

ALTERNATIVES TO TRADITIONAL CONSTRUCTION MATERIALS AND THEIR ENVIRONMENTAL IMPACT

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Abstract

The growing rate of urbanization and infrastructural development across the world has intensified the demand for construction materials, leading to severe environmental consequences such as greenhouse gas emissions, deforestation, depletion of natural resources, and ecological degradation. Traditional construction materials including conventional cement, fired clay bricks, steel, and timber are associated with high embodied energy and environmental pollution. Consequently, the search for sustainable alternatives has become a critical concern within the global construction industry. This study examines alternatives to traditional construction materials and evaluates their environmental impacts with particular attention to Nigeria and Jos metropolis in Plateau State. The study adopts an empirical approach using questionnaires, interviews, and secondary data obtained from professionals in the construction industry. The paper explores sustainable alternatives such as bamboo, recycled steel, fly ash bricks, rammed earth, low-carbon concrete, and recycled plastic products. Findings reveal that alternative construction materials significantly reduce carbon emissions, minimize waste generation, conserve natural resources, and improve environmental sustainability. However, challenges such as low awareness, poor policy implementation, inadequate technical knowledge, and high initial costs hinder widespread adoption in Nigeria. The study further reveals that Jos metropolis possesses substantial potential for sustainable material adoption due to the availability of local earth materials and increasing awareness of environmental conservation. The paper concludes that sustainable construction materials offer practical solutions for reducing environmental degradation while promoting resilient and affordable housing development. It recommends stronger environmental regulations, incentives for green construction practices, investment in research and development, and public awareness campaigns to encourage the transition from traditional to sustainable construction materials in Nigeria and other developing economies.

Keywords: Sustainable construction materials, Alternative building materials, Environmental impact, green building technology and Environmental sustainability

Introduction

The construction industry remains one of the largest consumers of natural resources globally and contributes significantly to environmental degradation through excessive energy consumption, carbon emissions, and waste generation. Ahmadu *et al.*, (2024) buttressed that rapid urbanization, industrialization, and population growth have increased global demand for housing and infrastructure, thereby intensifying the extraction and utilization of traditional construction materials such as cement, timber, steel, and sand. Conventional cement production alone contributes nearly 8% of global carbon dioxide emissions, while excessive timber harvesting has accelerated deforestation and biodiversity loss across many parts of the world. These environmental concerns have compelled governments, researchers, and environmental organizations to advocate for sustainable construction practices and alternative building materials that reduce ecological footprints while ensuring structural durability and economic efficiency.. Across Africa, the construction sector has experienced rapid expansion due to increasing urban population growth, infrastructural deficits, and economic development initiatives. However, the continent continues to rely heavily on traditional construction materials that are environmentally unsustainable and economically expensive. Unegbu *et al.*, (2024) have increasingly advocated for green cement, bamboo construction, recycled aggregates, and compressed earth technologies as alternatives capable of reducing environmental stress while improving affordable housing delivery. Sustainable construction is gradually gaining recognition within African urban planning and environmental management frameworks because of its potential to reduce climate vulnerability and promote resource conservation. In Nigeria, the demand for residential, commercial, and infrastructural development has risen significantly over the last two decades. This rapid growth has increased dependence on traditional materials such as concrete blocks, imported steel, and fired bricks, most of which are associated with high production costs and environmental degradation. Building collapse incidents, environmental pollution, and unsustainable mining activities have become pressing concerns within the Nigerian construction sector. Study by Marut *et al.*, (2024) on sustainable construction materials in Nigeria reveal increasing interest in bamboo, recycled steel, low-carbon concrete, and fly ash products due to their environmental and economic advantages. Nevertheless, adoption remains relatively low because of inadequate government policies, limited technical expertise, and poor awareness among construction stakeholders. Regionally, North-Central Nigeria has witnessed extensive environmental degradation associated with quarrying, mining, and extraction of construction aggregates. Plateau State in particular has experienced severe ecological disturbances resulting from decades of tin and columbite mining activities. These activities have altered landscapes, destroyed vegetation, polluted water bodies, and increased soil erosion across several communities. While the region possesses abundant natural stone and earth materials suitable for sustainable construction, unsustainable extraction methods continue to threaten environmental quality and public health. by Marut *et al.*, (2024) emphasize the need for environmentally responsible construction practices and the adoption of closed-loop construction systems capable of minimizing pollution and construction waste within the region. Jos metropolis represents one of the fastest-growing urban centers in Plateau State with increasing demand for housing, institutional buildings, and transportation infrastructure. The city relies heavily on conventional construction materials sourced through quarrying and

