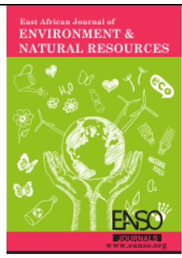

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Original Article

Comparative Analysis of the Acceptability of Bamboo and Wood Products and Their Utilisation in the Construction Industry

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Bamboo, Timber Substitution, Construction Materials, Value Addition, Sustainability, Acceptability, Kenya.

ABSTRACT

Bamboo has emerged globally as a sustainable and versatile alternative to timber due to its strength, rapid growth, and wide range of applications. This study examined the acceptability of bamboo products compared to wood products in Narok North Sub-County, with a focus on construction, fuelwood, basketry, and furniture. The study objectives were to assess the economic potential of bamboo, compare levels of acceptability between bamboo and timber, and evaluate community perceptions of durability, affordability, and quality. A mixed-methods design was adopted, involving household questionnaires, interviews with environmental and forestry officers, focus group discussions, and photography. Quantitative data were analysed using percentages, chi-square tests, and descriptive statistics, while qualitative data were summarised thematically. Results revealed that while timber remains dominant for fuelwood (85.3%) and furniture (92.2%), bamboo was highly preferred for basketry (89.2%) and exhibited strong potential in construction, with 70.6% of respondents indicating willingness to adopt bamboo if raw materials were readily available. Chi-square tests indicated significant associations between current and potential uses of bamboo for fuelwood ($\chi^2=18.242$, $p<0.001$), furniture ($\chi^2=11.461$, $p<0.01$), and construction ($\chi^2=3.913$, $p<0.05$). However, no significant associations were found in basketry ($\chi^2=1.193$, $p=0.275$) or raw material availability ($\chi^2=0.175$, $p=0.676$). Respondents cited affordability, environmental sustainability, and durability as key drivers of acceptability, though timber was still perceived as higher quality where modern bamboo processing and value-addition technologies were lacking. The findings demonstrate that bamboo holds significant promise as an alternative to timber, particularly in construction and basketry, but barriers such as weak supply chains, lack of treatment standards, and limited awareness constrain its adoption. With policy support, value-addition technologies, and community sensitisation, bamboo could play a transformative role in reducing deforestation, supporting livelihoods, and advancing sustainable development in Kenya.

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INTRODUCTION

Bamboo is increasingly recognised as a sustainable and versatile resource capable of addressing both ecological and socio-economic challenges. Its remarkable strength, flexibility, and workability have positioned it as a potential alternative to conventional timber in multiple applications (Chan et al., 2023). Studies demonstrate that bamboo can withstand pressures of up to 3656 kg/cm² (358.53 MPa) (Paudel, 2008; IP Das, 2025) and has a tensile strength comparable to steel at approximately 28,000 N/m² (0.028 MPa) (Nurdiah, 2016). These qualities make bamboo particularly suitable for construction, furniture, basketry, and other industries where strength and durability are required.

Globally, the extensive use of timber has placed increasing pressure on natural forests. Wood remains widely used in construction, furniture, tools, and transportation, but its demand has intensified concerns about sustainability, raw material costs, and environmental degradation (Xu et al., 2022; Singh et al., 2024). Traditional tree-based timber takes 30 to 50 years to mature, whereas bamboo matures within 3 to 5 years, making it one of the most important non-timber forest products (NTFPs) in the world. Its rapid growth, affordability, and favourable physical properties have made it a preferred raw material in Asia, particularly in China and India, where large-scale bamboo industries are flourishing (A. Rogerson, 2020).

In Kenya, the reliance on timber for fuelwood, furniture, and construction continues to degrade natural forests, including fragile ecosystems such as the Mau Forest Complex. Bamboo offers a viable substitute that is eco-friendly, fast-growing, and aligned with sustainable development goals. However, despite its advantages, bamboo adoption in Kenya remains constrained by inadequate awareness, weak supply chains, a lack of standardised preservation and treatment methods, and cultural preferences for timber.

