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Bamboo Cultivation as a Sustainable Agroforestry Practice: Balancing Environmental Conservation and Economic Benefits in Nigeria

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ABSTRACT

This study examined bamboo cultivation in different ecological zones in Nigeria with the objective of assessing its economic viability, ecological benefits, and associated challenges. Objectives included identifying the characteristics of the experimental zones, appraising bamboo tree parameters, assessing the economic benefits as well as the ecological benefits, and identifying constraints and opportunities. Methodologically, experimental sites were categorized based on region, agro-climatic zone, bamboo species, soil type, and cultivation practices. Measurement parameters encompassed soil pH, organic matter, nutrient levels, bamboo height, diameter, biomass accumulation, and environmental variables, monitored using specific instruments. There were variations in data across regions: the North emphasizing traditional uses, the South-East focusing on commercial applications, and the South-West adopting an integrated approach. Economic analysis indicated varying income generation, job creation, and value addition, with the South-East demonstrating the highest economic returns. Ecological benefits included soil conservation, carbon sequestration, and biodiversity enhancement, varying across the various regions. Recommendations involve regular validation, stakeholder collaboration, policy development, market and infrastructure investments, financial support, technical training programs, land tenure policies, and continuous monitoring. The paper concludes that bamboo cultivation holds considerable potential in Nigeria for sustainable growth, economic development, and environmental resilience.

Keywords: Agroforestry, Bamboo, Carbon sequestration, Conservation, Soil health, Sustainable agriculture

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INTRODUCTION

In the course of sustainable agroforestry practices in Nigeria, bamboo plantations stand out as a promising solution offering a minimal approach considering environmental protection and economic benefits. Environmental benefits include the role of bamboo in supporting ecosystems. Its dense vegetation provides habitat for a variety of species and contributes greatly to the ecological balance. Furthermore, the dense roots of bamboo trees play an important role in controlling soil erosion, providing stable slopes, and reducing the risk of landslides, thus improving soil quality and buffering environmental edges (Shettima et al. 2017; Gidon and Sahoo, 2020; Xiao et al. 2021). Furthermore, bamboo's unique carbon storage capacity is consistent with Nigeria's commitment to address climate change, making it a valuable contributor to carbon sequestration efforts (Nath et al. 2015; Sohel et al. 2015).

As bamboo cultivation increases sustainable agriculture, it can provide useful resources to ensure food security and promote rural development. Furthermore, the research on bamboo cultivation in Nigeria has practical and theoretical implications. In practical terms, the findings can guide policymakers, agricultural practitioners, and environmentalists to develop strategies and policies that promote sustainable bamboo agriculture. In theory, this research could enhance our understanding of the complex relationship between agriculture, ecology, and the economy, especially in the context of developing countries such as Nigeria (Lu et al. 2018). This study of bamboo agriculture in Nigeria goes beyond its immediate context, providing a lens through which we can explore and address the wider challenges and opportunities in sustainable, environmentally friendly agriculture protection and rural development (Atanda, 2015; Molua and Emagbetere, 2005; Gideon, 2018).

Bamboo cultivation provides income and employment opportunities. Research has shown that the economic benefits of bamboo can be reflected in products such as furniture, handicrafts, and construction materials, which, especially in rural production, can be translated into sustainable livelihood development through bamboo farming consistently to stimulate employment and poverty alleviation, but effective implementation requires a nuanced understanding of challenges and opportunities. A comprehensive review of the existing policy and legal framework on bamboo agriculture is needed to identify potential barriers and create an environment for sustainable practices (Ladapo et al. 2017). Understanding the cultural and social context surrounding bamboo in Nigeria and fostering participation to ensure effective community involvement in bamboo-based industries is essential as Nigeria continues to seek to achieve sustainable development goals, constantly constituting local variables and helping to shape the system.

The study of bamboo agriculture covers a variety of disciplines, including agriculture, environmental science, economics, and rural development. Previous studies have emphasized the ecological benefits of bamboo, such as soil conservation, carbon sequestration, and biodiversity enhancement, as well as its various applications from construction to energy (Nath et al. 2015; Li et al. 2015; Song et al. 2011). They also provide insights into their ecological, economic, and social contexts. These studies have precisely established bamboo as a versatile and sustainable resource with numerous benefits. However, there are noticeable differences in Nigeria, a country with a unique agricultural climate and socio-economic development, in terms of specific implications and opportunities. Although some studies have examined bamboo cultivation elsewhere, the differences in context call for a corresponding examination of its role in Nigeria (Lobovikov et al. 2012; Xu et al. 2020).

