where 50% agree/strongly agree bamboo is cost-effective, while 16.6% disagree. The findings reflect a cautiously optimistic view of bamboo's economic viability, consistent with literature suggesting that while bamboo's initial costs may vary due to processing and supply chain limitations, its long-term affordability is driven by low maintenance and renewability (Call & Herber, 2022). The moderate agreement on cost-effectiveness aligns with studies like Kuo, McManus & Lee (2021), which emphasize that stakeholder confidence in bamboo's value improves with familiarity and proven performance over time.

C. Durability and Maintenance Assessment

While 70% perceive bamboo as *more durable*, over 50% report moisture/pest issues, suggesting durability perceptions may not fully align with practical maintenance challenges. Biological degradation (pests/moisture) and fire risk emerge as primary threats, highlighting areas needing technical intervention (e.g., treatment technologies).

Table 6: Durability Perception (Compared to traditional materials)

Durability Perception	Frequency	Percentage
Much more durable	18	30.0%
Slightly more durable	24	40.0%
Equally durable	14	23.3%
Slightly less durable	4	6.7%
Much less durable	0	0%
Total	60	100%

Source: Author, 2025

A strong majority (70%) perceive bamboo as *more durable* than traditional materials (30% "much more," 40% "slightly more"). Only 6.7% view it as less durable, indicating broad confidence in bamboo's structural resilience. The high perceived durability of bamboo aligns with research highlighting its impressive tensile strength and structural performance, often comparable to or exceeding that of traditional materials like timber (Huang, 2021; Negrão, Gomes, Carvalho & Emmendoerfer, 2024). This broad confidence reflects growing awareness of treated bamboo's resilience against environmental stressors, as documented in studies promoting its suitability for long-term structural applications when properly processed and maintained (Ghobadi & Sepasgozar, 2023).

Table 7: Maintenance Issues (Multiple responses)

Maintenance Issue	Frequency	Percentage
Pest infestation	34	56.7%
Rotting or moisture damage	32	53.3%
Fire risk	20	33.3%
Structural failure	14	23.3%
No major issues	8	13.3%

Source: Author, 2025

Pest infestation (56.7%) and moisture damage (53.3%) dominate maintenance concerns, reflecting bamboo's susceptibility to biological degradation. Fire risk (33.3%) is another significant challenge, while only 13.3% report no issues. These findings echo established literature that untreated or poorly treated bamboo is vulnerable to pests and moisture-related decay, which significantly affects its longevity and market acceptance (Madhushan, Buddika, Bandara, Navaratnam & Abeysuriya, 2023). The notable concern over fire risk is also consistent with studies emphasizing the need for fire retardant treatments and improved building codes to enhance bamboo's safety profile in mainstream construction (Iroegbu & Ray, 2021).

D. Market Acceptance and Adoption Barriers

Despite 70% citing durability concerns, earlier data showed 70% perceive bamboo as more durable, highlighting a disconnect between personal experience and market narrative. Lack of awareness (70%) and regulatory issues (63%) dominate barriers, suggesting policy/education interventions could drive adoption more than technical improvements.

Table 8: Market Acceptance Perception

Perception	Frequency	Percentage
Very high	0	0%
High	0	0%
Moderate	6	10.0%
Low	32	53.3%

Very low	22	36.7%
Total	60	100%

Source: Author, 2025

Over 90% perceive market acceptance as low (53.3%) or very low (36.7%), indicating widespread skepticism about bamboo's commercial viability. Only 10% see moderate acceptance, with no respondents reporting high/very high acceptance. The overwhelmingly low perception of market acceptance reflects persistent challenges identified in literature, where bamboo's commercial adoption is hindered by regulatory gaps, limited standardization, and cultural biases favoring conventional materials (Chilton, Kadivar & Hinkle, 2025). This skepticism underscores the need for policy support, certification systems, and public education to shift bamboo from a niche or informal material to a widely accepted construction solution (Dhurve, 2024).

Table 9: Future Use Consideration

Response	Frequency	Percentage
Yes	36	60.0%
Not sure	18	30.0%
No	6	10.0%
Total	60	100%

Source: Author, 2025

Despite low market acceptance, 60% would use bamboo again, signaling a "personal adoption vs. market pessimism" paradox. However, 40% (no + not sure) remain hesitant, highlighting lingering reservations. This paradox between personal willingness and market pessimism mirrors findings in adoption theory, where early adopters may recognize the benefits of innovative materials despite broader industry reluctance (Vitug & Alvarez, 2024). As noted by Amuah, Fei-Baffoe, Sackey, Douti & Kazapoe, 2022), individual acceptance often precedes institutional support, suggesting that increasing technical validation and policy backing could convert hesitant stakeholders and bridge the gap between personal use and mainstream adoption.