mining activities around its surrounding environments. This dependence has contributed to land degradation, dust pollution, and resource depletion within Jos and neighboring communities. However, Jos also possesses significant opportunities for sustainable construction because of the availability of local earth materials, granite deposits, bamboo potentials, and recyclable construction waste.

Oruonye *et al.*, (2024) highlighted the environmental and economic benefits of utilizing local alternative materials in reducing pollution and promoting sustainable urban development within Jos metropolis. Despite growing awareness of sustainable construction globally, many developing countries including Nigeria continue to face challenges in transitioning from traditional construction systems to environmentally friendly alternatives. Poor policy enforcement, inadequate investment in sustainable technologies, and limited professional training continue to hinder progress. Nevertheless, increasing environmental concerns, climate change impacts, and resource scarcity have reinforced the urgency of adopting sustainable alternatives capable of balancing infrastructural development with environmental conservation. Oruonye *et al.*, (2024) suggests that their adoption remains limited due to inadequate awareness, poor technical capacity, and weak policy implementation. Therefore, this study seeks to examine the alternatives to traditional construction materials and assess their environmental impacts with a view to promoting sustainable construction practices in Jos metropolis and Nigeria at large.

The aim of this study is to examine alternatives to traditional construction materials and evaluate their environmental impacts within the context of sustainable construction practices in Nigeria, with particular focus on Jos metropolis. The specific objectives are to:

- i. To assess the level of awareness and preference for Sustainable Construction Materials
- ii. Examine the environmental impacts of alternative construction materials.
- iii. Assess the Level of Adoption of Sustainable Construction Materials in Jos Metropolis
- iv. Identify Barriers to the Adoption of sustainable alternative Construction Materials.

Literature Review

Concept of Sustainable Construction Materials

Sustainable construction materials refer to environmentally responsible materials that minimize ecological damage throughout their life cycle, from extraction and production to usage and disposal. These materials are designed to reduce carbon emissions, conserve natural resources, and improve energy efficiency within the built environment. Ahmadu *et al.*, (2024) argued that sustainable construction materials are central to achieving global climate goals and sustainable urban development because of their capacity to reduce the environmental burden associated with conventional building systems. Researchers have identified several characteristics of sustainable construction materials including recyclability, durability, low embodied energy, renewability, and reduced environmental toxicity. Materials such as bamboo, rammed earth, recycled steel, and low-carbon concrete are increasingly recognized for their environmental

advantages compared to traditional cement and steel products. Studies further reveal that sustainable materials contribute significantly to indoor environmental quality, thermal efficiency, and reduced operational energy consumption in buildings. In Nigeria, awareness of sustainable construction materials has grown gradually due to increasing environmental concerns and rising construction costs

Alternative Construction Materials

Alternative construction materials are substitutes for conventional materials such as cement, steel, timber, and fired bricks. These alternatives are developed to improve environmental sustainability while maintaining structural efficiency and affordability. Common examples include fly ash bricks, hempcrete, recycled plastics, bamboo, compressed earth blocks, and recycled steel. Studies reveal that these materials significantly reduce environmental pollution and resource depletion associated with traditional construction systems. Bamboo has gained global recognition as a sustainable construction material due to its rapid growth rate, flexibility, and high tensile strength. Ahmadu *et al.*, (2024) argues that bamboo absorbs substantial amounts of carbon dioxide during growth and regenerates faster than timber, making it environmentally advantageous. Similarly, recycled steel reduces mining activities and minimizes industrial waste generation compared to virgin steel production. In Nigeria, alternative materials such as low-carbon concrete and earth-based construction technologies are increasingly promoted as cost-effective solutions for affordable housing delivery. Mba *et al.*, (2024) explained that these materials are particularly relevant in regions like Jos where natural earth and stone resources are abundant. Despite their advantages, widespread implementation remains limited because of cultural preferences for conventional materials and weak construction regulations.

