



IMPACT OF AGROFORESTRY TECHNOLOGIES ADOPTION AMONG RURAL FARMERS IN KADUNA STATE, NIGERIA

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ABSTRACT

The study examined the determinants of agroforestry technologies' adoption among rural farmers in Kaduna State, Nigeria. Multi-stage sampling technique was used to select 400 respondents. Structured questionnaires were used for data collection and analysed using descriptive and inferential statistics. The results revealed that windbreak (95.9%), alley cropping (94.2%), and live fencing (93.3%) were the most widely recognized agroforestry technologies among the respondents and were ranked 1st, 2nd, and 3rd, respectively. Meanwhile, alley cropping (96.1%) is the most widely adopted agroforestry technology among respondents, followed by live fencing (86.2%) and silvo-pasture (85.9%). The perception of respondents toward agroforestry technologies varied, as indicated by the mean values in Table 4. The findings showed that agroforestry helps in preventing soil erosion and land degradation (Mean = 4.40), silvopasture (Mean = 4.32), agroforestry increases farm productivity and provides an additional source of income (Mean = 4.06), and windbreaks and shelterbelts reduce wind speed and protect crops from damage (Mean = 4.13) were highly perceived by farmers. The result of t-test analysis revealed that there was a significant ($P < 0.01$) difference between incomes before and after adoption of agroforestry technologies. Inadequate capital (98.15%), insecurity (97.24%), and climate change (96.13%) were the major constraints to agroforestry technology adoption in the study area and were ranked 1st, 2nd, and 3rd, respectively. The study concluded that there is significant improvement in farmers' income following the adoption of agroforestry technologies since the average annual income of those after agroforestry technologies adoption is greater than those before adoption of agroforestry technologies. The study recommended that government and financial institutions should provide low-interest credit facilities strengthened farmers cooperatives to ease financial burdens on farmers and enjoys economy of scale. Local security agencies should strengthen rural security through community policing strategies to protect farmers and their investments.

Keywords: Impact, Agroforestry, Technologies, Adoption.

INTRODUCTION

Agriculture remains the backbone of rural livelihoods in Nigeria, providing food, income, and employment for a significant portion of the population (Wanjira and Muriuki, 2020). However, challenges such as soil degradation, deforestation, and erratic weather patterns have negatively impacted agricultural productivity and sustainability (Shidiki *et al.*, 2020). Agroforestry, which integrates trees and shrubs with crops and livestock, presents a sustainable approach to addressing these challenges by improving soil fertility, enhancing biodiversity, and increasing farmers' resilience to climate change (Razafindratsima *et al.*, 2021). In Kaduna State, where most rural farmers depend on agriculture for their livelihoods, the adoption of agroforestry technologies has the potential to enhance food security, improve household incomes, and contribute to environmental conservation.

The impact of adopting agroforestry technologies extends beyond environmental benefits to socio-economic advantages for farmers (Rosati *et al.*, (2021). Agroforestry practices such as alley cropping, silvopasture, and agro-silviculture have been found to improve farm productivity and profitability by providing additional sources of income through the sale of tree products, fodder, and fuelwood (Singh *et al.*, 2021). Additionally, agroforestry plays a crucial role in climate change



adaptation by mitigating the adverse effects of extreme weather conditions, reducing erosion, and conserving water resources (Lowe *et al.*, 2021). Despite these benefits, the level of agroforestry adoption among rural farmers in Kaduna State varies, raising concerns about the extent of its impact on agricultural productivity and income of rural populace.

The success of agroforestry adoption is largely influenced by socio-economic factors, institutional support, and farmers' access to knowledge and resources. Farmers who receive adequate extension services and training tend to implement agroforestry practices more effectively, leading to increased farm yields and economic stability (Dou *et al.*, 2023). However, financial constraints, insecure land tenure, and limited access to markets often hinder farmers from fully benefiting from agroforestry initiatives. Understanding how agroforestry adoption influences farmers' income is crucial for formulating policies and programs that encourage widespread adoption.