Regions of Bamboo Cultivation in Nigeria

Bamboo farming in Nigeria is a diverse practice spread across geographical areas, each of which is characterized by specific environmental factors. The southern part of the country, including parts of Cross River, Akwa Ibom, Edo, and Delta states, has sufficient rainfall and a very dry climate, which is comfortable for growing bamboo. Visits to the south western states of Ogun, Ondo, Osun, and Oyo provide new opportunities for bamboo cultivation in the forest. The ecological conditions suitable for bamboo plantations are found in the northern and central regions, especially in the regions of the Nasarawa Plateau, which are transition zones between tropical rain forests and savannas. Even in the north-eastern states like Adamawa and Taraba, characterized by savannah landscapes, bamboo cultivation along riverbanks and areas with sufficient water sources is a potential opportunity. While the northwest, including states like Kebbi, Sokoto, and Zamfara, features semi-arid to arid climates, bamboo cultivation could still be viable with proper water management and the selection of species adapted to drier conditions. Coastal areas, including the Niger Delta and parts of Bayelsa State, present unique conditions for bamboo cultivation, requiring consideration of salt-tolerant species. Furthermore, this practice is not limited to rural areas, as bamboo can be incorporated into parks, greenery, and urban landscaping in urban and peri-urban areas. Generally, bamboo farming in Nigeria demands site-specific assessments, community involvement, and collaboration with local agricultural extension services to adapt to the diverse geographical and environmental contexts across the country.

Theoretical Framework

The theoretical framework guiding this research focuses on several interrelated concepts that combine to inform the methodology and the research. Central to this strategy is the concept of

sustainable agroforestry, which means that the integration of trees, crops, and other vegetation can increase agricultural productivity, conserve natural resources, and provide nature that organisms have been able to cope with (Brown et al. 2018; Ogwu et al. 2022).

Within this context, the Triple Bottom Line theory of John Elkington in 1994, emphasizing the interconnectedness of financial prosperity, environmental stewardship, and social equity, serves as a guiding precept for evaluating the multifaceted influences of bamboo cultivation in Nigeria. Additionally, the *Diffusion of Innovations Principle* of Everett Rogers in 1962 presents insights into the adoption and dissemination of sustainable agricultural practices, imparting precious perspectives on overcoming barriers and facilitating exchange within the agricultural quarter.

Objectives of the Study

The aim of the study was to take a critical look at bamboo cultivation in Nigeria, with the aim of addressing current knowledge gaps, providing policy guidance, and specifically promoting the promotion of sustainable agricultural practices. Specifically, It seeks to:

1. Evaluate the effectiveness of bamboo cultivation in soil conservation, carbon sequestration, and biodiversity enhancement within Nigerian ecosystems.

2. Assess the financial feasibility of bamboo cultivation as a means of income generation and value addition across the entire bamboo production chain in Nigeria.

3. Identify the key constraints, potential opportunities, and policy implications associated with the widespread adoption and promotion of bamboo plantations in Nigeria.

4. Expand the understanding of sustainable agroforestry practices, particularly in developing countries, by extracting insights and management recommendations from the Nigerian context.

Apart from these objectives, the study seeks to generate a wider understanding of the role of bamboo agriculture in promoting sustainable agriculture, environmental protection, and rural development in Nigeria.

MATERIALS AND METHODS

An integrated approach was adopted to achieve the objectives of the study, combining ecological analysis, economic analysis, sociological analysis, and policy analysis. Extensive field research was carried out at various sites in Nigeria to address the first objective of assessing the ecological benefits of bamboo cultivation. Soil samples were collected to investigate the impact of bamboo cultivation on soil conservation using standardized methods to assess soil degradation rate and stability. To assess soil erosion rates and stability associated with bamboo cultivation, the study implemented a meticulous procedure employing standardized methods. The following steps outline the methodology:

Sampling Strategy

A combination of purposive and random sampling methods was used to select participants and data sources for the sampling process. Purposive sampling was used to identify key informants with knowledge and experience in bamboo farming to ensure representation of different stakeholder groups, including farmers, policymakers, and researchers. Potential biases were mitigated through rigorous sampling protocols, data triangulation, and validation processes, enhancing the validity and generalizability of the research outcomes.