This study investigates the acceptability of bamboo products compared to traditional timber in Narok North Sub-County, with emphasis on household and community preferences in construction, basketry, fuelwood, and furniture. The research seeks to answer three key questions:

- What is the level of community preference for bamboo over timber in household and construction applications?

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- How do affordability, quality, and durability perceptions shape the choice between bamboo and timber?
- What are the ecological and socio-economic implications of promoting bamboo as an alternative material?

By addressing these questions, the study contributes evidence toward positioning bamboo as a sustainable and practical alternative to timber, with potential benefits for environmental conservation and local livelihoods.

LITERATURE REVIEW

Mechanical Properties of Bamboo

Bamboo has gained recognition as a strong, lightweight, and renewable construction material. Research shows it has tensile properties comparable to steel, with tensile strength values as high as 28,000 N/m² (0.028 MPa) (Nurdiah, 2016). Depending on the species, bamboo can withstand pressures up to 3656 kg/cm² (358.53 MPa) (Paudel, 2008; IP Das, 2025). Its strength allows it to be used as horizontal members less than 3–3.6 m long without middle support (Nwoke & Ugwuishiwu, 2011). However, strength characteristics vary with species, age, culm diameter, wall thickness, moisture content, and the radial position of the load (Asif, 2009; Ibrahim, 2010; Mahdavi, Clouston, & Arwade, 2011).

Leake et al. (2010) and Kyakula & Gombya (2008) observed that not all bamboo species offer the same mechanical reliability, which is a key factor influencing adoption in the construction sector. Nevertheless, the combination of tensile strength, compressive resistance, and elasticity underscores its potential as a timber substitute. These properties explain bamboo's expanding use in engineered products such as laminated bamboo lumber (LBL), oriented strand lumber (OSL), and bamboo-woven plywood (A Rogerson, 2020).

Bamboo Versus Timber: Sustainability and Substitution

Wood has historically served as the principal raw material for construction, furniture, and consumer goods. However, unsustainable logging practices have led to rising costs and severe biodiversity loss. These ecological and economic pressures have intensified the search for renewable alternatives. According to Xu et al. (2022) and Singh et al. (2024), the depletion of global timber resources has created a significant demand for substitutes such as bamboo. Unlike tropical hardwoods that require 30–50 years to mature, bamboo reaches maturity within 3–5 years, making it an attractive renewable option.

From an environmental perspective, bamboo offers considerable benefits. It has low embodied energy, enhances carbon sequestration, prevents soil erosion, and conserves biodiversity (Manathar et al., 2019). Once regarded as "the poor man's timber," bamboo has, over the past three decades, become a cornerstone for diversified industries, particularly in Asia and India, where it contributes significantly to national economies (Xu et al., 2022). This transformation underscores bamboo's potential as a sustainable substitute for timber.

Industrial Applications and Market Potential

Bamboo's uses extend beyond traditional household applications such as baskets, poultry cages, and incense sticks. Advances in processing technologies now allow the production of laminated bamboo timber, particleboard, and bamboo composites with mechanical properties comparable to, or in some cases exceeding, conventional timber (Chaowana, 2013). Rogerson (2020) highlights the emergence of bamboo mat boards, cement-bonded panels, and wood–plastic composites, which have increased commercial demand.

India, holding approximately 40% of the world's bamboo forest area after China, demonstrates how strategic investment, research, and supportive policy frameworks can scale bamboo industries rapidly. In Kenya, however, industrial bamboo

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utilisation remains underdeveloped, limiting its penetration into the construction sector.

Preservation and Treatment

A critical challenge for bamboo adoption is its susceptibility to fungal attacks, insect damage, and decay. Kudva (2024) stresses the importance of preservative treatment to extend bamboo's lifespan, particularly in outdoor and load-bearing contexts. Common treatments include copper chrome arsenate (CCA), copper chrome boron (CCB), and borax–boric acid solutions. These enhance bamboo's durability, making it competitive with timber for structural applications. Nevertheless, in many African contexts, bamboo remains untreated and is thus perceived as inferior to timber. This undercuts community confidence in bamboo as a durable substitute.

