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ASSESSMENT OF FACTORS INFLUENCING ADOPTION OF IMPROVED AGRO-FORESTRY TECHNOLOGIES AMONG SMALL-SCALE FARMERS IN NASARAWA STATE, NIGERIA

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ABSTRACT

This study assessed the factors influencing the adoption of improved agroforestry technologies among small-scale farmers in Nasarawa State, Nigeria. Data were collected from 111 registered agroforestry farmers using structured questionnaires and analysed using descriptive statistics, Likert-scale analysis, and multiple linear regression. Results showed that 77.3 % of the respondents were male, 91.8 % were married, and the mean age was 41.7 years. The most commonly adopted agroforestry technologies were boundary planting (mean = 4.0), shelterbelt/home gardening (mean = 3.6), alley cropping (mean = 3.3), and alley farming (mean = 3.1), while biomass transfer (mean = 1.9) and woodlots (mean = 2.9) had the lowest adoption. Benefits cited by respondents included increased income (80.9 %), firewood (49.1 %), erosion control (44.5 %), and provision of staking materials (39.1 %). Regression analysis revealed that extension contact ($\beta = 2.232$, $p < 0.01$) and farm size ($\beta = 0.194$, had significant $p < 0.05$) positive influences on adoption, whereas education ($\beta = -0.256$, $p < 0.05$) had a significant negative effect. The study concludes that agroforestry adoption is higher for practices that offer immediate benefits and are supported by extension services. Strengthening extension delivery, providing access to inputs, and promoting awareness are recommended to enhance the adoption of agroforestry technologies in the region.

Keywords: Adoption, agro-forestry, assessment, factors, improved, influencing, technologies

INTRODUCTION

Agriculture has historically been the foundation of Nigeria's economy, supporting the livelihoods of a significant segment of the population, especially smallholder farmers. However, various environmental challenges such as deforestation, land degradation, and the impacts of climate change continue to threaten food security and rural development. In response, sustainable practices like agroforestry, an approach that integrates trees with crops and/or livestock on the same land, are gaining relevance. Agroforestry not only improves agricultural output but also promotes environmental conservation and enhances the socio-economic conditions of rural communities (Boni *et al*., 2022). Adoption refers to the consistent use of an innovation once it is introduced (Orisakwe and Agomuo, 2011), and is often considered the most rational course of action (Abay *et al*., 2016; Garba, 2013). Technology, in this context, involves the systematic application of scientific knowledge for practical purposes (Orisakwe and Agomuo, 2011).

Agroforestry systems integrate trees and shrubs with crops and/or livestock in a deliberate, sustainable manner (Orisakwe and Agomuo, 2011). These systems support biodiversity, improve soil health, generate income, and strengthen food security by integrating woody perennials with farming activities (Olujobi, 2018). Agroforestry is a globally recognised practice, known for its role in combating deforestation, hunger, and poverty (Mulukh *et al*., 2017; Olujobi, 2018). It serves as a sustainable land-use model that boosts production while conserving ecosystems and mitigating climate change through carbon sequestration (Akinwalere, 2017).

Agroforestry is a dynamic and ecologically driven system with social, economic, and environmental benefits. It involves integrating trees into farmland or rangeland settings, contributing to long-term sustainability (Ishola *et al*., 2020; Awe *et al*., 2021; Ogunkalu *et al*., 2017). Nawaz *et al*. (2016) define agroforestry as a land-use strategy in which woody species are intentionally combined with crops and/or animals to foster ecological and economic interactions. The practice is now acknowledged as a distinct scientific discipline. According to Sangeetha *et al*. (2016) and Naibi (2013), agroforestry is a sustainable and culturally appropriate system that boosts soil fertility and resource conservation. It can take either sequential (e.g., improved fallows) or simultaneous (e.g., alley cropping) forms, with at least 18 major practices documented

(Akosim *et al*., 2020). Gillian (2010) characterises agroforestry as a resource management tool that enhances and diversifies production systems. Similarly, Akosim *et al*. (2020) define it as the purposeful integration of trees into farming systems for both ecological and economic gains. Agroforestry technologies encompass a wide range of practices that combine elements of agriculture, forestry, horticulture, and animal husbandry. These practices help mitigate production risks while increasing output. Traditionally, indigenous mixed cropping systems were used by farmers to reduce uncertainty (Amonum, 2009). Due to their complexity, agroforestry systems are often classified based on structure, function, and ecological distribution. The primary categories include agrisilviculture (trees and crops), silvopastoral (trees and livestock), and agrosilvopastoral (trees, crops, and livestock). Additional components include apiculture, aquaculture, and multipurpose tree lots.

Despite the availability of these technologies, their adoption remains low due to weak linkages between research and extension services, as well as mismatches between technologies and farmers' socio-economic realities (Orisakwe and Agomuo, 2011). Farmers are less likely to embrace innovations that do not align with their specific needs or conditions. Agroforestry practices can be classified as either farm-based (such as woodlots and intercropping) or forest-based (such as collection of food and gum) (Peter *et al*., 2019). These systems improve household income through diverse outputs (Ibrahim *et al.*, 2019). Trees commonly used in agroforestry, such as mango, cashew, citrus, guava, and native species like *Parkia biglobosa*, *Vitellaria paradoxa*, and *Azadirachta indica*, are critical for maintaining land productivity. Improved agroforestry systems include agrisilviculture, silvopastoral systems, agrosilvopastoral systems, and multipurpose tree plantations (Amonum *et al*., 2009). Measuring adoption often involves assigning numerical values to reflect farmers' decisions and behaviour.

