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SOCIOECONOMIC DETERMINANTS OF FARMERS' ADOPTION AND AWARENESS OF AGROFORESTRY TECHNOLOGIES IN BENUE STATE, NIGERIA

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Abstract

This study assessed the socioeconomic characteristics, knowledge, awareness, and factors influencing the adoption of agroforestry (AF) technologies (Gliricidia sp, Leucaena sp and vertiver grass) among smallholder farmers in Benue State, Nigeria. Data were collected from 60 direct beneficiaries, 300 secondary beneficiaries/neighbouring farmers, and 10 extension agents using semi-structured questionnaires and interviews. Results showed that agroforestry beneficiaries were predominantly female (58.3%), with most farmers within the age range of 51–60 years (53.3%). A large proportion of beneficiaries had either non-formal or primary education (88.4%), operated small farm sizes between 1.1–2.0 ha (48.3%), relied solely on human labour (100%), and earned low annual farm incomes, mainly within ₦151,000–₦200,000 (46.7%). Awareness of agroforestry technology among neighbouring farmers was generally low, as most respondents (66.0%) had never heard of agroforestry practices, with media (44.0%) and extension agents (32.0%) being the major information sources for those aware. Gliricidia spp. and Leucaena spp., either singly or in combination with Vetiver grass, were the dominant agroforestry species across the area. Adoption of agroforestry technology was largely influenced by production-related benefits such as staking materials (20.5%), mulching (20.1%), and green manure (20.1%), while income ranked lowest (1.8%). Binary regression results revealed that education ($F = 11.62$, $p < 0.001$), income ($F = 11.54$, $p = 0.00$), family size ($F = 4.25$, $p = 0.05$), years of farming experience ($F = 5.77$, $p = 0.02$), and farm size ($F = 8.42$, $p = 0.01$) significantly influenced agroforestry adoption, whereas sex, age, marital status, access to information, and distance to farm showed no significant effect. The study revealed the need for targeted awareness creation, education-driven interventions, and institutional support to enhance agroforestry adoption in Benue State.

Keywords: Agroforestry adoption, Smallholder farmers, Adoption behaviour, Land-use systems, Sustainable land management

INTRODUCTION

Agroforestry technology has gained increasing attention as an important approach for enhancing agricultural productivity while maintaining environmental sustainability. It supports farming systems by combining tree-based components with conventional agricultural practices in ways that enhance soil quality, protect farmlands from degradation, and improve overall farm performance. Through its application, farmers make more efficient use of land and natural resources while reducing the risks associated with climate variability (Roy *et al*., 2025).

Beyond farm productivity, agroforestry technology contributes to rural livelihoods by providing multiple outputs such as food, fuelwood, fodder, and income-generating products (Agera *et al.,* 20219). It also strengthens ecosystem functions by improving biodiversity, conserving water resources, and enhancing carbon storage (Torhemen *et al.,* 2024). These combined benefits make agroforestry an increasingly relevant option for sustainable agricultural development and resource management, particularly in regions facing land degradation, population pressure, and climate-related challenges. However, the adoption of agroforestry technology by smallholder farmers is hampered by several factors such as limited access to land, seeds, insecurity, and inadequate financing (Japheth *et al.,* 2023). These issues are made worse by poor funding, policies and ineffective policy implementation. Farmers are frequently discouraged from making these investments due to socio-economic problems, for instance, poverty and restricted financial access (Japheth *et al.,* 2023; Torhemen *et al.,* 2024).

Farmers in Benue State face significant challenges such as land degradation, soil erosion, and decreasing fertility, which threaten agricultural productivity and sustainability, as well as the well-being of the local communities (Chagbe *et al.*, 2013). Agroforestry practices can help address these problems by enhancing soil fertility, revitalizing damaged lands, and enhancing carbon storage (Yasin *et al.,* 2024; Abebaw *et al.,* 2025). The introduction of agroforestry species, such as Leucaena, Vetiver, and Gliricidia, has shown potential benefits in the region, including improved soil quality, reduced erosion, and increased biodiversity (Torhemen *et al.,* 2024). On-farm Adaptive research (OFAR) trial of Agroforestry technology in Benue State also recorded success in alley farming and erosion control. The technologies were found to improve soil fertility and crop yield. Agroforestry technologies have proven to have several benefits (Agera *et al.,* 20219).