Despite the significant benefits associated with adoption of agroforestry technologies, its impact among rural farmers in Kaduna State remains inconsistent. While some farmers have integrated agroforestry practices into their farming systems, others continue to rely on traditional agricultural methods, limiting the potential positive impact on their income. There is limited empirical evidence on the extent to which agroforestry adoption has influenced farmers' income in the study area. Understanding the impact of agroforestry adoption is essential to determine whether it significantly improves rural farmers' income or otherwise.

Previous studies (Tega *et al.*, 2023; Quandt *et al.*, 2023; Tebkew *et al.*, 2023; and Amare *et al.*, 2019) have emphasized the role of agroforestry in enhancing economic empowerment. However, little is known about the specific impacts on rural farmers' income in the study area. This study aims at examine the impacts of agroforestry adoption on income of rural farmers in the Kaduna State. The findings will help policymakers, extension agencies, and development organizations design targeted interventions that promote sustainable farming practices and improve farmers' livelihoods. It was on this note that this study was conducted. The broad objective of this study was to examine the impact of agroforestry technologies adoption among rural farmers in Kaduna State, Nigeria. The specific objectives of the study were to;

- i. examine the level of awareness on agroforestry technologies among respondents;
- ii. identify the agroforestry technologies adopted among respondents in the study area;
- iii. assess the perceptions of agroforestry technologies among respondents;
- iv. examine the impact of adoption of agroforestry technologies on income of the respondents;

METHODOLOGY

The Study Area

The study was conducted in Kaduna State. The State is located between Latitude 10.3764° N, and Longitude 7.7095° E of the Greenwich Meridian (Yusuf, 2021). It shares boundary with the Federal Capital Territory to the South West, Niger to the West, and Zamfara to the North West, Kano and Katsina to the North and Bauchi and Plateau to the East. The state is located within the savannah ecological zone. The climate is characterized by alternating wet and dry season; Kaduna State's vegetation consists of Northern Guinea Savannah in the North and Southern Guinea Savannah in the south. The state covers a land area of approximately 46,053 km². The mean or enjoys an average of 5 month of raining season. with an average rainfall is about 1,482mm, the temperature of Kaduna State ranges from 35°C to 36°C, which can be as low as 10°C to 23°C during the harmattan period (Besar *et al.*, 2020). The population of Kaduna as at 2021 was 89,032,200 based on 2024 projection at 3.0% growth rate (National Bureau of Statistics [NBS], 2024). They are involved in agricultural activities. The people are also involved in agroforestry production technology. Crops grown include: okra, pepper, maize, ginger, sorghum, rice, yam, cassava, millet, and tomatoes. Animal reared include: cattle, goats, sheep, rabbit, and poultry (Balogun *et al.*, 2022). Major economic activities in Kaduna State include farming and trading. The vegetation cover comprises indigenous forest species such as *Pakia biglobosa* (Dorawa), *Ceiba pentandra* (Silk Cotton), and *Adansonia digitata* (African Baobab), as well as exotic species like *Azadirachta indica* (Neem), *Tectona grandis* (Teak), *Eucalyptus spp.*, *Gmelina spp.*, and *Pinus caribaea* (Pine) (Nguyen *et al.*, 2020).



Sampling Technique and Sample Size

Multi-stage sampling technique was used in selecting the respondents. The State is divided into four Agricultural zones namely: Lere, Maigana, Samaru and Birnin-Gwari. The first stage involves purposive selection of three (3) zones: (Birnin-Gwari, Maigana and Samaru) out of the four agricultural zones in the State due to high level of agroforestry technologies activities in the area. In the second stage, three (3) Local Government Areas (LGAs) were randomly selected i.e one (1) from each of the selected zone namely; Ikara, Igabi and Sanga, respectively. The third stage involved the systematic selection of three (3) Districts from each of the selected LGAs making a total of nine (9) Districts. The fourth stage involved a random selection of two (2) communities from each of the selected district making a total of 18 communities. In the final stage, 35% of the respondents were proportionately and randomly selected making a total of 400 respondents drawn from the study area as the sample size for the study.