Improved agroforestry technologies such as alley farming, shelterbelts, windbreaks, home gardens, fodder banks, biomass transfer, improved fallows, trees on farmland, and woodlots offer numerous advantages. These include sustainable land management, increased resilience to climate shocks, enhanced crop yields, poverty reduction, income generation, food security, improved soil fertility, and overall environmental conservation. Yet, despite these benefits, the adoption of such technologies remains relatively low. This limited adoption is often due to a lack of comprehensive understanding of the various factors influencing farmers' decisions. These factors may include socio-economic, cultural, educational, and institutional variables. This study aimed to investigate these influencing factors to understand better what encourages or hinders the uptake of agroforestry technologies. The findings will provide valuable insights for designing effective policies and extension strategies that promote widespread adoption. Ultimately, the goal is to enhance agricultural productivity and environmental sustainability in Nasarawa State. The study thus seeks to bridge a critical knowledge gap in agroforestry adoption. The broad objective of the study was to assess the adoption of improved agroforestry technologies among small-scale farmers in FCT and Nasarawa State, Nigeria. The specific objectives were to:

i Describe the socio-economic characteristics of agroforestry small-scale farmers in Nasarawa State.
ii Assess farmers' awareness of improved agroforestry technologies in the study area.
iii Assess the level of adoption of improved agroforestry technologies by the respondents.
iv Identify the perceived benefits of adopting agroforestry technologies by the respondents, and
v. Determine the factors influencing farmers' adoption of enhanced agroforestry technologies in the study area.

MATERIALS AND METHODS

Study Area

The study was conducted in Nasarawa State, North Central Nigeria. Nasarawa State is located at latitudes 7° and 90 N and longitudes 80° and 320 E. Nasarawa State was created from the former Plateau State in 1996 and is located in Nigeria's North Central region. The state has a land mass of about 27,117 km2 (Nasarawa State Government, 2022). The state has a tropical climate typical of its location. It has a mean temperature range from 25 °C in October to about 36 °C in March, while rainfall varies from 1373 mm in some places to 1450 mm in others (NADP, 2021). The state is divided into three Agricultural Zones (Southern, Central and Western). Agriculture forms the foundation of the state's overall development thrust, with farming as the main occupation of the people in the area (NADP, 2014). The major crops grown in the zone include maize, yams, groundnuts, rice, sesame, sorghum, millets and cowpea. Other crops produced within the area include cassava, melon, sweet potato, okra, and tree crops such as mango, cashew and shea trees (NADP, 2021). The major ethnic groups in the area include Afo, Egbira, Mada, Nyankpa, Eggon, Gwandara, Rindre, and Migili, among many others.