Despite their proven benefits, the adoption rates of these agroforestry technologies in Benue are low. Torhemen *et al* (2024) assessed the adoption of *Leucaena* agroforestry technology among smallholder farmers in Benue State, which indicated that farmers adopted the technology in the study area. Thus, it is necessary to conduct this assessment to determine the extent of adoption and levels of challenges for sustainable agroforestry practices in the study area. Other technologies, such as *Gliricidia* and *vertiver grass,* introduced in the study area, are not comprehensively evaluated. A comprehensive evaluation of the benefits and challenges can reveal impacts, barriers, and opportunities for enhancing adoption and sustainable agroforestry practices (Kiyani *et al.,* 2017). Thus, this research investigates the impact of factors influencing the adoption and long-term viability of agroforestry in the study area.

The study is in line with Sustainable Development Goals (SDGs), Goal Two (2) and Goal Fifteen (15). Goal two (2) seeks to end hunger in all its form by 2030 which entails improving the productivity and incomes of small-scale farmers by promoting equal access to land, technology and market, sustainable food production systems and resilient agricultural practices while goal fifteen (15) seeks to protect life on land by ensuring the conservation,

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restoration and promotion of sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, halt deforestation, wetland.

MATERIALS AND METHODS

Location of the Study

The study was conducted in Benue State, Nigeria. Benue State lies within the Lower River Benue Trough in the Middle Belt region of Nigeria. Geographically, the State is located between longitudes 7.50°E and 10.00°E and latitudes 6.25°N and 8.25°N, covering a land area of approximately 34,059 km² (Nyagba, 1995; Hula and Ukpong, 2013). The State is positioned in the central part of Nigeria and shares an international boundary with the Republic of Cameroon in the Southeast (Figure 1).

Benue State experiences a typical tropical climate characterized by distinct seasons: the wet (rainy) season and the dry season. The rainy season spans from April to October, with mean annual rainfall ranging between 1,200 mm and 2,000 mm, while the dry season lasts from November to March and is influenced by dry north-easterly Harmattan winds, particularly between November and February (Nyagba, 1995; Hula and Ukpong, 2013). The south-westerly monsoon winds prevail during the rainy season. Mean annual temperatures range between 23°C and 38°C. The vegetation reflects a transition between semi-rainforest and Guinea savanna, with predominantly tall grasses, shrubs, and scattered trees. Riparian forests occur mainly along riverbanks and low-lying areas. The State lies within the Guinea savanna ecological zone, one of the largest vegetation belts in Nigeria (Nyagba, 1995). Common tree species include African mahogany (*Khaya senegalensis*), African copaiba (*Daniellia oliveri*), doka tree (*Isoberlinia doka*), African locust bean (*Parkia biglobosa*), African mesquite (*Prosopis africana*), shea tree (*Vitellaria paradoxa*), wild syringa (*Burkea africana*), African rosewood (*Pterocarpus erinaceus*), Afzelia (*Afzelia africana*), African fan palm (*Borassus aethiopum*), red-flowered silk cotton tree (*Bombax costatum*), African birch (*Anogeissus leiocarpa*), and bush mango (*Irvingia gabonensis*). (Dagba *et al.,* 2016). Continuous vegetation removal through farming, logging, and bush burning has resulted in regrowth and parkland landscapes, which increasingly attract pastoral activities into the State (Hula and Ukpong, 2013). The study area is not designated for conservation, and the local population is primarily engaged in farming activities (Egwumah *et al.,* 2024).