Bamboo as a Sustainable Construction Material

Bamboo's strength-to-weight ratio, flexibility, and renewability position it as an excellent construction material (OJ Adebowale, 2024). Its tensile strength ranges from 70–210 MPa, compressive strength from 20–65 MPa, and elastic modulus from 2,500–17,500 MPa. These values make bamboo suitable for beams, columns, and reinforcements. Engineered products such as laminated and scrimber bamboo are already being used in flooring, roofing, and concrete reinforcement (Xu et al., 2025; P Ramani, 2025). For example, bamboo-reinforced concrete (BRC) and bamboo-fibre-reinforced concrete (BFRC) demonstrate superior shear and flexural behaviour compared to plain concrete.

Beyond structural performance, bamboo cultivation has ecological co-benefits. Selective harvesting allows continuous regeneration, while its root system stabilises soils, reduces erosion, and enhances carbon sequestration (Manathar et al., 2019). Bamboo's lightweight yet durable properties also make it suitable for disaster-resistant housing, especially in earthquake-prone regions.

Applications in Building and Construction

Bamboo's versatility supports its application in almost every building component, from foundations and walls to scaffolding and flooring. Sakaray et al. (2012) and Salzer et al. (2016) note its diverse uses, though direct application in foundations is limited by its rapid deterioration in damp soils. Innovations such as bamboo–concrete composites and preservative-treated poles have helped overcome these weaknesses. Bamboo's adaptability for prefabricated and modular housing enhances its sustainability profile, since components can be dismantled, reused, and recycled.

Value Addition and Circular Economy Potential

In the face of shrinking forest reserves, metal depletion, and plastic pollution, bamboo offers unique opportunities within a circular economy (Jaiswal et al., 2022). Unlike linear production systems, bamboo's short growth cycle and biodegradability align with global sustainability goals, including reducing deforestation and mitigating climate change (Chauhan et al., 2020).

Bamboo's composition—cellulose, lignin, and starch—enables its conversion into high-value products such as charcoal, activated carbon, and biochar (Kaur et al., 2016a; Chien et al., 2011). Bamboo-based biochar, for example, improves soil fertility, captures greenhouse gases, and filters pollutants (Wang et al., 2022; Chartuvedi et al., 2023). Its application in electromagnetic shielding further demonstrates bamboo's versatility. Kidane (2024) emphasises the need for a holistic approach to bamboo utilisation in which all parts of the plant are valorised in a closed-loop system, maximising sustainability outcomes.

Literature Gaps

While global studies highlight bamboo's industrial promise, Africa—and Kenya in particular—lags behind due to limited awareness, inadequate supply chains, insufficient processing technologies, and weak preservation standards. Current literature

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lacks comprehensive analyses of bamboo's acceptability and competitiveness against timber in Kenya's construction sector. This gap necessitates localised empirical research to inform sustainable policy and industrial strategies.

RESEARCH METHODOLOGY

This study was undertaken in Narok North Sub-County, Narok County, which spans 2,603 km² with a population of 251,894 people (KNBS, 2019). The area lies at an altitude of about 1,800 meters above sea level, with undulating hills, and experiences annual rainfall ranging from 500 to 1,800 mm. Temperatures vary between 12°C and 28°C, with long rains from March to June and short rains in October and December. These agro-ecological conditions are favourable for large-scale wheat and maize farming and present potential opportunities for bamboo cultivation as an alternative land use.

The study adopted a mixed-methods design, combining both quantitative and qualitative techniques. According to Creswell (2021), such an approach provides a more comprehensive understanding of social phenomena than relying on one method alone. Quantitative data was obtained through household questionnaires, while qualitative insights were gathered through key informant interviews with environmental officers and forest officers, focus group discussions (FGDs) with community members, and photography to document bamboo use and environmental practices.