Environmental Impacts of Traditional Construction Materials

Traditional construction materials have significant environmental impacts arising from extraction, processing, transportation, and disposal activities. Cement production releases substantial carbon dioxide emissions while quarrying operations destroy landscapes and ecosystems. Timber extraction contributes to deforestation, habitat destruction, and biodiversity loss, particularly in developing countries where environmental regulations are weak. Steel manufacturing is another major contributor to industrial pollution due to high energy consumption and greenhouse gas emissions. Mba *et al.*, (2024) revealed that traditional construction systems generate enormous construction waste, much of which ends up in landfills and contributes to environmental contamination. Additionally, unsustainable mining practices associated with aggregate production have intensified erosion and land degradation in many urban regions. In Jos metropolis, quarrying and mining activities linked to construction material extraction have resulted in severe environmental degradation including soil erosion, abandoned mining pits, dust pollution, and destruction of vegetation. Ahmadu *et al.*, (2024) believed that the growing awareness of climate change and environmental sustainability has encouraged some construction firms to adopt recycling and low-carbon production systems

Challenges of Adopting Sustainable Construction

Materials Despite the environmental advantages of sustainable construction materials, several challenges hinder their widespread adoption. One major challenge according Ahmadu *et al.*, (2024) is inadequate awareness among construction professionals and the general public regarding the benefits and applications of alternative materials. Many developers continue to perceive conventional materials as more durable and prestigious than sustainable alternatives. High initial costs, limited technical expertise, and absence of supportive government policies according to Marut *et al.*, (2024) also discourage the use of sustainable construction materials. In many developing countries, sustainable technologies are poorly integrated into construction curricula and professional training programs. Consequently, architects, engineers, and contractors often lack the skills required for sustainable construction implementation. In Jos metropolis, poor regulatory enforcement and insufficient institutional support further limit sustainable construction practices. Addressing these barriers is essential for achieving environmentally sustainable urban development within the region.

Methodology

This study adopted an empirical research design involving both quantitative and qualitative approaches to examine alternatives to traditional construction materials and their environmental impacts within Jos Metropolis, Plateau State, Nigeria. The design was considered appropriate because it enabled the collection of field-based data from construction professionals and environmental stakeholders regarding the awareness, adoption, and environmental implications of sustainable construction materials. The major instrument used for primary data collection was a structured questionnaire titled “Alternative Construction Materials and Environmental Impact Questionnaire (ACMEIQ)”. The questionnaire was divided into sections covering respondents’ demographic characteristics, awareness of sustainable construction materials, environmental impacts of traditional materials, level of adoption of alternative materials, barriers to implementation, and policy recommendations. The questionnaire was validated by experts in Environmental Management, Architecture, Building Technology. Their observations and corrections were incorporated into the final draft of the instrument before administration. To determine the reliability of the instrument, a pilot study was conducted using 20 respondents outside the main study area but with similar characteristics to the target population. The reliability of the questionnaire was tested using the Cronbach Alpha reliability method, which produced a reliability coefficient index of 0.84. This coefficient indicated that the instrument possessed high internal consistency and was therefore reliable for the study.

Secondary data used in the study were obtained from multiple scholarly and institutional sources including: Academic journals on sustainable construction and environmental management; Government publications from the Federal Ministry of Environment and Plateau State Environmental Protection and Sanitation Agency (PEPSA); Environmental reports from the United Nations Environment Programme (UNEP); Conference proceedings and technical reports on green building technologies; Textbooks, dissertations, theses, and internet-based scholarly materials related to sustainable construction materials and environmental

sustainability. These secondary materials provided theoretical, conceptual, and empirical foundations for the study.