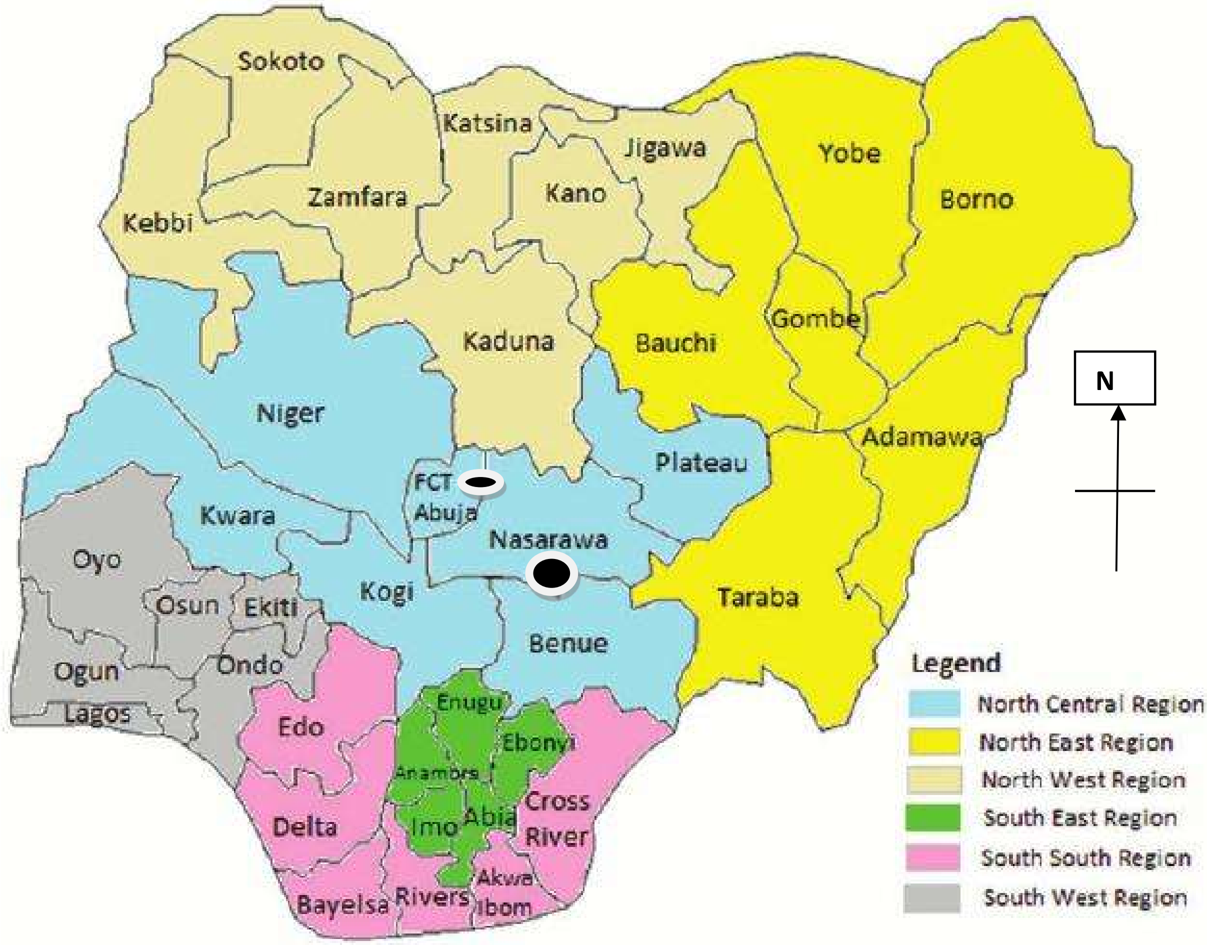

Figure 1: Map of Nigeria showing study area

Source: Map data @ Google Imagery (2018).

Key

Nasarawa State

Population and Sampling Procedure

The population for this study comprised 222 registered small-scale agroforestry farmers in Nasarawa State, as documented by the Ministry of Environment and Natural Resources (2024). A multi-stage sampling technique was employed to select respondents. In the first stage, five Local Government Areas (LGAs) were purposively selected based on their active engagement in agroforestry practices: Awe, Nasarawa, Karu, Wamba, and Toto. In the second stage, two communities notable for agroforestry activities were purposively selected from each of the five LGAs: Awe town and Tunga (Awe LGA); Nasarawa town and Laminga (Nasarawa LGA); Karshi and Uke (Karu LGA); Mama and Jida (Wamba LGA); and Toto town and Gadabuke (Toto LGA).

In the third stage, 50 per cent of the registered small-scale agroforestry farmers in each of the 10 selected communities were selected using simple random sampling, yielding a total sample of 110 respondents.

Method of Data Collection

Primary data were collected using structured questionnaires administered to selected agroforestry farmers in the study areas. The data covered socioeconomic characteristics, types of agroforestry technologies practised, sources of information, levels of adoption, and challenges faced in adopting these technologies—trained enumerators assisted in administering the questionnaires.

Method of Data Analysis

The collected data were subjected to simple descriptive statistics, such as frequency distributions, Percentages, and means, to describe the socioeconomic characteristics of agroforestry farmers (objective i) and to identify the perceived benefits of adopting agroforestry technologies by the respondents (objective iv). A five-point Likert scale was used to ascertain the level of awareness of improved agroforestry technologies among farmers (objective ii) as well as the level of adoption of improved agroforestry technologies among farmers (objective iii). Binary logit regression was used to examine the effects of selected socioeconomic variables on farmers' adoption of improved agroforestry technologies (objective iv).

Five-Point Likert Scale

The respondents' awareness and adoption of improved agroforestry technologies were assessed using a five-point Likert scale. This scale measures attitudes, preferences, and subjective responses by gauging the degree of agreement with specific items (Likert, 1932).

Level of Awareness of Improved Agroforestry Technologies

A five-point Likert-type scale was used to measure respondents' level of awareness of improved agroforestry technologies in the study area. Respondents were asked to specify the degree of agreement with statements regarding their awareness of improved agroforestry technologies using a 5-point Likert scale of fully aware (FA) =5, aware (A) =4, undecided (U) =3, not fully aware (NFA) =2 and not aware (NA) =1. Weights of 5, 4, 3, 2, and 1 were assigned to each response. A weighted mean of ≥ 3 means aware, whereas any weighted mean of < 3 means not aware. For each response, a weighted average is obtained as follows:

$$\overline{X} = \sum Fi\ (Ai)$$

$$5 + 4 + 3 + 2 + 1/5$$

Where,

Fi = frequency of respondents who agreed with a particular rating

Ai = value assigned to each rating

N = sample size

∑ = summation

FA = fully aware

A = aware

U = undecided

NFA = not fully aware

NA = Not aware

Level of Adoption of Improved Agro-Forestry Technologies

Similarly, a five-point Likert-type scale was used to measure the level of adoption of improved agro-forestry technologies among respondents in the study area. Respondents were asked to specify the degree of agreement with statements regarding the level of adoption of improved agro-forestry technologies using a 5-point Likert scale of fully adopted (FA) =5, adopted (A) =4, undecided (U) =3, not fully adopted (NFA) =2 and not adopted (NA) =1. Weights of 5, 4, 3, 2, and 1 were assigned to each response. A weighted mean of ≥ 3 means adopted, whereas any weighted mean of < 3 means not adopted. For each response, a weighted average is obtained as follows:

$$\overline{X} = \sum Fi\ (Ai)$$

$$5 + 4 + 3 + 2 + 1/5$$

Where,

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Ai = value assigned to each rating

N = sample size

∑ = summation

FA = fully adopted

A = adopted

U = undecided

NFA = not fully adopted

NA = Not adopted

The weighted means were further analysed to evaluate the relationship between the level of adoption (dependent variable) and other independent variables. The weighted score served as the dependent variable (Y) in the regression analysis.