The target population included village elders, community service workers, environmental officers, and forestry personnel, selected due to their knowledge of forest use and management. Using Nassiuma's (2000) formula, a sample size of 100 respondents was drawn from the total population of 251,862. To ensure representativeness, a stratified random sampling method was employed across the six administrative wards of Narok North—Olokurto, Olpusimoru, Nkareta, Melili, Olorropil, and Narok Town. This allowed proportional distribution of respondents per ward, reflecting population differences.

The sample size was determined using the formula recommended by Nassiuma (2000) as;

$$n = \frac{NCv^2}{(Cv^2 + (N-1)\, e^2}$$

Where n= sample size

N=population

Cv = Coefficient of variation (take 0.5)

e = Tolerance of the desired level of confidence taken as 0.05 % at a 95 % confidence level

Since Narok North Sub-County had a total population of 251,862 persons as per the 2019 Kenya Population and Housing Census (KPHC), the formula was applied as follows;

$$N \times C_v^2 = 251{,}862 \times 0.25 = 62{,}965.5$$

$$C_v^2 + (N - 1) \times e^2 = 0.25 + (251{,}861 \times 0.0025) = 0.25 + 629.6525 = 629.9025$$

$$n = 62{,}965.5 \div 629.9025 \approx 100.0$$

This gives a total of approximately 100 respondents as the sample size.

Data collection instruments were pre-tested in Nkareta Ward using 30 pilot questionnaires, which helped refine questions for clarity, consistency, and reliability (Mugenda & Mugenda, 2003). Structured questionnaires contained both closed and open-ended items, while FGDs comprised 6–10 participants representing diverse socio-economic and cultural groups. Photography provided visual evidence complementing verbal responses, as Creswell (2018) notes, photographs enhance data credibility by capturing observable phenomena.

Data analysis employed both descriptive and inferential techniques. Quantitative data was analysed using percentages, chi-square tests, and measures of variation such as standard deviations

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and errors. These were presented in tables, charts, and graphs for ease of interpretation. Qualitative data was thematically analysed, allowing patterns and emerging issues to be compared with quantitative findings. Pearson's correlation coefficient was further applied to explore relationships between bamboo adoption and sustainable forest management outcomes, with the margin of error set at 5%.

Ethical considerations guided the entire research process. Approvals were obtained from Maasai Mara University, the National Commission for Science, Technology and Innovation (NACOSTI), and the Narok County Government. Local administrative officers were consulted before data collection began. Participants gave informed consent, were assured of confidentiality and anonymity, and were informed of their right to withdraw at any stage. The research adhered to principles of integrity and respect for community values.

RESULTS AND DISCUSSION

Response to Research Questions

The study addressed three main research questions: the economic potential of bamboo for sustainable socio-economic development, the comparative acceptability of bamboo and timber products, and community awareness of bamboo's ecological role. The findings confirm that each question was adequately answered through quantitative surveys, focus group discussions (FGDs), and photographic documentation.

Current Use of Timber and Bamboo Products

Survey results show that timber remains dominant in high-value household applications such as fuelwood (85.3%) and furniture (92.2%), while bamboo accounts for only 14.7% and 7.8%, respectively. Conversely, bamboo overwhelmingly dominates basketry (89.2%) compared to timber (10.8%) and is nearly competitive in construction, with 45.1% usage compared to timber's 54.9%.

Discussions from FGDs complemented these results by highlighting that timber's dominance is influenced by cultural familiarity, established supply chains, and perceptions of durability. However, participants acknowledged bamboo's affordability, flexibility, and environmental benefits, especially for basketry and small-scale construction. Photographic documentation reinforced these findings, capturing bamboo's practical uses in basketry, fencing, and household crafts, while timber featured prominently in furniture and structural work.