The topography of Benue State is predominantly undulating plains with occasional elevations of about 150–300 m above sea level. Geologically, the area consists mainly of shale, sand, silt, and clay derived from the basement complex, expressed in rolling hills, residual mountains, mesas, inselbergs, valleys, and plains. These physical features, combined with the state's location within Nigeria's ecological transition belt and favourable rainfall pattern, support a wide range of crops and livestock production.

Agriculture forms the backbone of the Benue State economy, engaging over 70% of the working population and earning the state its reputation as one of Nigeria's major food baskets. Despite this potential, agricultural production remains largely traditional, with limited adoption of modern

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technologies. Mechanization, plantation agriculture, and agroforestry practices are still at early stages of development. Although farm inputs such as fertilizers, improved seeds, insecticides, and other modern methods are increasingly used, high costs and limited availability remain major constraints. Important cash crops cultivated in the state include soybeans, rice, groundnuts, mango, and citrus, while other crops such as oil palm, melon, African pear, chilli pepper, and tomatoes are also common. Staple food crops include yams, cassava, sweet potatoes, beans, maize, millet, guinea corn, and vegetables. Irrigation agriculture is minimally practised, with limited use of modern irrigation techniques.

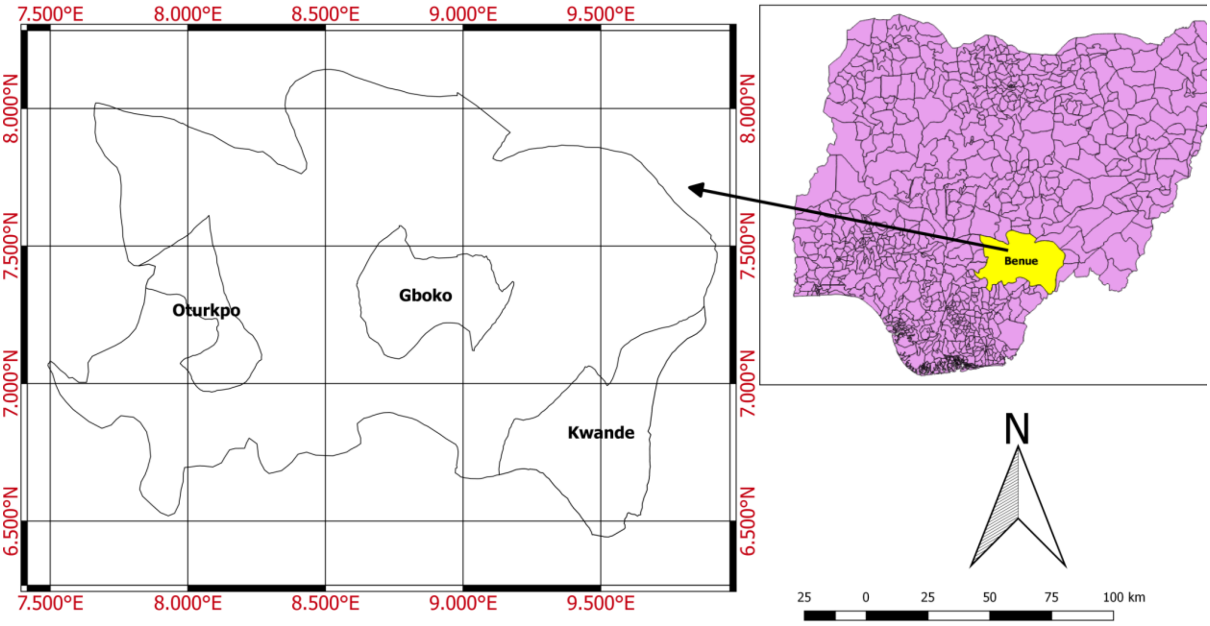

Figure 1: Map of Benue State showing the Study Area

Source: Mapped with QGIS Desktop (version 3.18.3) (2021)