Decision:

For this study, adoption status was classified using the equal interval method, i.e.

Divide the full scale range (1–5) into 3 equal parts:

Range = 5.00 −1.00 = 4.00

Interval width = 4.00/3 = 1.33

Thus,

- Low Adoption: 1.00 – 2.33
- Moderate Adoption: 2.34 – 3.67
- High Adoption: 3.68 – 5.00

Multiple Linear Regression model is stated as follow:

$Y = a + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta B_8X_8 + \beta_9X_9 + \beta_{10}X_{10} + e$

Where:

Y= cumulative mean adoption score per respondent

a= Constant term

β_1 β_2---- β_{10} = Regression coefficients

The independent variables specified are the determinant factors influencing the adoption of agro-forestry technologies and are defined below:

X_1 = Gender (Dummy: 1=male, 0=female)

X_2 = Age (years)

X_3 = Household size (number of dependent persons)

X_4 = Education (years spent in formal education)

X_5 = Marital Status (Married =1, single =0)

X_6 = Farming experience (years)

X_7 = Extension contact (yes =1, No = 0)

X_8 = Amount of credit obtained (in naira)

X_9 = Farm size (Ha)

X_{10} = Total annual income (amount in naira)

E = error term

RESULTS AND DISCUSSION

Socio-economic Characteristics of Respondents

Age**:** The socio-economic characteristics of respondents, as shown in Table 1, indicated a mean age of 41.7 years for agroforestry farmers. Most respondents were over 38 years (68.2 %), indicating that they are within productive age brackets and constitute a viable labour force. Age is crucial in influencing the adoption of improved agroforestry technologies, aligning with findings by Ibrahim *et al*. (2019), who reported a similar mean age (40.9 years) in New Bussa, Nigeria.

Sex: About 77.3 % of respondents were male. This suggests male dominance in agroforestry activities, possibly due to the physical nature of the work and land ownership patterns that favour men. This agrees with Ishola *et al*. (2020), who noted male predominance in farming due to labour demands.

Marital Status*:* A large proportion of respondents were married (91.8%). Married individuals may engage in agroforestry to support their families. Single farmers, though fewer in number, may benefit from independent decision-making and skill development. Ibrahim *et al*. (2019) similarly found that 66.7% of farmers were married and argued that married farmers tend to be more rational in decision-making.

Household Size*:* About 44.5% had households of 6–10 persons. The mean household size was 9 persons. Larger households imply greater family labour availability but may also increase household expenses. Obadimu *et al*. (2020) also found that the majority of farmers had 6–10 household members, suggesting access to family labour.

Educational Qualification: The respondents' educational status indicates that 46.4 % had primary education, 24.5 % secondary education, and 29.1 % tertiary education. Education enhances farmers’ ability to adopt and manage improved technologies. Ishola *et al*. (2020) similarly reported that 91.67 % of respondents were educated, facilitating the adoption of innovations.

Farming Experience*:* Most (85.5 %) of the farmers had 1–10 years of agroforestry experience. Experience fosters better adoption of sustainable practices, resource use efficiency, and resilience. This aligns with Ishola *et al*. (2020), who found that 76.67% had over six years of experience.

Cooperative Membership*:* Majority (90.9 %) belonged to cooperatives, with many of them having 1–10 years of membership. Cooperatives support members with collective input procurement, credit access, and market linkage. This reflects an awareness of the benefits of group participation.

Extension Contact*:* About 71.8% had contact with extension agents. Most had 1–2 contacts during the last season. Despite this, the overall frequency of extension visits was low, limiting access to training and the dissemination of innovation. Extension support is critical for improving farmers' knowledge and technology uptake.

Access to Loan*:* About 71.8% of agroforestry farmers had access to credit. This suggests relatively good access to financial services, which can enhance technology adoption and farm productivity. The sources of loans included cooperative societies (31.8%), friends (20.0%), neighbours (10.0%), and banks (10.0%). These findings indicate that cooperative societies and informal sources, such as friends, were the primary sources of credit for agroforestry farmers in the study area. Access to loans is critical for investing in improved seeds, equipment, agrochemicals, and other farm inputs and technologies, thereby enhancing productivity and efficiency. It also enables farm expansion and adoption of improved agroforestry practices.

Regarding the loan amounts accessed, 35.5 % accessed between ₦1,000 and ₦200,000; 19.1 % accessed between ₦201,000 and ₦400,000; and 17.3 % accessed over ₦400,000. The average loan accessed was ₦295,636.36. This amount is considered low, which may limit farmers' ability to invest in modern agroforestry technologies.

Method of land acquisition*:* In the aspect of land acquisition, 90.0 % of respondents used family land, 12.7 % used purchased land, and 3.6 % used gifted land. This shows that family land was the predominant mode of land acquisition in the study area. Access to land is crucial as it supports not only food production and economic returns but also environmental sustainability and social well-being.