The population of the study comprised construction and environmental stakeholders operating within Jos Metropolis. The target population included: Architects, Builders, Civil engineers, Quantity surveyors, Contractors, Environmental officers, Construction material suppliers, an Urban planning officials. The estimated study population was approximately 520 stakeholders obtained from professional associations, construction firms, and environmental agencies operating within Jos Metropolis. A sample size of 150 respondents was selected for the study using purposive and stratified sampling techniques. Purposive sampling was used to identify professionals directly involved in construction and environmental management, while stratified sampling ensured adequate representation of the various professional groups within the study area.

Primary data were collected through; Structured questionnaires, Oral interviews, and Field observations. Field observations were conducted around quarrying zones, construction sites, and mining environments within Jos metropolis to assess visible environmental impacts such as land degradation, dust pollution, excavation pits, and waste generation. Analytical Tools Used in the Study data collected from the field were analysed using both descriptive and inferential statistical tools. The analytical techniques included: Frequency distribution, Percentages, Mean score analysis, Pie Charts, Weighted Mean Analysis, and Thematic content analysis for qualitative responses obtained from interviews and observations. The Statistical Package for Social Sciences (SPSS Version 25) was used to organize and analyze quantitative data. The study adopted a 4-point Likert Scale for measuring respondents' opinions on issues relating to sustainable construction materials and environmental impacts. The response categories included: Strongly Agree (SA) = 4, Agree (A) = 3, Disagree (D) = 2, Strongly Disagree (SD) = 1 The decision rule was based on the criterion mean of: $\frac{4 + 3 + 2 + 1}{4} = 2.50$

Therefore: Any mean score of 2.50 and above was regarded as Accepted/Agreed. Any mean score below 2.50 was regarded as Rejected/Disagreed. The analytical procedures adopted were appropriate because they enabled effective interpretation of stakeholder perceptions and environmental realities associated with sustainable construction practices in Jos Metropolis.