Data Collection and Analysis

This research employed a mixed-method approach, leveraging both primary and secondary data to investigate the development of Agroforestry (AF) in the study area. Primary data on AF technologies (*Gliricidia sp, Leucaena* sp and *vertiver grass*) were collected from 60 direct beneficiaries, 300 secondary beneficiaries/neighbouring farmers, and 10 extension agents using semi-structured questionnaires administered using *Kobocollect* Toolbox. The questionnaires assessed the respondents' perspectives on AF practices. The collected data underwent coding, processing, and outlier removal, followed by analysis using the Statistical Package for Social Sciences (SPSS Version 11.5) and Excel spreadsheet software.

The data collected were analyzed using descriptive statistics (mean, frequencies, percentages, and tables) and inferential statistics (Binary regression).

RESULTS

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Socioeconomic Characteristics of Smallholder Farmers on Agroforestry (AF) in Benue State, Nigeria

The socioeconomic characteristics of respondents, as presented (Table 1), show that (58.3%) of the respondents (farmers) were female, while (41.7%) were males. Most (53.3%) of respondents have an average age of 55 years (between 51 – 60 years), this was followed by those with an average age of 65 years (61-70 years), while 3.3% of the farmers were within an average age of 46 years (41-50 years. Based on Table 4, 63.3% of the farmers had one form of informal education or the other, with the majority (51.7%) attending primary education. Most of the farmers (65.6%) had a family size of 6-10, with an average family size of 8. All respondents (100%) were engaged primarily in farming, indicating that agriculture is the dominant and possibly sole source of livelihood for the beneficiaries. This shows the direct relevance of agroforestry technologies to their economic activities and household sustenance. Most farmers (53.3%) cultivated farms located between 1.1 and 2.0 km from their homes, with an average distance of 1.6 km, while a smaller percentage of respondents had farms situated either closer, ranging from 0.1–1.0 km (average 0.6 km), or farther away, between 2.1–4.0 km (average 3.0 km). This indicates that most farmers operate relatively close to their residences, allowing for easier access and more frequent management of their agroforestry plots.

All farmers (100%) relied solely on human labour, with no use of machinery. This shows the smallholder nature of the farms and limited access to mechanization, which may affect productivity and operational efficiency. The majority (46.7%) of the farmers earned between ₦151,000 and ₦200,000, with an average annual income of ₦175,500 from their farm produce, followed by 20.0% who earned ₦101,000–₦150,000 (average ₦125,500), while smaller groups earned either higher or lower amounts. This distribution indicates that most farmers fall within the low-income category, underscoring the need for income-enhancing interventions such as improved agroforestry practices and better market access.

Table 1: Socioeconomic Attributes of Farmers who benefited from the Selected Agroforestry Technology in the Study Area

Variables		Frequency	Percent
Gender	Male	25	41.7
	Female	35	58.3
	Total	**60**	100.0
Age category	41-50	2	3.3
	51—60	32	53.3
	61-70	22	36.7
	70 above	4	6.7
	Total	**60**	100.0
Level of education	non formal	22	36.7
	Primary	31	51.7
	Secondary	5	8.3
	Tertiary	2	3.3
	Total	**60**	100.0
Occupation	Farming	61	101.7
Marital Status	Divorced	0	0.0
	Married	49	81.7
	widow(er)	11	18.3

	Total	**60**	100.0
Family size Category	1-5	18	30.0
	6-10	39	65.0
	11-15	2	3.3
	21 Above	1	1.7
	Total	**60**	100.0
size of farm	0.1-1.0	3	5.0
	1.1-2.0	29	48.3
	2.1-3.0	21	35.0
	3.1-4.0	5	8.3
	4.1 Above	2	3.3
	Total	**60**	100.0
Distance category from home to farm (Km)	<1	1	1.7
	0.1-1.0	9	15.0
	1.1-2.0	32	53.3
	2.1-3.0	14	23.3
	3.1-4.0	2	3.3
	4.1 above	2	3.3
	Total	**60**	100.0
Type of labour	Human labor	60	100.0
	Machine labor	0	0.0
	Total	**60**	100.0
Annual income range (from the farm produce)	151-200K	28	46.7
	101-150K	12	20.0
	201-250K	9	15.0
	251K- Above	8	13.3
	50-100K	3	5.0
	Total	**60**	100.0