Method of Data Collection

Structured questionnaire was used for data collection. Both open and closed ended question was designed to meet the objectives of the study. A total of 400 questionnaires were administered to the respondents while 362 were retrieved from the field and subjected for analysis.

Method of Data Analysis

Data collected were analysed using both descriptive and inferential statistics. Descriptive statistics such as frequency, percentages and mean were employed to achieve objectives i, ii and iii. A t-test as an inferential statistic was used to examine whether the adoption of agroforestry technologies significantly improved farmers' income or otherwise (objective iv) i.e to examine the impact of adoption of agroforestry technologies on income of the respondents. It is specified as;

$$t = \frac{\sum d}{\sqrt{\frac{n(\sum d^2) - (\sum d)^2}{n-1}}}$$

Where d = difference per paired value

N = number of samples

RESULTS AND DISCUSSION

Awareness Status of Specific Agroforestry Technologies among Respondents

Result in Table 1 shows awareness status of specific agroforestry technologies among respondents. The findings in Table 1 indicated that windbreak (95.9%), alley cropping (94.2%), and live fencing (93.3%) were the most widely recognized agroforestry technologies among the respondents and were ranked 1st, 2nd, and 3rd, respectively. This suggests that these practices are well-promoted and potentially integrated into local farming systems. Silvopasture (90.1%), apiculture (87.8%), and taungya (86.5%) implying that integrating trees with livestock production is a familiar and potentially beneficial practice among respondents. These were ranked 4th, 5th, and 6th, respectively. Respondents were also aware of riparian buffer (41.2%) and improved fallow (14.1%) and were ranked 7th and 8th, respectively. The high awareness of windbreaks, alley cropping, and live fencing aligns with studies conducted by Sanou *et al.* (2022); Ibrahim & Nabage, (2023) that farmers are more familiar with agroforestry technologies that provide immediate economic or environmental benefits.



Table 1: Distribution of Respondents According to Awareness Status of Specific Agroforestry Technologies (n=362)

Agroforestry technologies	Frequency	Percentage*	Ranking
Wind break	347	95.9	1 st
Alley cropping	341	94.2	2 nd
live fencing	328	93.3	3 rd
Silvopasture	326	90.1	4 th
Apiculture	318	87.8	5 th
Taungya system	313	86.5	6 th
Riparian buffer	149	41.2	7 th
Improve fallow	51	14.1	8 th

Source: Field Survey, 2024.

*Multiple response recorded

Type of Agroforestry Technologies Adopted by the Respondents

The findings in Table 2 indicate that alley cropping (96.1%) is the most widely adopted agroforestry technology among respondents, followed by live fencing (86.2%) and silvopasture (85.9%). The high adoption of alley cropping implies that farmers recognize its benefits in enhancing soil fertility and improving crop productivity. Similarly, the widespread use of live fencing may be attributed to its cost-effectiveness as a natural barrier for farm protection, while the adoption of silvopasture indicates an increasing awareness of integrating livestock production with tree planting to maximize land use efficiency. The adoption of windbreaks (82.6%) and riparian buffers (73.8%) implies farmers' recognition of their roles in preventing soil erosion and protecting water bodies, which are crucial for sustainable farming in areas prone to environmental degradation. Apiculture (65.7%) is also popular, as beekeeping is increasingly seen as a profitable agroforestry venture. However, improved fallow (51.7%) and taungya (38.1%) exhibit lower adoption among the respondents, likely due to constraints such as land tenure issues, long maturation periods, and a lack of technical support.

Table 2: Distribution of Respondents according to Type of Agroforestry Technologies Adopted (n=362)

Agroforestry technologies adopted	Frequency	Percentage*	Rank
Alley cropping	348	96.1	1 st
Live fencing	312	86.2	2 nd
Silvopasture	311	85.9	3 rd
Wind break	299	82.6	4 th
Riparian buffer	267	73.8	5 th
Apiculture	238	65.7	6 th
Improve fallow	187	51.7	7 th
Taungya	138	38.1	8 th

Source: Field Survey, 2024.