Table 10: Adoption Barriers (Multiple responses)

Barrier	Frequency	Percentage
Lack of awareness	42	70.0%
Regulatory constraints	38	63.3%
Perceived lack of durability	34	56.7%
High perceived cost	34	56.7%
Cultural preferences	28	46.7%
Limited availability	26	43.3%
Absence of popular case studies	4	6.7%

Source: Author, 2025

Lack of awareness (70%) and regulatory hurdles (63%) are the dominant barriers, followed closely by durability concerns (57%) and cost perceptions (57%). Cultural resistance (47%) and supply limits (43%) are also significant. The prominence of awareness and regulatory barriers aligns with literature emphasizing that inadequate knowledge dissemination and the absence of formal building standards significantly obstruct bamboo's integration into mainstream construction (Ahmed, 2021). Additionally, concerns about durability, cost, and cultural preferences reflect deep-rooted perceptions that, as Bredenoord (2024) argue, can only be shifted through targeted education, reliable supply chains, and evidence-based performance data.

V. CONCLUSION AND RECOMMENDATIONS

This study set out to assess the economic viability of bamboo as a construction material compared to traditional options such as concrete, steel, and timber, with a specific focus on cost-effectiveness and stakeholder perceptions. The findings reveal a nuanced outlook: while bamboo's initial cost perception remains mixed, with some respondents viewing it as slightly more expensive, the long-term cost benefits are more widely acknowledged, with a weighted average score leaning toward "slightly lower." Additionally, over 70% of respondents consider bamboo more durable than traditional materials, despite ongoing concerns about biological degradation and fire risk, highlighting a distinction between theoretical performance and on-the-ground maintenance realities.

Significantly, all respondents had prior experience using bamboo, grounding their feedback in practical knowledge. The majority used bamboo in non-structural applications like wall panels and roofing, with limited adoption for structural frameworks, pointing to lingering concerns about engineering acceptance and regulatory standards. Although personal willingness to reuse bamboo is strong (60%), broader market acceptance is perceived as critically low, driven by a lack of awareness, inadequate regulation, and deeply embedded cultural and professional biases toward conventional materials.

These findings support earlier literature indicating that while bamboo offers compelling environmental and long-term cost benefits, its wider adoption is impeded more by perception, policy, and infrastructure gaps than by actual material limitations. Stakeholders who recognize bamboo's advantages are often constrained by weak institutional support, limited technical guidelines, and lack of success case visibility. Therefore, this study recommends the following:

i. Policy and Code Integration: Regulatory bodies should develop and enforce bamboo-inclusive building codes and certification systems to legitimize its use in mainstream projects.

ii. Technical Training and Capacity Building: Construction professionals require targeted training on bamboo treatment, structural integration, and safety management to boost confidence and technical competence.

iii. Awareness Campaigns and Demonstration Projects: Government and private sector collaboration should promote large-scale pilot projects to increase bamboo's visibility and counter market skepticism.

iv. Subsidy and Incentive Structures: Economic incentives such as tax breaks, subsidies, or fast-track approvals for bamboo-based designs can reduce financial barriers and encourage adoption.

v. Investment in Supply Chain Infrastructure: Strengthening the bamboo supply chain, from cultivation to standardized treatment and distribution, will help reduce cost variability and improve accessibility.

These recommendations, if adopted, could help align the recognized environmental promise of bamboo with its economic potential, unlocking its role in sustainable construction across varied scales and contexts. While this study provides valuable insights, it also reveals several directions for deeper investigation:

i. Life-Cycle Costing (LCC): Future studies should apply comprehensive LCC models to compare bamboo and traditional materials across diverse building types and geographic contexts.

ii. Structural Performance Studies: Empirical testing on treated bamboo's load-bearing capacity under varying conditions can validate its use in primary structural elements.

iii. Market Dynamics and Consumer Behavior: Broader surveys including end-users (homeowners, tenants) can explore how aesthetic, cultural, and resale perceptions influence bamboo's market adoption.

iv. Policy Impact Assessment: Evaluating how different regulatory frameworks (local and international) impact bamboo integration would inform policy design for adoption acceleration.

v. Digital Tools and BIM Integration: Investigating how bamboo construction can be incorporated into Building Information Modeling (BIM) environments could improve planning and uptake among professionals.

In summary, while bamboo shows considerable promise as a sustainable and potentially cost-effective construction material, its full economic viability will only be realized through a combination of technical, regulatory, and perceptual shifts.

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