The majority (52.3%) of the neighbouring small farmers were males, while 47.7% were females (Table 2). Similarly, 74.7% of the respondents were below 51 years, with 34.3% falling within the 41–50 years age group, having an average age of 45 years. In contrast, 25.3% of neighbouring smallholder farmers were aged 51 years and above, with 16.5% within the 51–60 years range and an average age of 55 years. The overall average age of respondents was approximately 45 years, while that of neighbouring small farmers was about 55 years.

The result showed that the majority (89.6%) of the neighbouring small farmers had one form of education, the other with 59.3% of them attaining secondary, while 10.3% of the respondents had non-formal education. The majority (98.3%) of the respondents were fully involved in farming; this was followed by trading (1.3%), while a few (0.3%) of the respondents were civil servants. The result on marital status of the respondents revealed that the majority (81.7%) of the respondents were married (7.3% were single, 7.3% were widows/widowers, while 3.7% of neighbouring small farmers were divorced/separated.

The result also showed that the majority (47.3%) of neighbouring small farmers in the area had a family size of 6-10 members, with an average of 8 members; 42.7% of them had an average of 3 members. The size of the respondents indicates that most (47.0%) of the respondents had a farm size of 1.5 hectares. Human labour on farms was dominantly used by the majority (99.7%) of the respondents, while a few (0.3%) used machines on their farms. mechanized farming

Most of the respondents (39.3%) had their farmland away from their homes, with a walking distance of about 1.1 – 2 km (an average of 1.6 km). The majority (57.3%) of the respondents were Tiv, (41.7%) were Idoma, while a few (1%) of the respondents were Agatu. Also, most of the respondents (98.3%) were Christians, while 1.3% of the respondents practice traditional religion in the study area. The result also revealed that a good number (37.0%) of the respondents' annual income of ₦151-200,000, with an average of ₦175,500.

Table 2: Socioeconomic Attributes of Neighbouring Farmers in the Study Area

Variables		Frequency	Percent
Gender	Male	157	52.3
	Female	143	47.7
	Total	**300**	100.0
Age category	21-30	23	7.7
	31-40	98	32.7
	41-50	103	34.3
	51—60	50	16.6
	61-70	23	7.7
	70 above	3	1.0
Average	±		
Level of education	non formal	31	10.3
	Primary	58	19.3
	Secondary	178	59.3
	Tertiary	33	11.0
	Total	**300**	100.0
Occupation	civil servant	1	0.3
	Farming	295	98.3
	Trading	4	1.3
	Total	**300**	100.0
Marital status	Divorced	11	3.7
	Married	245	81.7
	Unmarried	22	7.3
	widow(er)	22	7.3
	Total	**300**	100.0
Family size Category	1-5	128	42.7
	6-10	142	47.3
	11-15	24	8.0
	16-20	5	1.7
	21 Above	1	0.3
Average	±		
Size of farm	0.1-1.0	21	7.0
	1.1-2.0	141	47.0
	2.1-3.0	103	34.3
	3.1-4.0	30	10.0
	4.1 Above	5	1.7
Average	±		
Distance category from home to farm (Km)	<1	1	0.3
	0.1-1.0	78	26.0
	1.1- 2.0	118	39.3
	1.1-2.0	26	8.7
	2.1-3.0	60	20.0