Farm size: In terms of land size, 89.1 % farmed on 1–5 hectares, while 10.9 % farmed on 6–10 hectares. The average landholding was 3.4 hectares, indicating that the majority of agroforestry farmers are smallholders. Limited land size may constrain diversification and the full adoption of agroforestry practices, which require integrating trees, crops, and sometimes livestock. Smallholders may also struggle to access capital and markets, further limiting their productivity.

Boni *et al*. (2022) reported a mean agroforestry farm size of 2.71 hectares, attributing this to persistent rural poverty in Nigeria.

Annual Income: The income distribution showed that 49.1% of agroforestry farmers earned above ₦1,000,000 annually**,** 35.5 % earned between ₦501,000 and ₦1,000,000**,** and 15.5 % earned between ₦1,000 and ₦500,000**.** The average annual income was ₦1,384,545.45. Generally, the findings indicate that agroforestry farming provides a sustainable source of income for practitioners in both areas, likely supported by the adoption of improved agroforestry technologies.

Table 1: Socio-economic Characteristics of Agro-Forestry Farmers in Nasarawa State

Variable	Frequency	Percentage	Mean
Sex			
Male	85	77.3	
Female	25	22.7	
Age (years)			
18-28	4	3.6	
29-38	31	28.2	
Above 38	75	68.2	41.7
Marital status			
Single	9	8.2	
Married	101	91.8	
Household size			
1-5	35	31.8	
6-10	49	44.5	
Above 10	26	23.7	9
Level of education			
Primary education	51	46.4	
Secondary education	27	24.5	
Tertiary education	32	29.1	
Farming experience			
1-10	94	85.5	
11-20	16	14.5	7.7
Access to loan			
Yes	79	71.8	
No	31	28.2	
Source of loan			
No access to loan	31	28.2	
Neighbours	11	10.0	
Friends	22	20.0	
Cooperative societies	35	31.8	
Banks	11	10.0	
Amount of loan accessed (Naira)			
No access to loan	31	28.2	

1,000-200,000	39	35.5	
201,000-400,000	21	19.1	
Above 400,000	19	17.3	295, 636.36
Membership of cooperative society			
Yes	100	90.9	
No	10	9.1	
Extension contact			
Yes	79	71.8	
No	31	28.2	
Number of visits received			
No extension visits	31	28.2	
1-5	77	70.0	
6-10	2	1.8	
Above 10	0	0.0	
Method of land acquisition			
Farm on family land	92	83.7	
Farm on purchased land	14	12.7	
Gifted land	4	3.6	
Farm size (hectares)			
1-5	98	89.1	
6-10	12	10.9	3.4
Total annual income			
1,000-500,000	17	15.5	
501,000-1,000,000	39	35.5	
Above 1,000,000	54	49.0	1, 384, 545.45

Source: Field survey, 2024

Awareness of Improved Agroforestry Technologies in Nasarawa State

Table 2 presents the level of awareness of improved agroforestry technologies among the respondents. The responses were measured using a five-point Likert scale ranging from Fully Aware (5) to Not Aware (1). The mean scores for each technology were computed, and a score of 3.0 and above was considered an indication of awareness. Of the ten agroforestry technologies listed, six had mean scores of 3.0 or higher, suggesting that respondents were generally aware of these practices. In contrast, the remaining four had mean scores below 3.0, indicating low levels of awareness. Among the assessed technologies, Multipurpose Trees on Cropland recorded the highest mean score of 3.9, indicating that most respondents were aware of this practice. This high awareness could be attributed to the visibility and usefulness of such trees in providing shade, improving soil fertility, serving as sources of firewood, and contributing to overall farm productivity. Alley Farming also showed a high level of awareness, with a mean score of 3.6. This may be linked to its integration into existing farming systems and its benefits in reducing erosion and maintaining soil structure. Alley-Cropping (Hedgerow Intercropping) had a mean score of 3.4, indicating that the practice is relatively well known among the respondents. The similarity between alley farming and alley-cropping could explain this level of awareness. Taungya Farming and Boundary Planting both recorded mean scores of 3.3, reflecting moderate awareness. The Taungya system is likely known for its historical use in combining forestry and food crop production. At the same time, boundary planting is appreciated for its role in land demarcation, wind protection, and the provision of fodder or wood. Improved Fallows also recorded a mean score of 3.1, suggesting some familiarity, likely due to its role in restoring natural soil fertility.

On the other hand, Fodder Bank had a mean score of 2.9, indicating low awareness despite its importance in livestock feed management. This may be due to the predominance of crop farming over livestock among the respondents or inadequate extension services targeting this practice. Shelterbelt/Windbreak and Home Gardening was at the threshold with a mean score of 3.0, suggesting moderate awareness. Its slightly higher score may be due to its relevance in areas prone to strong winds and its benefits for home food security. The least known technologies were Woodlots and Biomass Transfer, with mean scores of 2.4 and 2.1, respectively. The low level of awareness of woodlots might be due to issues related to land ownership or the long-term nature of returns from such investments, which may not appeal to smallholder farmers. Biomass transfer, which recorded the lowest mean, may be poorly understood or perceived as complex and labour-intensive, especially where there are limited practical demonstrations or support services.

In summary, the findings reveal that awareness was generally high for agroforestry practices that are directly beneficial, easy to integrate into existing systems, or offer immediate economic returns. However, awareness was low for practices that require technical knowledge, long-term investment, or are less familiar within the local context. This underscores the need for targeted extension interventions, awareness campaigns, and practical demonstrations to promote the adoption of underutilised but beneficial agroforestry technologies.

