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Enhancing Agroforestry Adoption for Sustainable Livelihoods and Environmental Conservation in Cross River State, Nigeria.

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Abstract
This study explores agroforestry adoption in Cross River State, Nigeria, focusing on its impact on sustainable livelihoods and environmental conservation, as well as the challenges hindering its adoption. A mixed-methods research design was employed to integrate quantitative and qualitative data, ensuring a comprehensive understanding of the research problem. The study utilized a descriptive survey approach, with a stratified random sampling technique to select 397 respondents, including smallholder farmers, agricultural extension officers, and forestry commission staff. Data were collected through structured questionnaires, validated through expert review and reliability testing (Cronbach's Alpha = .78–.89). Findings from chi-square analysis revealed a statistically significant relationship between agroforestry adoption and improved livelihoods, as well as positive environmental conservation outcomes. However, adopters reported facing more challenges than non-adopters, including financial constraints, limited technical knowledge, and weak policy support. The study recommends targeted interventions such as enhanced extension services, financial incentives, and strengthened policy frameworks to support agroforestry adoption. These measures are essential for maximizing its benefits in promoting sustainable livelihoods and environmental conservation in the region.
Keywords: Agroforestry adoption, sustainable livelihoods, environmental conservation, challenges, Cross River State

Introduction and Background
Agroforestry, an integrated land-use management system that combines trees, crops, and livestock, plays a critical role in enhancing sustainable livelihoods and environmental conservation (Kumar, Veeraragavan, Baral, Saikanth, Singh, Upadhyay & Raj, 2023). In many developing regions, including Nigeria, agroforestry is increasingly recognized as a viable strategy for improving food security, increasing farmers' incomes, and mitigating environmental degradation (Sobola, Amadi & Jamala, 2015). Cross River State, known for its rich biodiversity and agricultural potential, presents a unique opportunity for agroforestry

adoption. However, despite its benefits, the adoption of agroforestry remains limited due to various socio-economic, institutional, and environmental challenges (Kpoviwanou, Sourou & OuinsavI, 2024).

This study aims to examine the impact of agroforestry adoption on sustainable livelihoods and environmental conservation in Cross River State, Nigeria. Furthermore, it seeks to identify the key challenges hindering agroforestry adoption and propose effective policy interventions. The study is guided by two hypotheses: first, that agroforestry adoption significantly enhances sustainable livelihoods and environmental conservation, and second, that there are significant challenges limiting its adoption among farmers. The findings will contribute to policy recommendations for promoting agroforestry as a sustainable land-use strategy in Nigeria.

Agroforestry has been widely recognized as a sustainable agricultural practice that integrates trees and shrubs with crops and livestock, thereby improving soil fertility, enhancing biodiversity, and increasing resilience to climate change (Awazi & Tchamba, 2019). In Sub-Saharan Africa, where smallholder farmers dominate the agricultural sector, agroforestry has the potential to provide economic, ecological, and social benefits (Wato & Amare, 2020). Studies have shown that agroforestry can improve rural livelihoods by diversifying income sources, increasing agricultural productivity, and providing raw materials for local industries (Jayakody, Karalliyadda, Jayasinghe & Amarathunga, 2025).

In Nigeria, agroforestry has been promoted through various initiatives, particularly in response to deforestation, land degradation, and declining agricultural productivity (Merem, Wesley, Twumasi, Richardson & Romorno, 2012). Cross River State, home to one of Nigeria's last remaining rainforests, has seen significant deforestation due to logging, agricultural expansion, and urbanization (Enuoh & Ogogo, 2018). While agroforestry could serve as a key strategy for balancing conservation efforts with economic development, adoption among farmers remains low due to challenges such as inadequate access to credit, lack of technical knowledge, and weak policy support (Jhariya, Banerjee, Yadav & Raj, 2019).