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	3.1-4.0	13	4.3
	4.1-5.0	3	1.0
Average	±		
Category of annual income category (from the farm produce)	₦50,000-100,000	35	11.7
	₦101,000 - 150,000	53	17.7
	₦151,000 – 200,000	111	37.0
	₦201,000-250,000	70	23.3
	₦251,000- Above	31	10.3
Average	±		

Farmers' Knowledge and Awareness of Agroforestry Technology in Benue State

This finding (Table 3) shows that the majority (66%) of the respondents reported that they had never heard of AF technology in the study area, while 34% of respondents agreed that they had heard about AF technology. The result also revealed that of those who were aware of AF technology, 30.8% of respondents got the information through extension agents, (42.3%) of the respondents stated that their major sources of information on AF technology were through media such as social media, TV, radio jungles.

Table 3: Neighbouring Farmers' Knowledge and Awareness of Agroforestry Technology in Benue State

Variables		**Frequency**	**Percent**
Ever heard of agroforestry technology	Yes	102	34.0
	No	198	66.0
	Total	**300**	100.0
Source of information	Association/group meeting	14	14.0
	Community meeting	10	10.0
	Extension agent	32	32.0
	Traditional chief	1	1.0
	media	44	44.0
	Total	**101**	**100.0**

The distribution of plant species utilized as agroforestry technologies (Figure 2) varied across the three zones in the study area. In Zone A, *Gliricidia sp* accounted for 18.4% of reported practices, while in Zone B it represented 23.8% and in Zone C 13.9%. The combined use of *Gliricidia sp* and vetiver grass comprised 2.6% of practices in Zone A, 16.7% in Zone B, and 33.3% in Zone C. The adoption of vetiver grass alone constituted 7.9% in Zone A, 7.1% in Zone B, and 0.0% in Zone C. The combination of vetiver grass and *Gliricidia sp* made up 2.6% of practices in Zone A, 0.0% in Zone B, and 5.6% in Zone C. The use of *Gliricidia sp* and Leucaena sp represented 5.3% of adoption in Zone A, 23.8% in Zone B, and 8.3% in Zone C. The utilization of Leucaena sp alone

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accounted for 44.7% in Zone A, 2.4% in Zone B, and 8.3% in Zone C. The combination of Leucaena sp and *Gliricidia sp* constituted 2.6% of practices in Zone A, 23.8% in Zone B, and 27.8% in Zone C. Other agroforestry species and combinations contributed 15.8% of reported practices in Zone A, 2.4% in Zone B, and 2.8% in Zone C.

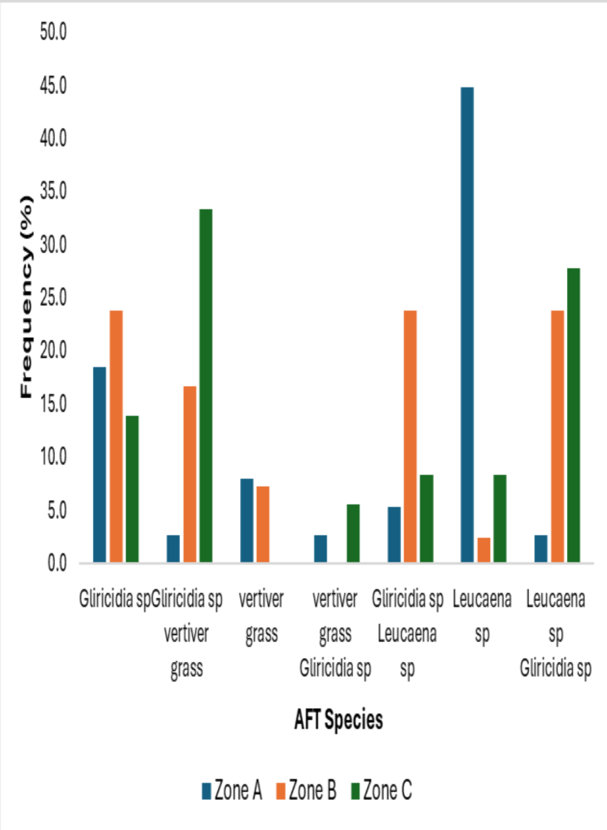

Figure 2: Plant Species Utilized by Smallholder Farmers as AF Technology in Benue State