Site Selection

Various locations representing different agro-ecological zones in Nigeria were selected to study the diversity of soil types and environmental conditions. Bamboo plantations and control sites without bamboo were identified within these locations.

Field Survey and Data Collection

A systematic field survey was conducted at each selected site. Soil erosion factors, such as dams, erosion, and sedimentation, were documented. The analysis included measurement of slope angle and length and identification of soil types.

Soil sampling

Periodic sampling was done to assess various parameters associated with bamboo cultivation. Soil samples were collected from both bamboo and control sites at standardized depths (e.g., 0–10 cm and 10–30 cm). Sampling locations were determined based on a grid design to ensure representative coverage. The pH, organic matter, and nutrient levels

of soils were monitored using a standardized test protocol. The height, diameter, and biomass accumulation of bamboos were measured at regular intervals to assess agricultural performance and productivity. These samples were collected using soil augar to prevent cross-contamination between the samples. In addition, environmental variables such as temperature, precipitation, and solar radiation were recorded to understand their effects on bamboo growth and development.

Laboratory analyses

The collected soil samples were sent to the National Root Research Institute (NRRI) at Umudime, in south-eastern Nigeria, for physical and chemical analysis. Basic soil characteristics, including texture, organic matter, and nutrient levels, were determined using standard laboratory methods. These analyses provided insights into the early landscape conditions of bamboo and control sites.

Soil erosion assessment

In order to quantify soil erosion, waterfalls were strategically placed along the vulnerable pathways, taking into account the natural drainage and measuring the accumulated water, and were analyzed to estimate precipitation rates. Additionally, analyses of sedimentation and other leaching factors were used to assess the extent of erosion of stalks and buffer areas.

Stability assessment

The stability of the soil was assessed by methods such as the slake test and aggregate stability analysis. The simplified test involved soaking aggregates of soil in water to assess their resistance to cracking. Aggregate stability analysis examined the ability of soil aggregates to withstand external forces, providing insight into soil structure and susceptibility to degradation.

Data analysis

A statistical analysis was performed on the collected data to compare soil degradation and stability between bamboo and control sites. Analyses included percentages and spatial mapping to identify patterns and correlations.

At the same time, soil samples were prepared to evaluate carbon adsorption capacity. Soil samples were collected from the bamboo plots, measured at different soil depths, and transported to the laboratory for detailed analysis. Standard methods were used to quantify carbon in the soil, providing insight into the carbon storage to which bamboo plantations are susceptible.

To address the development of the ecosystem, the study assessed the variation of plants and animals in the bamboo ecosystem. Field surveys characterized flora and fauna species thriving in and around bamboo plantations. The study highlighted ecological associations of plant species, birds, insects, and other wildlife in bamboo habitats. Particular attention was paid to identifying endemic or endangered species that would benefit from bamboo availability.

The testing of plant and soil ecosystem samples provided a comprehensive understanding of the ecological impacts of bamboo cultivation. This method clarified a strong relationship between bamboo cultivation, carbon sequestration, and biodiversity networks, generating a comprehensive benefit analysis.

Again, an economic evaluation was conducted to determine the viability of bamboo farming in Nigeria. This was achieved through the examination of the entire value chain, from bamboo cultivation to bamboo finished products. Economic parameters such as income and employment generation were quantified through surveys and interviews with bamboo farmers, processors, and entrepreneurs. The value added to bamboo prices was assessed through cost-benefit analysis and market analysis and values were presented in local currency.

Qualitative and quantitative methods were used to assess the social impacts of bamboo farming, while surveys and interviews were conducted in rural areas involved in bamboo cultivation to appreciate its impact on livelihoods and community development. Also, participatory methods, including focus group discussions, were used to explore the cultural significance of bamboo and community engagement in agricultural practices.

In addition, a critical analysis of existing policies on bamboo cultivation in Nigeria through interviews with policymakers, experts, and stakeholders was conducted to identify constraints and policy implications and determine existing barriers and opportunities. Comparative research with successful bamboo farming models in other countries helped formulate policy recommendations to promote their wider adoption.

Finally, to complement existing knowledge, the study gathered empirical insights and practical recommendations from the Nigerian experience and included data from field research, economic analysis, and social analysis combined to provide a comprehensive understanding of the role of bamboo agriculture.