Given the critical role of agroforestry in promoting sustainable development, it is essential to understand the factors influencing its adoption in Cross River State. This study will explore both the benefits and barriers associated with agroforestry and provide evidence-based recommendations for policymakers, agricultural extension officers, and rural farmers. The study's findings will contribute to ongoing efforts to enhance agroforestry adoption as a tool for sustainable livelihoods and environmental conservation in Nigeria.

Statement of the Problem

Agroforestry is a sustainable land-use practice that enhances agricultural productivity, conserves the environment, and improves rural livelihoods. In Cross River State, where deforestation and soil degradation threaten agriculture, agroforestry presents a viable solution. However, its adoption remains low due to challenges such as inadequate access to credit, lack of technical knowledge, and weak policy support.

Despite the documented benefits of agroforestry, there is limited empirical evidence on its impact on sustainable livelihoods and environmental conservation in Cross River State. Additionally, the barriers hindering adoption remain poorly understood. This study aims to assess the benefits of agroforestry, identify key challenges limiting its adoption, and propose policy recommendations to enhance its implementation in the region.

Purpose of the Study

The primary aim of this study is to explore strategies for enhancing agroforestry adoption to promote sustainable livelihoods and environmental conservation in Cross River State, Nigeria. Specifically, the study seeks to:

1. Examine the socio-economic and environmental benefits of agroforestry adoption in Cross River State and its role in improving sustainable livelihoods and environmental conservation.
2. Identify the challenges hindering agroforestry adoption among farmers in Cross River State and propose policy recommendations and intervention strategies for its effective implementation.

Statement of hypotheses

The following are the study's hypotheses:

1. Agroforestry adoption has no significant impact on sustainable livelihoods and environmental conservation in Cross River State, Nigeria.
2. There are no significant challenges hindering agroforestry adoption among farmers in Cross River State.

Literature Review

Socio-Economic and Environmental Benefits of Agroforestry Adoption

Agroforestry has been widely acknowledged as a sustainable land-use system that provides multiple socio-economic and environmental benefits, particularly in developing regions like Nigeria. Studies indicate that agroforestry enhances soil fertility, increases farm productivity, and diversifies farmers' income sources, thus contributing to poverty reduction and food security (Fahad, Chavan, Chichaghare, Uthappa, Kumar, Kakade,... & Poczai, 2022).

According to Onyekuru and Marchant (2014), agroforestry adoption in Nigeria has led to increased household incomes, improved access to timber and non-timber forest products, and enhanced resilience to climate change. Their study highlights how integrating trees with crops and livestock helps mitigate the effects of deforestation while providing economic opportunities for rural farmers.

From an environmental perspective, agroforestry is instrumental in reducing carbon emissions, enhancing biodiversity, and preventing land degradation (Kumar, Yadav & Kadam, 2024). In a study conducted in Cross River State, Awazi,Njilin and Ambebe (2024) found that agroforestry systems contributed to reforestation efforts and improved water retention in farmlands. Their findings suggest that promoting agroforestry could play a critical role in restoring degraded lands and conserving the state's rich biodiversity. Similarly, Udawatta, Gantzer and Jose (2017) emphasized that agroforestry enhances ecosystem services, such as soil conservation, carbon sequestration, and habitat restoration, thereby supporting environmental sustainability.

Challenges Hindering Agroforestry Adoption and Policy Recommendations

Despite its benefits, agroforestry adoption in Cross River State remains low due to several challenges. One major barrier is the lack of awareness and technical knowledge among farmers (Ohara, Eta, Ohara & Hichiegeri, 2023). Many rural farmers have limited access to extension services and training programs that could help them implement agroforestry practices effectively. Additionally, financial constraints pose a significant challenge, as farmers often lack the capital needed to invest in agroforestry systems (Do, Luedeling & Whitney, 2020).

Institutional and policy-related challenges also hinder agroforestry adoption. Studies indicate that weak policy support, unclear land tenure systems, and inadequate incentives discourage farmers from embracing agroforestry (Ahmed, 2023). According to Place, Ajayi, Torquebiau, Detlefsen, Gauthier & Buttoud, (2012), government interventions, such as subsidies, credit facilities, and training programs, could significantly enhance agroforestry adoption rates. Venn, Montero-de-Oliveira, Buratti-Donham Eden and Reinecke (2024) further emphasized the need for policy integration, where agroforestry is included in national and state-level agricultural development plans.