Table 2: Awareness of Improved Agro-Forestry Technologies by the Respondents

Improved Agro-forestry Technology	FA (5)	A (4)	U (3)	FNA (2)	NA (1)	Sum Mean
Alley farming	155	196	9	22	16	398	3.6*
Alley-cropping	120	208	15	18	20	381	3.4*
Shelter belt/wind break/home gardening	95	156	21	36	27	335	3.0*
Multipurpose trees on cropland	165	236	9	16	7	433	3.9*
Fodder bank	55	144	33	66	19	317	2.9
Improved fallows	105	132	27	50	22	336	3.1
Taungya farming	120	156	21	50	15	362	3.3*
Boundary planting	135	152	12	44	19	362	3.3*
Biomass transfer	30	44	39	88	36	237	2.1
Woodlots	45	68	18	110	23	264	2.4

FA=fully aware, A=aware, U=Undecided, FNA=fully not aware, NA=not aware

NOTE: *means Aware

Level of Adoption of Improved Agroforestry Technologies by the Respondents

Table 3 presents data on the adoption levels of various improved agroforestry technologies among respondents. The adoption levels were assessed using a five-point scale ranging from Fully Adopted (5) to Not Adopted (1). The total score for each technology was computed, and mean scores were used to determine the level of adoption. A mean score of 3.0 and above indicates that a technology has been adopted, while a mean score below 3.0 suggests low or no adoption.

From the data, it is evident that only 4 of the 10 agroforestry technologies assessed were adopted by the respondents, as they recorded mean scores of 3.0 or higher. These are Boundary Planting (4.0), Shelterbelt/Windbreak and Home Gardening (3.6), Alley-Cropping (3.3), and Alley Farming (3.1).

Boundary Planting recorded the highest level of adoption with a mean score of 4.0. This suggests that respondents are not only aware of this practice but also actively implementing it, likely due to its multiple benefits, including farm boundary demarcation, fuelwood provision, and wind protection. Similarly, Shelterbelt/Windbreak and Home Gardening, with a mean of 3.6, were highly adopted. This may be attributed to its immediate visible benefits in controlling wind erosion and supporting household nutrition and income through home gardening.

Alley-Cropping (Hedgerow Intercropping) and Alley Farming also recorded adoption, with mean scores of 3.3 and 3.1, respectively. Their moderate levels of adoption could be linked to their compatibility with existing cropping systems, benefits in soil fertility improvement, and availability of technical knowledge or demonstration through extension services.

In contrast, the remaining six agroforestry technologies had mean scores below the adoption threshold, indicating low adoption among respondents. For example, Multipurpose Trees on Cropland, which had the highest awareness level in Table 2, recorded a low adoption mean of 2.6. This suggests a gap between awareness and actual implementation, possibly due to constraints such as a lack of planting materials, land tenure issues, or long gestation periods for the benefits of trees.

Similarly, Improved Fallows, Fodder Banks, and Taungya Farming recorded mean scores of 2.6, 2.4, and 2.4, respectively, reflecting limited adoption. These practices, while beneficial, may require more labour, land, or time before benefits are realised, which could discourage their adoption among resource-constrained farmers.

Woodlots, with a mean score of 2.9, came close to the adoption threshold but still fall into the low-adoption category. The low adoption may stem from the same reasons noted for multipurpose trees, such as limited land access and the long-term commitment required to establish woodlots.

Biomass Transfer had the lowest adoption level, with a mean score of 1.9. This may reflect a lack of awareness or understanding of the technology, as well as challenges associated with its labour intensity and the need for technical knowledge or external support.

In summary, the data show that adoption is highest for agroforestry technologies that are easy to integrate, offer immediate benefits, or are supported by extension services. However, there is a clear gap between awareness and adoption of several beneficial technologies, indicating the need for targeted interventions, such as farmer training, input provision, and the promotion of practical demonstrations to enhance adoption.

Table 3. Level of Adoption of Improved Agro-Forestry Technologies

Improved Agro-forestry Technology	FA(5)	A(4)	U(3)	FNA(2)	NA(1)	Sum	Mean
Alley farming	115	152	9	40	26	342	3.1*
Alley-cropping	105	200	15	18	25	363	3.3*
Shelter belt/wind break/home gardening	145	184	21	36	10	396	3.6*
Multipurpose trees on cropland	80	88	33	66	28	295	2.6
Fodder bank	45	68	18	110	23	264	2.4
Improved fallows	75	84	33	66	30	288	2.6
Taunya farming	55	84	21	82	30	272	2.4
Boundary planting	185	232	12	8	7	444	4.0*
Biomass transfer	15	32	39	88	42	216	1.9
Woodlots	55	144	33	66	19	317	2.9

FA=fully adopted, A=adopted, U=Undecided, FNA=fully not adopted, NA=not adopted

NOTE: *means Adopted

Benefits of Adopting Improved Agro-Forestry Technologies

The results of the benefits of adopting improved agroforestry technologies by respondents, as presented in Table 4, showed that respondents benefited in areas of increase in income (80.9%), firewood (49.1%), erosion control (44.5%), staking materials (39.1%) and shelter (20.0%). This means that adopting improved agroforestry technologies offers many benefits to agroforestry farmers in the study area. The study revealed that farmers either plant agroforestry trees for income, fuelwood, and erosion control. The result also aligns with Mukundente's (2021) finding that these trees are planted for various uses, including fuelwood (18%), income (22%), and soil erosion (14%). The study found that farmers plant trees for additional benefits, such as stakes for crops, firewood, improved soil, reduced crop failure, and control of weeds and pests.