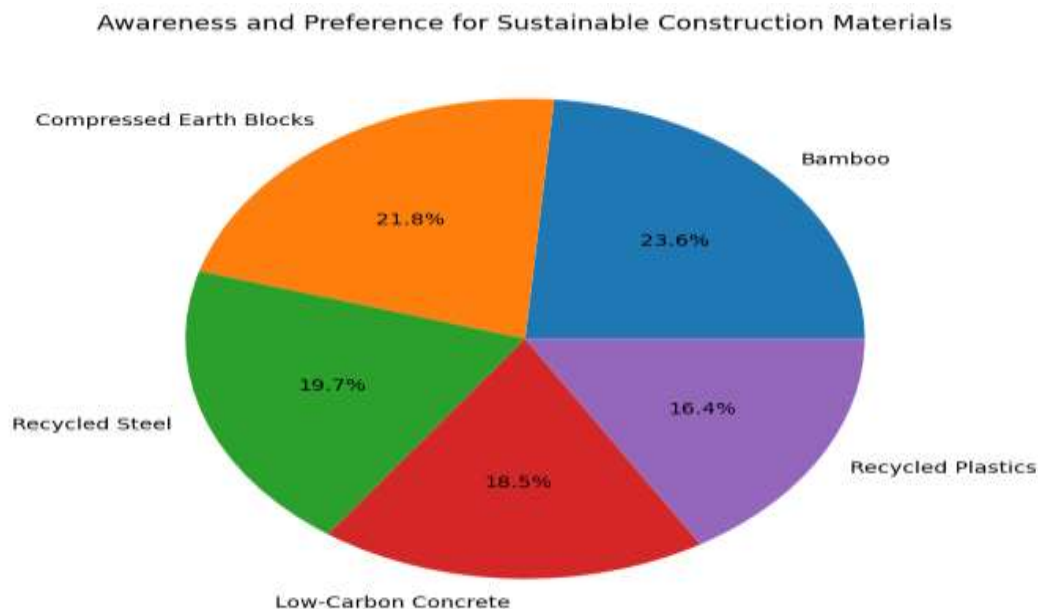
Results and Discussion

The empirical findings obtained from questionnaires, interviews, and field observations reveal significant trends regarding the adoption of sustainable construction materials and their environmental implications within Jos metropolis. The results indicate growing awareness among construction professionals concerning the environmental dangers associated with traditional construction materials such as cement, steel, and fired clay bricks. Respondents acknowledged that unsustainable quarrying, mining, and cement production contribute significantly to environmental degradation, particularly through land destruction, air pollution, greenhouse gas emissions, and waste generation.

Objective 1: Identify Major Alternatives to Traditional Construction Materials Used in Sustainable Construction

The study examined respondents' awareness and preference for alternative construction materials within Jos Metropolis. Findings revealed that bamboo, compressed earth blocks, recycled steel, low-carbon concrete, and recycled plastics were the most recognized sustainable alternatives among construction professionals and environmental stakeholders.

Pie Chart 1: Awareness and Preference for Sustainable Construction Materials

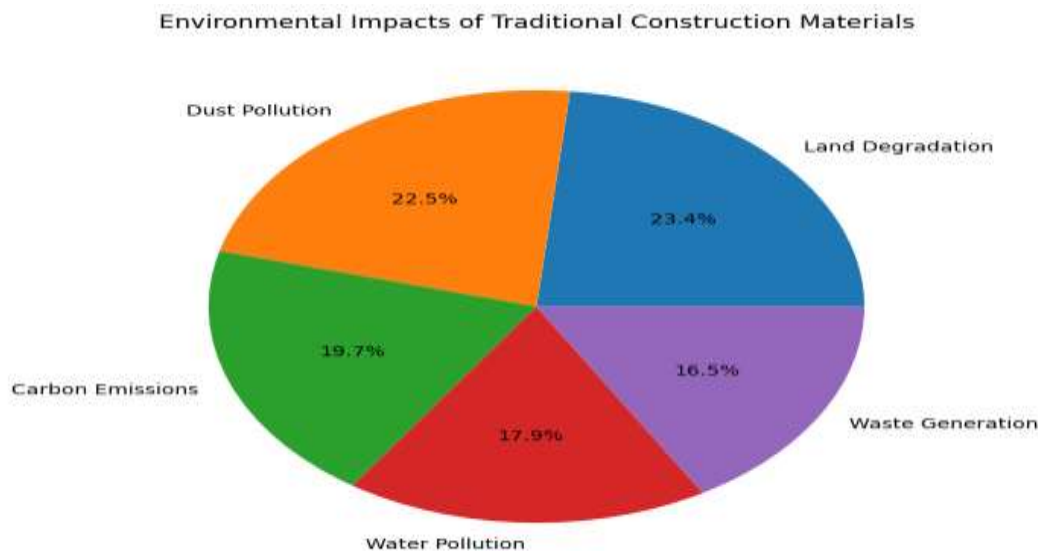


The findings indicate that bamboo recorded the highest level of awareness and preference among respondents with 23.6%, followed by compressed earth blocks at 21.8%. Respondents attributed the growing acceptance of bamboo to its affordability, local availability, flexibility, and environmental friendliness. Compressed earth blocks were also considered suitable because of their thermal efficiency and low embodied energy requirements. Field observations further revealed increasing use of earth-based materials in low-cost housing projects around Bukuru and Rayfield areas of Jos metropolis. Respondents noted that recycled steel and low-carbon concrete possess substantial environmental advantages compared to conventional steel and cement products because they reduce industrial waste and greenhouse gas emissions. However, the relatively lower acceptance of recycled plastics indicates that many stakeholders still possess limited technical knowledge regarding innovative sustainable construction technologies. The findings align with global studies emphasizing the importance of renewable and recyclable materials in achieving sustainable urban development. The results also support previous research which identified bamboo and earth-based technologies as viable sustainable construction materials within developing countries due to their affordability and adaptability to local environmental conditions.