*Multiple responses were recorded

Respondents' Perception of Agroforestry Technologies

The perception of respondents toward agroforestry technologies varied, as indicated by the mean values in Table 3. The findings show that agroforestry helps in preventing soil erosion and land degradation (Mean = 4.40), silvopasture (Mean = 4.32), agroforestry increases farm productivity and provides an additional source of income (Mean = 4.06), and windbreaks and shelterbelts reduce wind speed and protect crops from damage (Mean = 4.13) were highly perceived by farmers. This implies that respondents strongly believe in the perceived benefits of agroforestry technologies, particularly their roles in enhancing soil fertility, improving livestock productivity, increasing farm income, and protecting crops from wind damage. The high perception levels suggest that these practices are well understood and widely accepted by farmers. On the other hand, live fencing improves farm security and reduces the cost of conventional fencing (Mean = 3.94), agroforestry is an effective strategy for



restoring soil fertility (Mean = 3.93), and agroforestry promotes sustainable land use (Mean = 3.91) received a medium perception. This indicates a moderate level of confidence in their effectiveness, possibly due to limited awareness, practical experience, or concerns about feasibility in certain farming conditions.

However, the statement that "agroforestry helps in preventing soil erosion and land degradation" received the lowest perception score (Mean = 2.64), classified as low. This suggests that many farmers do not strongly believe that agroforestry effectively prevents soil erosion, which may be due to inadequate knowledge, lack of practical demonstrations, or previous negative experiences. The low perception of this important agroforestry benefit highlights the need for more awareness campaigns and extension efforts to educate farmers on soil conservation practices through agroforestry. The varying perception levels among the respondents indicate that while some agroforestry technologies are well-accepted, others require more sensitization and practical demonstrations to enhance farmers' understanding and adoption. The results is in tandem with Zemarku *et al.* (2022) reported that farmers perceptions are subjective to preferences, which are fundamental characteristics that may impact decision-making processes. Similarly, Jha *et al.* (2019), opined that farmer perceptions are affected by a variety of prior behaviours, experiences, and observations, as well as future aspirations.

Table 3: Distribution of Respondents according to Perception on Agroforestry Technologies (n=362)

Perception	Weighted Mean	Mean	Remark
Agroforestry helps in preventing soil erosion and land degradation	954	2.64	Low
Live fencing improves farm security and reduces the cost of conventional fencing	1426	3.94	Medium
Alley cropping enhances soil fertility and increases crop yield	1611	4.40	High
Apiculture in agroforestry increases farm productivity and provides an additional source of income	1472	4.06	High
Improved fallow is an effective strategy for restoring soil fertility	1423	3.93	Medium
The Taungya system promotes sustainable land use and benefits both forestry and agriculture	1416	3.91	Medium
Silvopasture improves livestock productivity and reduces feeding costs	1567	4.32	High
Windbreaks and shelterbelts reduce wind speed and protect crops from damage	1496	4.13	High
Cut-off mean for decision = 3.0			

Source: Field survey, 2024

Impact of Adoption of Agroforestry Technologies on Income of the Respondents

Table 4 shows the results of t-test comparing the mean income of farmers before and after agroforestry technologies adoption. The results indicated a statistically significant improvement in farmers' income following the adoption of agroforestry technologies. From the table the mean income of the farmers who adopted agroforestry technologies after was ₦4.73e+07 higher than the mean income of farmers before adoption of agroforestry technologies ₦1.27e+07 by ₦3.453 and is significant at 1% level of probability. This result implies that there was a significant difference between incomes before and after adoption of agroforestry technologies by the farmers. Implying that agroforestry technologies adoption has a positive impact on rural farmers' income. This finding aligns with Ajayi *et al.* (2021) that agroforestry technologies enhance household income by increasing farm productivity and diversifying income sources. Similarly, Franzel *et al.* (2024) reported that agroforestry contributes to sustainable livelihoods through improved crop yields and soil fertility conservation, ultimately boosting farmers' financial stability.