Factors Influencing the Adoption of Improved Agroforestry Technologies

Table 5 presents the results of a multiple regression analysis showing the influence of selected socio-economic and institutional variables on respondents' adoption of improved agroforestry technologies in Nasarawa State. The explanatory variables considered include sex, age, marital status, household size, level of education, agroforestry farming experience, loan amount, extension contact, farm size, and total annual income. The regression model's intercept (constant) is significant with a t-value of 9.537, indicating a solid baseline adoption level when all explanatory variables are held constant. Among the independent variables, three were statistically significant, indicating a meaningful influence on the adoption of improved agroforestry technologies. These are:

Table 4. Benefits of Adopting Improved Agro-Forestry Technologies

Benefits of Agroforestry	Frequency	Percentage
Source of income	89	80.9
Provision of staking materials	43	39.1
Control erosion	49	44.5
Climate regulation	19	17.3
Increase soil fertility	21	19.6
Weed control	17	15.5
Fire wood	54	49.1
Provision of shelter	22	20.0

Multiple responses

Extension contact(β=2.232): This variable showed a highly significant positive influence at the 1% level. The strong effect suggests that frequent interaction with extension agents significantly enhances the adoption of improved agroforestry practices. This implies that extension services play a critical role in disseminating knowledge, demonstrating best practices, and encouraging farmers to adopt innovations. Paul *et al*. (2015) reported that extension visits influenced the adoption of agroforestry technologies in Nigeria. This shows that an extension visit is a determinant of agricultural innovation adoption. The extension contact was significant at the 1 per cent level. The results revealed that an increase of 1 unit in the number of extension visits will increase the probability of adoption. This is because access to extension education exposes farmers to different farming techniques and systems, including agroforestry information, and enhances their decision-making regarding adoption.

Level of Education (β = -0.256): This variable had a significant negative effect at the 5% level. This suggests that higher levels of formal education among respondents may not necessarily lead to increased adoption of agroforestry technologies. It could be that more educated individuals in the study area are less involved in farming or more inclined towards non-farm occupations, thereby reducing their likelihood of adopting agroforestry practices.

Farm Size (β = 0.194): Farm size also had a positive and significant influence at the 5% level. This implies that farmers with larger landholdings are more likely to adopt improved agroforestry technologies. Larger farms offer greater flexibility in integrating trees with crops and livestock, making it easier for these farmers to experiment with and benefit from agroforestry systems. This is in line with the findings of Awe *et al.* (2021) who reported that farm size had positively and significantly related to adoption of agroforestry technologies, which implies that the larger the farm size, the higher the likelihood of a farmer to adopt agroforestry technologies, since the farmers will have enough land to accommodate both their tree and arable crops for optimal benefits.

Other variables, such as sex, age, marital status, household size, agroforestry farming experience, loan amount, and total annual income, were not statistically significant, indicating that these factors did not have a strong influence on the adoption of agroforestry technologies in this study. Although factors like farming experience and loan amount may intuitively support adoption, their effects were statistically weak in this case.

Table 5: Factors Influencing the Adoption of Improved Agro-Forestry Technologies

Explanatory variable	β- value	Str error	t-value
(Constant)	1.917	.201	9.537
Sex	.074	.235	.313
Age	.001	.012	.092
Marital status	.218	.368	.592
Household size	.005	.021	.231
Level of education	-.256	.125	-2.053**
Agro-forestry farming experience	.038	.029	1.297
Amount of loan	1.978E-7	.000	.815
Extension contact	2.232	.226	9.894***
Farm size	.194	.093	2.089**
Total annual income	-2.251E-7	.000	-1.451

In summary, the findings highlight the critical importance of extension services and farm size in promoting the adoption of improved agroforestry technologies in Nasarawa State. The unexpected negative influence of education suggests that more targeted sensitisation is needed among educated farmers. The lack of significance for most socio-economic factors suggests that institutional and structural supports, such as land access and technical guidance, may be more influential than demographic characteristics alone.

Conclusion

The study concludes that, despite high awareness, the adoption of improved agroforestry technologies among small-scale farmers in Nasarawa State remains limited, with only a few practices widely adopted. Key factors influencing adoption include extension contact and farm size, highlighting the need for targeted institutional support to bridge the gap between awareness and implementation for sustainable rural development.

The study recommends strengthening extension services through ICT integration and capacity building, alongside policy backed by input subsidies and distribution systems to improve farmers' access. Awareness campaigns and demonstration plots should be institutionalised, with educated farmers engaged as role models. Legislative reforms to enhance land tenure security are essential to encourage long-term agroforestry investment. Farmer cooperatives should be supported with credit, collective procurement, and market access, while proven high-impact agroforestry practices should be scaled up through public–private partnerships and extension-led demonstration farms.

Declaration of Conflict of Interest

The authors declare no conflict of interest.