Table 1: Currently Used Products between Timber and Bamboo

Use	Timber	Bamboo
Current fuel wood	85.3%	14.7%
Use if bamboo was available (fuel wood)	67.6%	32.4%
Current furniture	92.2%	7.8%
Use if bamboo was available (furniture)	66.7%	33.3%
Current basketry	10.8%	89.2%
Use if bamboo was available (basketry)	8.8%	91.2%
Current construction	54.9%	45.1%
Use if bamboo was available (construction)	29.4%	70.6%
Current use for other functions	82.4%	17.6%
Use if bamboo was available (other functions)	46.1%	53.9%

Source: *Researcher, 2025*

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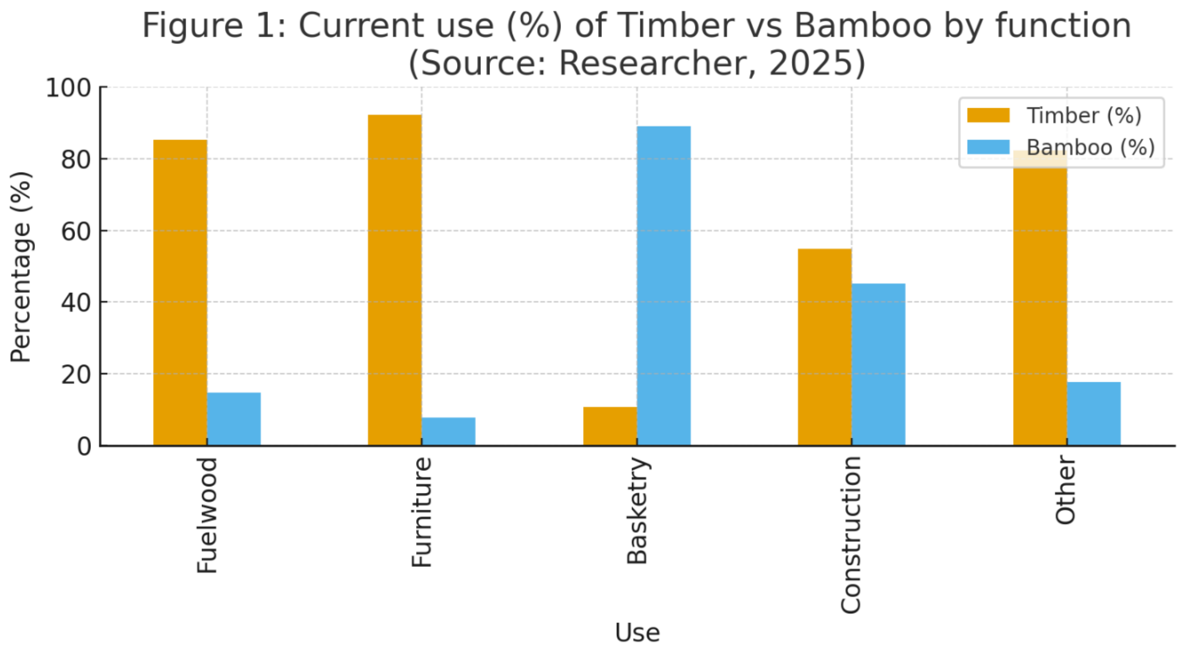
Figure 1: Current Use (%) of Timber vs Bamboo by Function



Source: *Researcher (2025)*

Photographic evidence documented bamboo's role in fencing and basketry, while timber was prominent in household furniture.

Image 1: Bamboo Used in Basketry (locally crafted basket).

Image 2: Wood Used in Household Furniture (chairs and tables).

Potential Use of Bamboo Products

When respondents were asked about their preferences if bamboo were more readily available, a major shift was observed. In construction, preference for bamboo rose sharply to 70.6%, surpassing timber (29.4%). Similarly, preference for bamboo in furniture increased to 33.3% from the current 7.8%, while 32.4% expressed willingness to