Table 4: Annual Income Variation Before and After Agroforestry Technologies Adoption

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.]	T= value
Income before adoption	362	1.27e+07	207823.3	3954108	1.23e+07	
Income after adoption	362	4.73e+07	287418.7	5468514	4.68e+07	97.9575***

*** Significant at 1% level of significance

Constraints to the Adoption of Agroforestry Technologies

The results in Table 6 indicate that inadequate capital (98.15%), insecurity (97.24%), and climate change (96.13%) were the major constraints to agroforestry technologies adoption in the study area and were ranked 1st, 2nd, and 3rd, respectively. This finding aligns with Mbow *et al.* (2024), who reported that financial constraints significantly hinder farmers' ability to invest in agroforestry technologies, as the initial costs of establishment and maintenance are often beyond their financial capacity. Insecurity, which was ranked as the second major constraint, reflects the challenges posed by conflicts and instability in rural areas. This is consistent with Mercer *et al.* (2024) in Northern Nigeria, where ongoing security concerns deterred farmers from making long-term investments in tree-based farming systems. Furthermore, climate change, ranked 3rd, is a significant threat to agroforestry adoption, as erratic rainfall patterns, droughts, and extreme weather conditions affect tree survival. This supports the findings of Lin *et al.*, (2017) in Southeastern Nigeria, who reported that unpredictable climate variations discourage farmers from adopting agroforestry due to uncertainties in tree growth and productivity.

The results also revealed that social and cultural resistance (95.03%), which was ranked 4th, plays a crucial role in limiting agroforestry adoption. Many farmers adhere to traditional farming systems that do not incorporate trees, believing that trees compete with crops for nutrients and space. This agrees with the findings of Centeri, *et al.*, (2022) in Southwestern Nigeria, where deeply ingrained cultural practices discouraged agroforestry adoption despite its potential benefits. Poor access to markets (67.13%) was ranked as the 5th constraint, highlighting the difficulty farmers face in selling tree products profitably. This aligns with Lin *et al.* (2017), who reported that weak market structures and poor transportation networks in rural Nigeria reduced farmers' incentives to adopt agroforestry technologies.

Table 5: Distribution of Respondents According to Constraints to the Adoption of Agroforestry Technologies (n=362)

Variable	Frequency	Percentage*	Rank
Inadequate capital	355	98.15	1 st
Insecurity	352	97.24	2 nd
Climate change	348	96.13	3 rd
Social and cultural resistance	344	95.03	4 th
Poor access to market	243	67.13	5 th

Source: Field Survey, 2024

*Multiple responses recorded

CONCLUSION AND RECOMMENDATIONS

The study concluded that there is significant improvement in farmers' income following the adoption of agroforestry technologies since the average annual income of the respondents after agroforestry technologies adoption is greater than before adoption of agroforestry technologies. Based on the findings of the study, the following recommendations were made;

- Government, financial institutions, and NGOs should provide low-interest credit facilities and grants tailored to smallholder farmers to support agroforestry adoption. Cooperative societies should also be strengthened to offer group financing and savings schemes to ease financial burdens on farmers.
- Government and local security agencies should strengthen rural security through community policing and conflict resolution strategies to protect farmers and their investments.



- iii Climate-smart agroforestry techniques, such as drought-resistant tree species and soil conservation methods, should be promoted to help farmers adapt to changing climatic conditions.
- iv Successful agroforestry farmers should be used as extension ambassadors to demonstrate the profitability and sustainability of tree-based farming systems.
- v Cultural leaders and influencers should be involved in advocacy programs to encourage the acceptance of agroforestry practices in traditional farming communities.
- vi Market linkages should be strengthened by creating cooperative marketing groups and facilitating direct farmer-to-buyer interactions.

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