Objective 2: Examine the Environmental Impacts of Alternative Construction Materials

The study assessed respondents' perceptions regarding the environmental impacts associated with traditional construction materials and the environmental benefits of sustainable alternatives.

Pie Chart 2: Environmental Impacts of Traditional Construction Materials

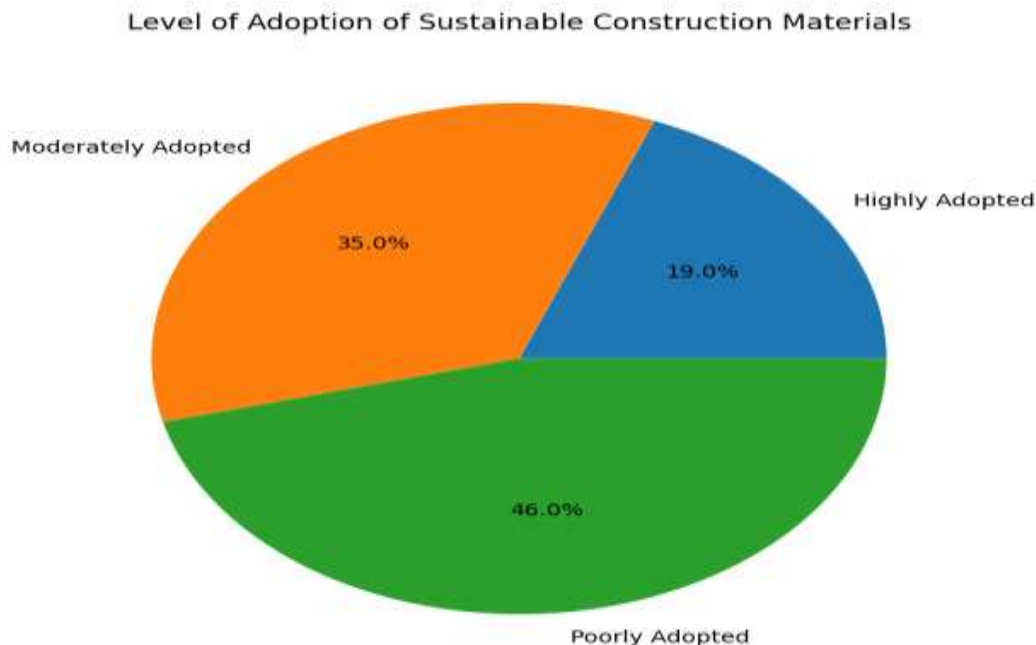


The findings revealed that land degradation constituted the most severe environmental problem associated with traditional construction materials, as indicated by 23.4% of respondents. Quarrying and mining activities around Jos metropolis were identified as major contributors to soil erosion, vegetation destruction, and landscape alteration. Field observations confirmed the existence of abandoned mining pits, degraded surfaces, and exposed rock formations around quarrying zones in Kuru and Farin Gada. Dust pollution ranked second with 22.5% of respondents acknowledging that quarrying, cement handling, and transportation activities contribute significantly to air pollution and respiratory health challenges. Carbon emissions associated with cement production and heavy industrial processes were also identified as major environmental concerns. Respondents emphasized that conventional cement manufacturing contributes substantially to greenhouse gas emissions and climate change. The findings further revealed that alternative construction materials such as bamboo, recycled steel, and compressed earth blocks possess lower environmental impacts because they reduce resource extraction, minimize waste generation, and conserve energy during production processes. These results correspond with previous studies which argued that sustainable construction materials are essential for reducing ecological footprints and enhancing climate resilience within urban environments. The study therefore demonstrates that sustainable alternatives can significantly reduce environmental degradation associated with conventional construction systems if properly integrated into urban planning and building policies.