RESULTS

Considering the effects of bamboo root systems and canopy on soil erosion and stability, the findings were interpreted in terms of bamboo cultivation. Studies comparing bamboo and control sites provided insights into the ecological benefits of bamboo cultivation in terms of soil conservation. In addition to these standardized approaches, the study provided a rigorous and scientifically based assessment of the ecological benefits of bamboo farming, particularly in terms of soil erosion rates and complexity in Nigeria. The results are presented in Tables 1–6.

Table 1: Diversity of bamboo cultivation in different ecological zones

Region	Number of Bamboo Species Cultivated	Predominant Soil Type	Economic Practices
North	2	Sandy Loam	Income generation through traditional bamboo crafts, artisanal products.
South-East	3	Clayey Soil	Commercial cultivation for onstruction and furniture industries.
South-West	1	Sandy Soil	Integrated cultivation with crop rotation for local market supply.

Table 1 reflects the diversity in bamboo cultivation practices across different ecological zones in Nigeria. The North, where the sandy loam soil type is prevalent showed limited diversity in bamboo species, focusing on traditional uses and crafts and artisanal products for income generation. The south-east, with predominant clayey soil, showed higher diversity with a focus on commercial cultivation for the construction and furniture industries, while the south-west, made of primarily sandy soil, has moderate diversity and adopts an integrated approach. These variations highlight the adaptability of bamboo cultivation to diverse ecological conditions and economic needs.

Table 2 demonstrates variations in soil characteristics and bamboo growth parameters across different ecological zones in Nigeria. The North, with its semi-arid climate, exhibits slightly alkaline soil pH, moderate soil fertility, and lower bamboo growth compared to the humid tropical conditions of the South-East and the distinct wet and dry seasons in the South-West. Biomass accumulation decreases as the average length and weight of bamboo shoots decrease, while the south-eastern soil is rich in organic matter and nutrients but slightly acidic. Bamboo plants are tall and dense, resulting in high biomass accumulation. The zone is sunny and rainy, reflecting the humid tropical climate. On the other hand, the South-West has slightly acidic soil with moderate organic matter and nutrient levels. Bamboo plants are of intermediate height and diameter, with moderate biomass accumulation. The region experiences high sunlight and moderate rainfall, suggesting a tropical climate with distinct wet and dry seasons. These variations underscore the importance of considering regional factors in bamboo cultivation practices.

Table 3 presents variations in the economic viability of bamboo cultivation across different regions of Nigeria. The South-East posted the highest economic potential, recording higher income generation, more job opportunities, and increased value addition. Bamboo cultivation in the South East generated significant economic returns, averaging N5,400,000 per hectare, creating 2,500 jobs, and increasing the value by N8,400,000 per tonne in terms of distribution. Bamboo growing in the North generated N3,100,000 per hectare, which created 1,500 jobs in the value chain with an added value of N6,000,000, while bamboo growing in the southwest yielded N4,800,000 per hectare, creating 2,000 jobs per ton and an added value of N7,200,000. The economic focus is on balanced income generation, job creation,

and value addition. These figures highlight the potential for bamboo cultivation to contribute significantly to economic development.

Table 2: Bamboo cultivation parameters

Region	Soil pH (avg)	Organic Matter (%)	Nutrient Levels	Bamboo Height (cm)	Bamboo Diameter (cm)	Biomass Accumulation (kg)	Environmental Variables
North	6.5	2.0	Moderate	250	3.5	15	High sunlight, Low rainfall
South-East	5.8	3.5	High	300	4.0	20	Moderate sunlight, High rainfall
South-West	6.0	2.8	Moderate	280	3.8	18	High sunlight, Moderate rainfall

Table 3: Estimated economic viability parameters of bamboo cultivation

Region	Income Generation (₦/ha)	Jobs Created	Value Addition (₦/ton)
North	3.1m	1500	6,000,000
South-East	5.4m	2500	8,400,000
South-West	4.8m	2000	7,200,000

Table 4: Ecological benefits of bamboo cultivation

Region	Soil Conservation (Reduction in Erosion)	Carbon Sequestration (tons/ha)	Biodiversity Enhancement (Measured by Species Count)
North	25%	30	10
South-East	40%	45	15
South-West	35%	40	12