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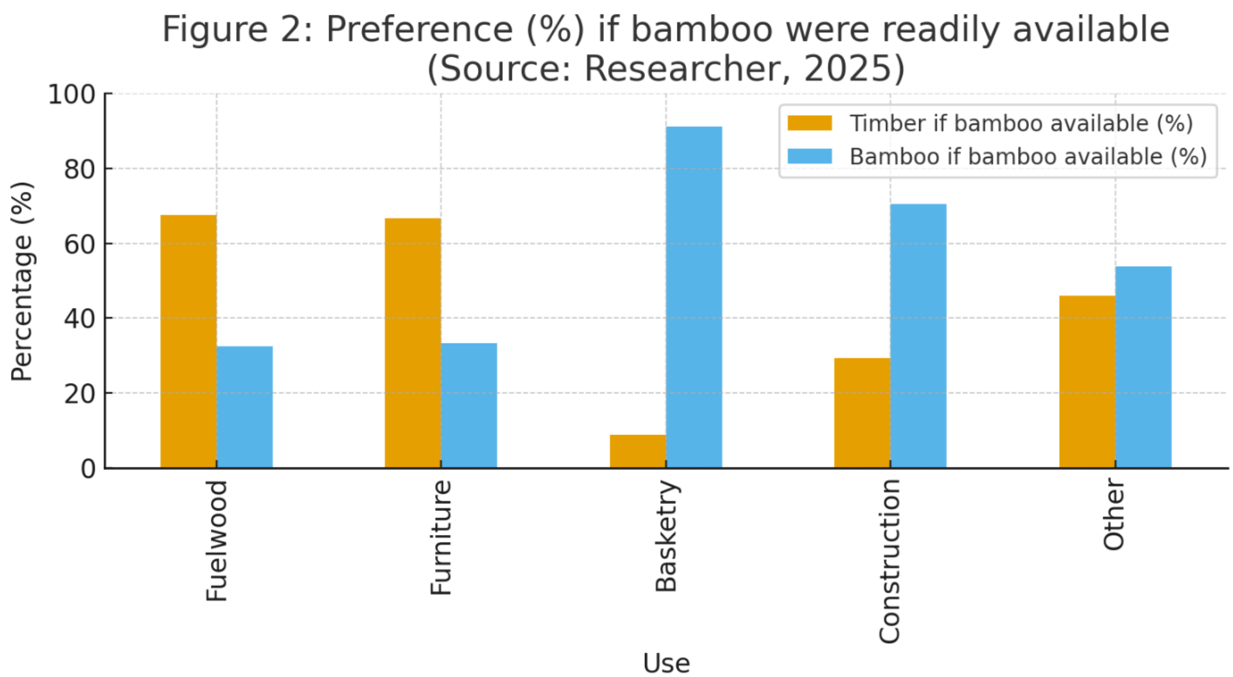
use bamboo for fuelwood. FGDs provided explanations for this shift—artisans stated that they would prefer bamboo if it were adequately processed, treated, and readily available in the local market. They emphasised that untreated bamboo deteriorates quickly, especially when exposed to moisture.

Figure 2: Preference (%) if Bamboo were Readily Available



Source: *Researcher (2025)*

Chi-Square Tests of Association

Affordability in Fuelwood

A chi-square test assessed whether there was an association between current use of timber/bamboo as fuelwood and affordability perceptions. Results showed a statistically significant relationship ($\chi^2(1)=18.242$, $p<0.001$). This implies that affordability influences choices, with timber currently seen as cheaper. Mutisya et al. (2021) support this finding, noting that modified cooking technologies in Kenya reduce firewood costs, making timber more affordable. However, Saha et al. (2022) counter this by suggesting that bamboo biomass is emerging as a competitive and affordable fuel alternative. Community discussions revealed that the perception of wood as the more economical choice stems from cultural familiarity and established local distribution systems. Some community elders also emphasised that traditional cooking practices favour wood or charcoal. However, emerging awareness of bamboo's potential as a renewable biomass source was evident, as households that had observed bamboo briquettes or bamboo charcoal production acknowledged its future affordability.