Data Availability

Data are available upon request from the first author or corresponding author or any of the other authors

REFERENCES

Abay, K. A., Behtane, G., Taffesse, A. S., Koru, B., & Abay, K. (2016). Understanding Farmers' Technology Adoption Decisions: Input complementarity and heterogeneity (IFPRI Discussion Paper No. 82). International Food Policy Research Institute (IFPRI). https://doi.org/10.2499/p15738coll2.214524

Akinwalere, B.O. (2017). Determinant of Adoption of Agro-forestry Practices among Farmers in Southwest Nigeria. *Applied Tropical Agriculture Journal,* 22:267-72.

Akosim, C., Tella, I.O., Jatau, D.F. (2020). Vegetation and Forest Resources of Adamawa State. Department of Geography. Paraclete publisher: pp. 32-35.

Amonum, J. I., Babalola, F. D., & Agera, S. I. N. (2009). Agroforestry systems in Nigeria: A review of concepts and practices. *Journal of Agricultural and Forestry Research,* 5(1), 15–27.

Awe, F., Oguntoye, TO., Olatunji, B.T. (2021). Determinants of Farmers' Adoption of Agroforestry Technology in Ibarapa Area of Oyo State, Nigeria. *Journal of Agriculture and Food Sciences.* 19(1), 189-200.

Boni, P.G., Goji, T.C., Teru, C.P. and Njodi, A.L. (2022): Evaluation of Factors Limiting Agroforestry Practice and Tree Species used by Agroforestry Farmers in Adamawa State, Nigeria. *Net Journal of Agricultural Science.* 10(1): 1-8.

Garba, U. (2013). Factors Influencing Adoption of Recommended Irish potato Production Practices in Kudan and Giwa Local Government Areas of Kaduna State, Nigeria. Available at: *kubanni.abu.edu.ng. Retrieved on 18/8/2023.*

Gillian, K. (2010). Uptake of Agroforestry Technologies among Smallholder Farmers in Zambia (Doctoral dissertation). Lincoln University, New Zealand.

Ibrahim, A.O., Adedeji, A.S. and Meduna, P.N. (2019). Constraints facing Agroforestry Practices among Farmers in New Bussa, Nigeria. *Journal of Research. in Forestry, Wildlife and Environment,*.11(3) 133-141.

Ishola, B.F., Ijah, A.A., Ayodele, J.T., Likita, M.S., Awobona, T.A., Omodona, S., Danbaki, C.A., Yahaya, U.F and Olukotun, O. (2020). Benefits and Challenges of Agroforestry Practices in Igabi Local Government Area of Kaduna State, Nigeria. *International. Journal of Research and Innovation in Applied Science,*.5(8): 89 – 94.

Likert, R. (1932). A technique for the measurement of attitudes. Archives of Psychology, 22(140), 1–55.

Mukundente, L. (2021). Impact of Agroforestry Technologies on Livelihood Improvement among Smallholder Farmers in Southern Province of Rwanda (Master's thesis). Kenyatta University, Nairobi, Kenya.

Mulukh, D. D., Mbaiske, V. M., Narkhede, S. S., Patil, V. K., & Rane, A. D. (2017). Farmers' preferences for indigenous trees suitable for agroforestry in Ratnagiri District of Maharashtra State. *Indian Journal of Tropical Biodiversity*, 25(2), 45–52.

Nasarawa Agricultural Development Programme. (2014). Annual Report. Lafia, Nigeria.

Nasarawa Agricultural Development Programme. (2021). Annual Performance Report. Lafia, Nigeria.

Nasarawa State Government. (2022). Nasarawa State statistical yearbook. Lafia: Ministry of Planning.

Nawaz, M.F., Gul, S. Farooq, T.H, Siddiqui, M.T., Asif, M; Ahmad, N. Niazi, K. (2016). Assessing the Actual Status and Farmer's Attitude towards Agro-forestry in Chiniot, Pakistan. *International Journal of Biological, Biomolecular, Agricultural, Food and Biotechnological Eng*. 10(8): 6-12.

Obadimu, O.O., Oke, O.S., Asunlegan, O.A., Alaje., M.A., Ojo, D; Olanrewaju, C.M (2020). Determinant of Agroforestry Practices among Small holder Farmers in Oyo State Nigeria. *Journal of Applied Science Environmental Management*. 24(12): 2107-2111.

Ogunkalu, O.A., Sodimu, A.I., Sulaiman, R.A. and Adedire, O.O. (2017). Survey of Benefits and Constraints of Urban Trees in Kaduna Metropolis. *Word News of Natural Sciences*, 11: 19 – 27.

Olujobi, O.J. (2018). Factors Influencing Adoption of Improved Fallow among Agro-forestry Farmers in Gbonyin Local Government, Ekiti State, Nigeria. *International Journey of Agric. Policy and Research*. l.6 (2): 21-27.

Orisakwe, L., Agomuo, F.O. (2011): Adoption of Improved Agroforestry Technologies among Contact Farmers in Imo State, Nigeria, 2(1): 1-9.

Paul, B. K., Nath, T. K., & Hossain, M. A. (2015). Extension contacts and adoption of agroforestry practices in developing countries. Journal of Agricultural Extension, 19(2), 112–124.

Peter, N., Moratego, AO., Felix, O.O .(2019). Constraints and Attitudes to Agro-forestry Practices among Farmers in Ekiti State, Nigeria. *Journal of Agricultura and Rural Dev.* 4(2): 26-33.