Objective 3: Assess the Level of Adoption of Sustainable Construction Materials in Jos Metropolis

The study evaluated the extent to which sustainable construction materials are currently utilized within the construction industry in Jos metropolis

Pie Chart 3: Sustainable Construction Materials

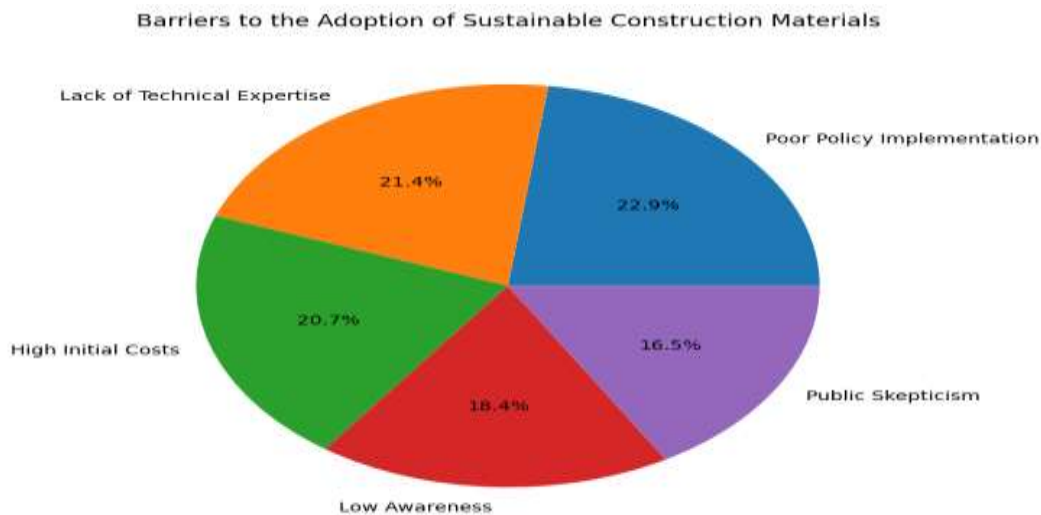


The results indicate that sustainable construction materials remain poorly adopted within Jos metropolis, with 46% of respondents indicating low implementation levels across the construction industry. Only 19% of respondents believed that sustainable materials are highly adopted in construction projects. Respondents attributed the low adoption rate to preference for conventional materials such as cement blocks and reinforced concrete, which are widely perceived as more durable and socially prestigious. Interviews conducted with contractors and developers revealed that many clients remain skeptical regarding the structural performance and durability of alternative construction materials despite their environmental benefits. Field observations further showed that sustainable construction practices are mostly limited to experimental residential projects and academic demonstrations rather than mainstream commercial developments. Nevertheless, the study observed gradual improvement in awareness among younger architects, engineers, and environmental professionals who increasingly advocate for environmentally responsible building systems. The findings suggest that although awareness of sustainable materials is increasing, practical implementation remains limited due to socio-cultural perceptions, market structures, and inadequate institutional support. This supports previous studies which emphasized that developing countries often experience slow transitions toward sustainable construction because of technological and policy-related constraints.

Objective 4 : Identify Barriers Associated with the Use of Alternative Construction Materials

The study investigated the major challenges affecting the adoption of sustainable construction materials within Jos metropolis.

Pie Chart 4: Barriers to the Adoption of sustainable Construction Materials



The findings revealed that poor policy implementation represents the most significant barrier affecting sustainable construction material adoption, as identified by 22.9% of respondents. Respondents argued that government agencies have failed to enforce environmental standards capable of encouraging sustainable construction practices. Existing building regulations were considered weak and poorly monitored. Lack of technical expertise also emerged as a major challenge with 21.4% of respondents emphasizing that many professionals lack adequate training in sustainable construction technologies. Architects, builders, and contractors indicated limited exposure to practical applications of alternative materials during professional training and construction practice. High initial costs associated with sustainable technologies were equally identified as major constraints limiting implementation. Although respondents acknowledged the long-term economic and environmental benefits of sustainable materials, many developers were discouraged by the perceived high installation and experimentation costs. Low public awareness and skepticism regarding durability and safety of alternative materials also hinder wider acceptance. Many residents and developers continue to associate sustainable materials with inferior quality and temporary structures. These findings reveal that socio-cultural perceptions, institutional weaknesses, and economic limitations collectively affect sustainable construction transitions within Jos metropolis. The findings align with previous studies which identified poor environmental governance, inadequate technological development, and limited awareness as major barriers affecting sustainable construction implementation in developing countries.