Quality of Furniture

The chi-square test for furniture quality also revealed a significant association ($\chi^2(1)=11.461$, $p<0.01$). Most respondents (93 out of 100) currently use timber for furniture and still associate it with higher quality. Gelaw et al. (2025) attribute this perception to the

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limited innovation in bamboo processing locally. Conversely, in China, advanced processing has elevated bamboo furniture into global markets (Gupta et al., 2025). Discussions with local artisans revealed that perceptions of bamboo quality often depend on the level of processing. In areas lacking modern treatment and finishing technologies, bamboo furniture is viewed as less durable compared to timber. However, some participants who had encountered bamboo furniture from other regions described it as sturdy and visually appealing.

Quality in Basketry

Unlike fuelwood and furniture, no significant association was observed for basketry ($\chi^2(1)=1.193$, $p=0.275$). Bamboo already dominates basketry (89.2%), indicating its entrenched role in this industry. Yan Sun et al. (2022) highlight how design technology innovations in weaving have enhanced the quality of bamboo basketry, while Liu et al. (2022) caution that shrinking practitioner groups threaten the sustainability of this craft. The FGDs confirmed that community members view bamboo as the traditional and preferred raw material for basketry due to its flexibility, availability, and cultural significance. Survey data confirmed this dominance numerically, while photographs captured real examples of locally woven bamboo baskets.

Durability in Construction

A significant association was found between construction material and durability perceptions ($\chi^2(1)=3.913$, $p=0.048$). While timber is seen as durable, 71% of respondents indicated they would prefer bamboo if available. This aligns with Amede et al. (2021), who describe bamboo as an adaptable and durable material. However, Opuku et al. (2016) highlight that in Africa, limited processing techniques and a lack of treatment reduce bamboo’s lifespan. Observations of local construction projects confirmed that bamboo is used selectively for fencing and small structures but remains underutilized for large-scale construction. Builders emphasized the need for proper treatment and preservation techniques, citing cost and limited access to modern processing as barriers.

Availability of Raw Materials in Construction

The chi-square test on raw material availability showed no significant association ($\chi^2(1)=0.175$, $p=0.676$). Although Africa has vast bamboo resources, Minale et al. (2020) argue that they remain largely untapped, while Ojelabi et al. (2025) note that technological limitations in processing and preservation hinder availability. However, FGDs clarified that “limited availability” referred not to scarcity in nature but to poor supply chain management and inadequate harvesting practices. This finding also aligned with survey responses.

Overall Acceptability of Bamboo Products

The findings reveal a complex picture of bamboo’s acceptability. Timber remains dominant in fuelwood and furniture, yet bamboo is clearly the material of choice in basketry and shows growing preference in construction when availability is not a constraint. Respondents associated bamboo with environmental benefits, affordability, and durability, but timber retained an edge in quality perceptions where modern bamboo value addition technologies were absent.

These outcomes resonate with international studies that underscore bamboo’s potential as a substitute for timber (van Dam et al., 2018; Xu et al., 2022). Yet they also reflect local barriers such as weak supply chains, insufficient awareness, and the absence of preservation standards.

Study Limitations

The study was geographically limited to Narok North Sub-County and may not fully represent national trends. Perception-based measures of quality introduced subjectivity, while photographs could not capture long-term durability.

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Additionally, the absence of laboratory testing of bamboo's mechanical properties limited technical depth. Despite these limitations, the study provides credible evidence of bamboo's acceptability and potential as a sustainable substitute for timber.

CONCLUSION

The study concludes that bamboo products are increasingly acceptable alternatives to timber in Narok North Sub-County, particularly in basketry and construction. While timber continues to dominate in furniture and fuelwood, bamboo's potential is evident where issues of availability, treatment, and value addition are addressed. Communities recognise bamboo's sustainability, affordability, and durability, linking it to reduced deforestation and enhanced environmental protection. However, cultural preferences, perceived quality gaps, and inadequate processing technologies still constrain widespread substitution. With policy support, improved supply chains, and investment in modern bamboo processing, bamboo could emerge as a transformative resource, providing livelihoods, conserving forests, and advancing Kenya's sustainable development agenda.

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