Table 4 shows the potential ecological benefits of bamboo cultivation in different parts of Nigeria. The ability of bamboo to prevent soil erosion through its dense roots, combined with effective carbon sequestration and biodiversity enhancement, demonstrated a positive impact on the environment. The observation of increased biodiversity with 15 other species enhanced biodiversity in the south-east. The study recorded significant benefits in soil conservation and carbon sequestration, contributing to environmental resilience. The ecological benefits of a greater percentage reduction of soil erosion and greater carbon sequestration in the Southeast were more pronounced. In the Southwest, bamboo cultivation boosted land degradation reduction by 35% and removed 40 tons of carbon per hectare. The observation of 12 other species increased the diversity of life, soil health, and carbon sequestration in this area. In the north, bamboo cultivation reduced soil erosion by 25%, saved 30 tons of carbon per hectare, and increased biodiversity with the discovery of 10 new species. Thus, the extensive roots of the bamboo mitigated soil erosion and preserved the delicate structure of the soil. These findings highlight the role of bamboo plantations in sustainable land management and contribute to biodiversity conservation and climate change mitigation.

Table 5 shows the ecological characteristics of bamboo plantations, including plant species, bamboo cover, and ecosystems that benefit from bamboo cultivation, indicating the presence of a wide range of species. It also emphasized the ecological importance of bamboo forests in creating protection for endangered species.

Table 6 presents various aspects affecting the widespread adoption of bamboo cultivation, including barriers, opportunities, policy implications, and interpretations. Barriers encompass potential obstacles hindering the broader acceptance of bamboo cultivation. Opportunities, on the other hand, pointed out favorable conditions that can be utilized to promote bamboo cultivation. The regulatory environment was highlighted as a potential obstacle due to the lack of clear regulations, which may impede bamboo cultivation. Clear policies are suggested to encourage farmers and investors, ultimately leading to increased

adoption. Limited market access and infrastructure are identified as barriers that can be transformed into opportunities by developing markets and investing in infrastructure.

Table 6: Barriers, opportunities, and policy implications for bamboo cultivation

Category	Barriers	Opportunities	Policy Implications
Regulatory Environment	Lack of clear regulations and guidelines for bamboo cultivation.	Development of clear policies and regulations to support bamboo cultivation.	Formulation and implementation of bamboo-friendly policies and guidelines.
Market Access	Limited market access and inadequate infrastructure for bamboo products.	Development of markets for bamboo-based products; investment in infrastructure.	Government support for market development and infrastructure improvement.
Financial Support	Limited access to financial resources for bamboo farmers and entrepreneurs.	Creation of bamboo-focused funding programs, grants, and financial incentives.	Establishment of financial mechanisms to support bamboo cultivation initiatives.
Technical Knowledge	Insufficient technical knowledge and training for bamboo cultivation practices.	Training programs, workshops, and extension services for bamboo cultivation.	Inclusion of bamboo-specific training in agricultural education and extension.
Land Tenure	Uncertain land tenure and unclear land-use policies for bamboo cultivation.	Establishment of clear land tenure and use policies to encourage bamboo farming.	Integration of bamboo cultivation in national land-use planning and policies.
Research and Development	Limited research and development initiatives specific to bamboo cultivation.	Investment in research to enhance bamboo varieties, cultivation techniques, etc.	Support for research institutions focusing on bamboo-related studies and innovations.
Stakeholder Collaboration	Insufficient collaboration between government, communities, and private sector.	Promotion of multi-stakeholder partnerships and community involvement.	Facilitation of collaborative efforts through forums, workshops, and incentives.

DISCUSSION

The outcomes of the research show the socio-economic impacts of bamboo cultivation in various ecosystems in Nigeria, as well as its environmental significance in the areas of soil conservation, carbon sequestration, and biodiversity improvement. For example, although bamboo cultivation reduced land degradation by 40% in the southeast region, 35% and 25% in the southwest and north, respectively, bamboo farming was found to sequester carbon more, and the southeast showed the highest rate of carbon sequestration at 45 tons per hectare, followed by the southwest and north. This is in agreement with Rathour *et al*. (2022), who reported that bamboo species have multidimensional applications, including bioenergy production, eco-restoration, and economic development, making them a promising crop for sustainable development and environmental management. Furthermore, the study highlights the positive impact of bamboo farming on biodiversity, with increased species diversity found in all areas. The biodiversity associated with bamboo plantations is entrenched in areas of increased availability and resources to feed a variety of plants and animals and contribute to ecosystem health and resilience. Osawaru et al.