Neighbouring farmers in the study area reported varying use of agroforestry technology species across the three zones (Figure 3). In Zone A, *Gliricidia spe*cies accounted for 34.9% of the species used, while the combination of Gliricidia and vetiver grass contributed 33.3%. Leucaena species represented 15.9% of the reported uses, whereas vetiver grass alone accounted for 6.3%. The use of other unspecified species constituted 9.5% in this zone.

In Zone B, *Gliricidia spe*cies formed 50.0% of the utilized agroforestry species, while Leucaena species accounted for 21.4%. The combination of Gliricidia and vetiver grass contributed 7.1%, with a similar proportion reported for Leucaena combined with Gliricidia. Vetiver grass alone accounted for 14.3%, and no other species were recorded. In Zone C, Leucaena species dominated the reported use at 90.5%. *Gliricidia spe*cies and the combination of Gliricidia with vetiver grass each accounted for 4.8%. No farmers reported the use of Leucaena combined with Gliricidia, vetiver grass alone, or other species in this zone.

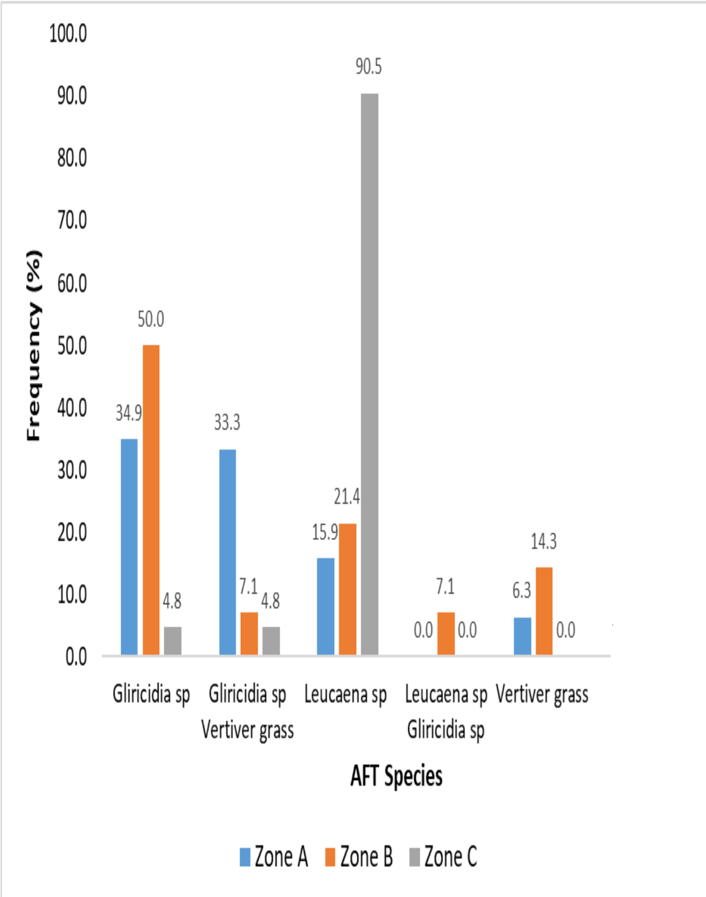

Figure 3: Plant Species Utilized by

Neighbouring Farmers as AF Technology in Benue State

Results on awareness of extension agents on AF technology in the study, as shown in Table 4, revealed that (100%) of the extension agents interviewed were aware of the AF technology; their sources of information on AF technology indicated that IITA training (100%) was their source of information. The result also revealed that (80.0%) of the extension agents were involved in the implementation of AF technologies. All (100%) of the agents reported that AF technologies, introduced through the OFAR trial in 1995 across different locations in the study area, with (30.00%) of the agents stating that the OFAR trial was established in Asa. According to the agents, the OFAR trial of AF technology was introduced in all three zones (A, B and C) of the State (Table 4). During the introduction of the AF technology in the study area, (100%) of the agents reported that farmers were given seedlings of high quality to boost AF systems in the study area and to encourage the establishment of such practices in the area; these seedlings were given to smallholder farmers in groups.