Discussion of Findings

Overall, the findings demonstrate that sustainable construction materials possess substantial environmental and socio-economic advantages capable of reducing ecological degradation associated with conventional construction systems. The study established that bamboo, compressed earth blocks, recycled steel, and low-carbon concrete represent practical alternatives for promoting environmentally sustainable urban development within Jos metropolis. The research further revealed that traditional construction materials contribute significantly to land degradation, dust pollution, greenhouse gas emissions, and resource depletion. Field observations confirmed that quarrying and mining activities associated with conventional construction materials continue to degrade landscapes and expose communities to environmental hazards within Jos metropolis. Despite increasing awareness of sustainable construction practices, adoption remains relatively low because of poor policy implementation, limited technical expertise, public skepticism, and inadequate institutional support. The findings therefore emphasize the urgent need for stronger environmental regulations, public sensitization, professional training, and investment in green technologies. The study concludes that effective integration of sustainable construction materials into urban planning and infrastructural development would significantly improve environmental sustainability, reduce climate-related risks, and promote resilient urban growth within Jos metropolis and Nigeria generally.

Conclusion

This study examined alternatives to traditional construction materials and their environmental impacts with particular focus on Jos metropolis, Plateau State, Nigeria. The study established that traditional construction materials such as cement, steel, timber, and fired bricks significantly contribute to environmental degradation through carbon emissions, deforestation, mining, and waste generation. The research further identified bamboo, recycled steel, compressed earth blocks, low-carbon concrete, and recycled plastics as major sustainable alternatives capable of reducing environmental impacts within the construction sector. The empirical findings revealed that sustainable construction materials possess substantial environmental, economic, and social benefits including reduced greenhouse gas emissions, improved resource conservation, waste reduction, and enhanced affordability of housing development. However, the study also established that sustainable material adoption in Jos metropolis remains relatively low due to poor awareness, weak policy implementation, limited technical expertise, and inadequate institutional support. These challenges continue to reinforce dependence on environmentally harmful conventional construction systems. The study concludes that sustainable construction materials represent viable alternatives for promoting environmentally responsible urban development in Nigeria. Adoption of sustainable materials and circular construction practices would significantly reduce ecological degradation associated with traditional construction activities in Jos metropolis and beyond. Therefore, integrating sustainable construction policies into urban planning and infrastructural development is essential for achieving environmental sustainability and climate resilience in Nigeria.

Recommendations

Government at federal, state, and local levels should formulate and enforce comprehensive policies promoting sustainable construction practices within Nigeria. Environmental regulations should encourage the use of low-carbon construction materials while discouraging environmentally harmful extraction activities such as indiscriminate quarrying and deforestation. Incentives including tax reductions, subsidies, and grants should also be provided to construction firms adopting sustainable materials and recycling technologies. Educational institutions, professional bodies, and research organizations should intensify research and training on sustainable construction materials and technologies. Universities and polytechnics should incorporate sustainable construction studies into architecture, engineering, and building technology curricula to improve technical expertise within the industry. Public enlightenment campaigns according to Lazarus *et.al.*, (2026) should also be organized to increase awareness regarding the environmental and economic benefits of sustainable construction materials. Furthermore, local governments and environmental agencies in Plateau State should promote the utilization of locally available sustainable materials such as bamboo, rammed earth, and recycled aggregates within housing and infrastructural projects. Sustainable urban planning strategies including closed-loop construction systems, recycling programs, and environmentally responsible mining practices should be encouraged within Jos metropolis. Effective collaboration between government agencies, private developers, and environmental stakeholders is necessary for achieving sustainable construction and environmental protection in Nigeria.

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