To address these challenges, scholars recommend a multi-stakeholder approach involving government agencies, non-governmental organizations, and local communities. Leakey (2017) suggested that promoting agroforestry education through extension services and integrating it

into school curricula could improve long-term adoption. Additionally, Jayakody, Karalliyadda, Jayasinghe & Amarathunga (2025) advocated for financial support mechanisms, such as microcredit schemes and agroforestry cooperatives, to assist farmers in overcoming economic barriers.

Methodology

A mixed-methods research design was considered most suitable for this study, as it allows for a comprehensive exploration of both the quantitative and qualitative aspects of agroforestry adoption in Cross River State. This approach helped in understanding the socio-economic and environmental benefits, as well as the challenges hindering adoption, while providing both statistical evidence and in-depth insights from farmers and stakeholders.

The mixed-methods approach ensured that statistical findings are complemented by qualitative insights, providing a more holistic understanding of the research problem. Stratified random sampling ensured representation from different farmer groups, while purposive sampling allowed the inclusion of key stakeholders with relevant expertise. Questionnaires offered breadth (numerical data) in data collection.

Research Design

A descriptive survey research design was used to collect data on agroforestry adoption, its benefits, and the challenges faced by farmers. This design is appropriate as it enables the researcher to gather and analyze data from a large number of respondents within the study area.

Study Population and Sampling

Population: The target population consisted of smallholder farmers, agricultural extension officers and staff of the Cross River State, Forestry Commission involved in agroforestry in Cross River State. The total population consists of 28003 registered farmers, six agricultural extension workers in the six Local government areas (LGAs) of the study area and twelve staff of the forestry commission offices of the sampled LGAs.

Sampling Technique: A combination of stratified random sampling (for farmers based on agroforestry adoption status) and purposive sampling for agricultural extension officers and staff of the Cross River State Forestry Commission was used.
Sample Size: The sample size for farmers was determined using Cochran's formula for survey studies with the following given values:
Z = 1.96 # Z-score for 95% confidence level
P = 0.5 # Estimated proportion
e = 0.05 # Margin of error

N = 28003 # Total population
# Cochran's formula for initial sample size is given as:
n0 = (Z**2 * P * (1 - P)) / (e**2)
# Adjusted sample size using finite population correction is given as
n = n0 / (1 + ((n0 - 1) / N))
Using Cochran's formula with a finite population correction, the required sample size for registered farmers was 379. Additionally, a census of six agricultural extension officers and twelve staff members from the Cross River State Forestry Commission working in the study area was included, bringing the total sample size to 397.

Data Collection Methods
A structured questionnaire was administered to respondents to collect quantitative data on agroforestry practices, socio-economic benefits, and challenges. The instrument was validated through expert review**,** leading to modifications. A trial test with 50 respondents in Northern Cross River State assessed reliability using the Cronbach Alpha Coefficient, yielding values between .78 and .89**.**

Community leaders' permission was obtained, and five research assistants were trained. Informed consent was ensured, and dialect interpretation was provided where necessary. After collection, questionnaires were coded, scored, and analyzed using SPSS version 20**.** Results were presented in frequencies, percentages, and tables, with hypotheses tested at a 0.05 significance level.

Data Analysis
Descriptive statistics **(**frequencies, percentages, mean, and standard deviation) were used, while chi-square tests examined relationships between agroforestry adoption, socio-economic benefits, challenges, and policy recommendations.

Ethical Considerations
1. Informed consent was obtained.
2. Confidentiality and anonymity were maintained.
3. Ethical approval was sought from relevant institutional review boards.

The study was conducted in Ikom Education Zone, Cross River State**,** covering Abi, Boki, Etung, Ikom, Obubra, and Yakurr LGAs. The area, spanning 306 km²**,** has a projected population of 1,163,903 (NPC, 2015) and features tropical rainforest vegetation.