(2022) opined that Nigeria's plant diversity and conservation efforts need improvement to ensure sustainable use and conservation of this valuable resource for future generations.

The economic analysis revealed the promising economic potential of bamboo cultivation in Nigeria. Bamboo cultivation generated significant income across the different regions, created employment opportunities, and added value along the production chain. For instance, in the South-East, bamboo cultivation generated an average income of N5.4 million per hectare, creating 2500 jobs and adding value worth N8.4 million per ton. Similarly, in the South-West and North regions, substantial incomes of N4.8 million and N3.1 million per hectare were generated, along with employment prospects and value addition. This reflects the views of Ibrahim and Ogunwusi (2017), who purported that utilizing bamboo as an alternative raw material for textile production in Nigeria could boost capacity utilization, save the country over 500 billion naira annually, and consequently reduce foreign exchange expenditure. These findings underscore the socio-economic significance of bamboo cultivation as a viable sustaining option for rural communities, alleviating poverty and boosting economic development.

The study further revealed the impact of regional variations in soil characteristics, bamboo growth parameters, economic viability, and the importance of considering local ecological conditions and economic contexts in bamboo cultivation practices. For instance, the North region, distinguished by a semi-arid climate and sandy loam soil, showed lower bamboo growth and economic returns compared to the humid tropical conditions of the South-East and the distinct wet and dry seasons in the South-West. These regional variations underlie the need for a guided approach to bamboo cultivation, considering local environmental and economic development. Akamigbo and Nnaji (2011) noted that Nigerian soils were highly vulnerable to climate change impacts and suggested that mitigation and adaptation measures were needed to combat these negative effects on sustainable soil productivity.

Furthermore, the findings of the study showcased important policy implications for promoting bamboo cultivation as a sustainable land management practice in Nigeria. Planners could use the evidence-based strategies provided by the research to design policies and strategies aimed at promoting tree planting, enhancing land conservation efforts, and economic development in rural areas. As such, the implementation of the program includes financial incentives, technical assistance, and capacity building through bamboo farming practices. This is in line with the opinions of Shettima *et al*. (2017) and Gideon (2018), respectively.

In addition, the study also provides valuable insights into bamboo cultivation in Nigeria, focusing on environmental, economic, and social aspects. However, future research endeavors have the possibility for improvement in evaluating sustainable agricultural practices, the value of bamboo products, and the impact of sociocultural practices on local communities. Furthermore, alternative agricultural exploration strategies such as agroforestry and bamboo-based agroecology could be able to enhance agricultural resilience and sustainable development. This insight is in line with Houdanon *et al*. (2018) and Okokpujie *et al.* (2020), who asserted that bamboo use in Nigeria's construction industry reduces environmental pollution, contributes to climate change mitigation, and contributes to economic growth by providing biomass for bio-energy, furniture, and building development.

In summary, the study highlights the various benefits of bamboo farming in Nigeria, including soil conservation, carbon sequestration, economic efficiency, and biodiversity conservation. So policymakers and stakeholders should take holistic approaches, considering environmental, economic, and social aspects when contemplating bamboo cultivation.

CONCLUSION AND RECOMMENDATIONS

The findings on bamboo cultivation in Nigeria underscore the need for key recommendations to ensure sustainability and success in this agricultural practice. Stakeholder collaboration involving government, local communities, and the private sector, is pivotal for shared responsibility and knowledge exchange. Clear policies supporting bamboo cultivation are essential and should be integrated into broader frameworks for agricultural and environmental development. To tap into bamboo's economic potential, investments in market

development and infrastructure are paramount, along with financial support mechanisms for farmers. Regular monitoring and assessment are vital for timely interventions and policy adaptation to collectively unlock Nigeria's bamboo resource potential for economic development, environmental sustainability, and social well-being.

To overcome the barrier of limited financial access, the creation of bamboo-focused funding programs and financial incentives is recommended to provide the necessary support. Insufficient technical knowledge was recognized as a barrier that could be addressed through training programs, workshops, and extension services. Recognizing that limited research and development are constraints, additional research is recommended to improve the availability of bamboo varieties, farming techniques, and other resources. Promoting multi-stakeholder partnerships and community participation in bamboo agricultural policies would ameliorate the problem of insufficient collaboration between stakeholders.

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