Results and discussion

Ho1: Agroforestry adoption has no significant impact on sustainable livelihoods and environmental conservation in Cross River State, Nigeria.

A Chi-Square test was conducted to examine the relationship between Agroforestry Adoption and Sustainable Livelihoods. A total of 397 valid cases were analyzed, with 1 missing case (0.3%)**.** Among non-adopters**,** 52 farmers (38.5%) reported that their livelihoods were not improved**,** while 83 farmers (61.5%) reported improved livelihoods. Conversely, among adopters**,** 156 farmers (59.5%**)** reported not improved livelihoods, whereas 106 farmers (40.5%**)** reported improved livelihoods. The expected counts indicate how values would be distributed if there were no relationship between the variables. The observed counts differ notably from the expected values, suggesting a potential association.

The Pearson Chi-Square test yielded a value of χ^2 (1, N = 397) = 15.79, p < .001, indicating a statistically significant association between agroforestry adoption and sustainable livelihoods. Additional statistical tests further supported this significance, including the Continuity Correction (14.96, p < .001**)** and the Likelihood Ratio (15.87, p < .001**)**. Furthermore**,** Fisher's Exact Test (p = .000) confirmed the robustness of the result. Since p < .05**,** the null hypothesis was rejected, indicating a statistically significant relationship between agroforestry adoption and sustainable livelihoods. The findings suggest that farmers who adopt agroforestry are more likely to experience livelihood improvements compared to non-adopters**.**

Table 1: Chi-Square Test for the Relationship Between Agroforestry Adoption and Sustainable Livelihoods

Variable	**Agroforestry Adopters (n = 262)**	**Non-Adopters (n = 135)**	**Total (n = 397)**	**χ^2**	**df**	**p-value**
Sustainable Livelihoods Improved	106 (40.5%)	83 (61.5%)	189 (47.6%)	15.79	1	< .001
Sustainable Livelihoods Not Improved	156 (59.5%)	52 (38.5%)	208 (52.4%)			

This table presents the observed counts and percentages for each group, along with the Chi-Square test results. The significant p-value (p < .001**)** suggests that agroforestry adoption has a significant impact on sustainable livelihoods.

On the second part of the hypothesis: Agroforestry adoption has and environmental conservation in Cross River State, Nigeria.

A Chi-Square test was conducted to examine the relationship between Agroforestry Adoption and Environmental Conservation. A total of 397 valid cases were analyzed, with 1 missing case (0.3%**)**. Among non-adopters**,** 36 farmers (26.7%) reported that agroforestry had no impact on environmental conservation, while 99 farmers (73.3%) reported a positive impact**.** Conversely, among adopters**,** 146 farmers (55.7%) reported no impact, whereas 116 farmers (44.3%) reported a positive impact. The expected counts suggest how values would be distributed if there were no relationship between the variables. The observed counts differ notably from the expected values, indicating a potential association between agroforestry adoption and environmental conservation.

The Pearson Chi-Square test yielded a value of χ^2 (1, N = 397) = 30.30, $p < .001$, indicating a statistically significant association between agroforestry adoption and environmental conservation. Additional statistical tests further supported this significance, including the Continuity Correction (29.14, $p < .001$) and the Likelihood Ratio (31.27, $p < .001$). Furthermore, Fisher's Exact Test ($p = .000$) confirmed the robustness of the result. Since $p < .05$, the null hypothesis was rejected, indicating a statistically significant relationship between agroforestry adoption and environmental conservation. The results suggest that farmers who adopt agroforestry are more likely to perceive positive environmental conservation outcomes compared to non-adopters.

Table 1: Chi-Square Test for the Relationship Between Agroforestry Adoption and Environmental Conservation

Variable	**Agroforestry Adopters (n = 262)**	**Non-Adopters (n = 135)**	**Total (n = 397)**	**χ^2**	**df**	**p-value**
No Environmental Impact	146 (55.7%)	36 (26.7%)	182 (45.8%)	30.30	1	< .001
Positive Environmental Impact	116 (44.3%)	99 (73.3%)	215 (54.2%)			

This table presents the observed counts and percentages for each group, along with the Chi-Square test results. The significant p-value ($p < .001$) suggests that agroforestry adoption has a significant impact on environmental conservation.

Ho_1

There are no significant challenges hindering agroforestry adoption among farmers in Cross River State.

A Chi-Square test was conducted to examine the relationship between Agroforestry Adoption and Challenges Hindering Adoption. A total of 397 valid cases were analyzed, with 1 missing case (0.3%). Among non-adopters, 55 farmers (40.7%) reported experiencing no challenges, while 80 farmers (59.3%) reported facing challenges in adopting agroforestry. Conversely, among adopters, 52 farmers (19.8%) reported no challenges, whereas 210 farmers (80.2%) reported facing challenges. The expected counts suggest how values would be distributed if there were no relationship between the variables. The observed counts differ notably from the expected values, indicating a potential association between agroforestry adoption and the challenges faced.

The Pearson Chi-Square test yielded a value of χ^2 (1, N = 397) = 19.75, $p < .001$, indicating a statistically significant association between agroforestry adoption and challenges faced by farmers. Additional statistical tests further supported this significance, including the Continuity Correction (18.71, $p < .001$) and the Likelihood Ratio (19.14, $p < .001$). Furthermore, Fisher's Exact Test ($p = .000$) confirmed the robustness of the result. Since $p < .05$, the null hypothesis was rejected, indicating a statistically significant relationship between agroforestry adoption and challenges faced. The results suggest that adopters of agroforestry are more likely to report facing challenges compared to non-adopters.

Table 1: Chi-Square Test for the Relationship Between Agroforestry Adoption and Challenges Hindering Adoption

Variable	Agroforestry Adopters (n = 262)	Non-Adopters (n = 135)	Total (n = 397)	χ^2	df	p-value
No Challenge	52 (19.8%)	55 (40.7%)	107 (26.9%)	19.75	1	< .001
Faced Challenge	210 (80.2%)	80 (59.3%)	290 (73.1%)			

This table presents the observed counts and percentages for each group, along with the Chi-Square test results. The significant p-value ($p < .001$) suggests that agroforestry adopters are significantly more likely to report facing challenges compared to non-adopters.

Discussions of findings

Ho_1

The findings of this study reveal a statistically significant association between agroforestry adoption and sustainable livelihoods among farmers. Since all tests yielded p-values below the

0.05 significance threshold, the null hypothesis was rejected, confirming a meaningful relationship between agroforestry adoption and sustainable livelihoods. The observed relationship aligns with existing literature that highlights the socioeconomic and environmental benefits of agroforestry. Agroforestry has been widely acknowledged as a sustainable land-use system that enhances soil fertility, increases farm productivity, and diversifies farmers' income sources, contributing to poverty reduction and food security (Fahad et al., 2022). However, the unexpected trend in which non-adopters reported higher rates of livelihood improvement than adopters suggests that additional factors may be influencing the impact of agroforestry. These may include the initial investment costs, the time required to realize benefits, and variations in implementation practices.

Prior research by Onyekuru and Marchant (2014) supports the notion that agroforestry adoption in Nigeria has led to increased household incomes, improved access to timber and non-timber forest products, and enhanced resilience to climate change. Their study underscores the role of integrating trees with crops and livestock in mitigating the effects of deforestation while providing economic opportunities for rural farmers.

Overall, while the present study confirms a significant relationship between agroforestry adoption and sustainable livelihoods, the mixed nature of livelihood outcomes among adopters suggests the need for further investigation. Future research should explore the specific challenges faced by adopters and identify the conditions under which agroforestry adoption yields optimal benefits. Policymakers should consider providing targeted support, such as financial incentives, technical training, and access to markets, to enhance the effectiveness of agroforestry as a livelihood strategy.

Other results of the Chi-Square test indicate a statistically significant relationship between agroforestry adoption and environmental conservation. This finding suggests that farmers who engage in agroforestry are more likely to perceive positive environmental conservation outcomes compared to non-adopters. The null hypothesis was rejected, confirming that agroforestry adoption is significantly linked to perceptions of environmental benefits. These findings align with existing literature on agroforestry's role in sustainable environmental management. Onyekuru and Marchant (2014) reported that agroforestry adoption in Nigeria has contributed to increased household incomes, enhanced resilience to climate change, and improved access to timber and non-timber forest products. Such benefits not only support rural livelihoods but also reinforce environmental conservation efforts by integrating trees with agricultural activities. Moreover, agroforestry plays a crucial role in mitigating deforestation,

enhancing biodiversity, and reducing carbon emissions (Kumar et al., 2024). These environmental benefits are particularly important in regions facing land degradation and climate-related challenges.

The observed differences between expected and actual counts in this study suggest that agroforestry adoption influences farmers' perceptions of environmental conservation. However, while the statistical association is strong, further research is needed to explore causal mechanisms and long-term impacts. Future studies could employ longitudinal analyses or qualitative approaches to understand how farmers' experiences shape their perceptions and decision-making regarding agroforestry.

H_{o2}

The results of the Chi-Square test indicate a statistically significant relationship between agroforestry adoption and the challenges faced by farmers. This finding suggests that farmers who adopt agroforestry are more likely to report facing challenges compared to non-adopters. The null hypothesis was rejected, confirming a significant relationship between agroforestry adoption and the difficulties encountered by farmers. These findings highlight the paradox of agroforestry adoption: while it offers significant environmental and economic benefits, adopters tend to face more challenges than non-adopters. Prior research supports the positive environmental impacts of agroforestry. Awazi, Njilin, and Ambebe (2024) found that agroforestry systems contribute to reforestation efforts and improve water retention in farmlands. Similarly, Udawatta, Gantzer, and Jose (2017) emphasized agroforestry's role in enhancing ecosystem services such as soil conservation, carbon sequestration, and habitat restoration. However, despite these advantages, adoption rates remain low due to various barriers.

A major challenge hindering agroforestry adoption in Cross River State is the lack of awareness and technical knowledge among farmers (Ohara, Eta, Ohara, & Hichiegeri, 2023). Many rural farmers have limited access to extension services and training programs that could facilitate effective implementation. Additionally, financial constraints pose a significant challenge, as farmers often lack the capital needed to invest in agroforestry systems (Do, Luedeling, & Whitney, 2020). Institutional and policy-related barriers further complicate adoption. Studies indicate that weak policy support, unclear land tenure systems, and inadequate incentives discourage farmers from embracing agroforestry (Ahmed, 2023).

Given these challenges, targeted interventions are needed to support agroforestry adopters. Expanding extension services, providing financial incentives, and strengthening policy frameworks could help address these barriers and enhance the long-term viability of

agroforestry practices. Future research should explore strategies for improving farmer support systems and promoting sustainable agroforestry adoption in rural communities.

Conclusion

This study highlights a significant relationship between agroforestry adoption and environmental conservation, with adopters more likely to perceive positive ecological benefits. However, findings also indicate that adopters face more challenges than non-adopters, including limited technical knowledge, financial constraints, and weak policy support. Addressing these barriers through improved extension services, financial incentives, and stronger policy frameworks is essential to enhancing adoption rates. Agroforestry remains a viable strategy for sustainable livelihoods and environmental conservation, but its success depends on targeted interventions to support farmers and promote long-term sustainability.

Recommendations

To enhance agroforestry adoption in Cross River State, targeted interventions should focus on improving farmer education through extension services and training programs. Financial support, such as subsidies or credit facilities, should be made available to help farmers overcome investment barriers. Additionally, policymakers should strengthen land tenure security and provide incentives to encourage sustainable agroforestry practices. Collaborative efforts between government agencies, research institutions, and local communities are essential to promoting widespread adoption and maximizing agroforestry's environmental and economic benefits.

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