Table 4: Extension Agents' Awareness of the Selected Agroforestry Technology in the Study Area

Variables		Frequency	Percent
Awareness of Agroforestry technology	Yes	10	100
	No	0	0
	Total	**10**	**100.0**
Source of awareness about AF technology	IITA training	10	100
	Total	**10**	**100.0**
types of AF technology involved in the implementation	*Leucaena sp*	8	80.0
	Leucaena/Gliricidia sp	1	10.0
	Leucaena/vertiver grass	1	10.0
	Total	**10**	**100.0**
Year of implementation of the OFAR trial of AF technologies	1995	10	100
	Total	**10**	**100.0**
Areas introduced AF technologies	Agbaher	1	10
	Amelladu	2	20
	Asa	3	30
	Gbatse	1	10
	Usar	1	10
	Usar, gbatse,	1	10
	Yandev	1	10
	Total	**10**	**100.0**
Zones AF technologies were introduced	Zone A	3	30
	Zone B	4	40
	Zone C	3	30
	Total	**10**	**100.0**

The farmers were given the seedlings as	Group	10	100
	Total	**10**	**100.0**

Factors Influencing *AF* Technology Adoption among the Smallholder Farmers in Benue State

The result of the distribution of respondents based on the factors influencing the adoption of agroforestry (AF) technology in the study area (Table 5) shows that a total of 295 responses were recorded across various identified factors. Staking material accounted for the highest frequency with 60 responses, representing 20.5% of the total. This was closely followed by mulching and green manure, each with 59 responses, representing 20.1%, respectively. Alley cropping had 14.7% of the total responses. Fuelwood had 32 responses, representing 10.9%, while erosion control and animal feeds had 18 (6.1%) and 17 (5.8%) responses, respectively. Income was the least influential factor with 7 responses, representing only 1.8% of the total.

Table 5: Factors Influencing Adoption of AF Technology in the Study Area

Factors	Frequency	Percent
Erosion control	18	6.1
Fuel wood	32	10.9
Feeds for animals	17	5.8
Alley cropping	43	14.7
Mulching	59	20.1
Green Manure	59	20.1
Staking material	60	20.5
Income	7	1.8
Total	**295**	**100.0**

Table 6 presents the results of the Omnibus ANOVA test assessing the influence of socioeconomic variables on the adoption of agroforestry technology. The results show that sex ($F = 2.00$, $p = 0.16$), marital status ($F = 0.71$, $p = 0.50$), access to information ($F = 2.23$, $p = 0.14$), age ($F = 3.28$, $p = 0.08$), and distance from farm ($F = 0.46$, $p = 0.50$) did not have a statistically significant influence on adoption. However, education ($F = 11.62$, $p < 0.001$), family size ($F = 4.25$, $p = 0.05$), income ($F = 11.54$, $p = 0.00$), years of farming experience ($F = 5.77$, $p = 0.02$), and farm size ($F = 8.42$, $p = 0.01$) had significant effects on the adoption of agroforestry technology. The residual mean square was 0.06, based on 47 degrees of freedom, representing the unexplained variation in the model.

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Table 6: Omnibus ANOVA Test Showing the Influence of Socioeconomic Variables on Agroforestry Technology Adoption

Socioeconomic Variables	Sum of Squares	df	Mean Square	F	p
Sex	0.11	1	0.11	2.00	0.16
Education	1.99	3	0.66	11.62	<.001
Marital_status	0.08	2	0.04	0.71	0.50
Access_info	0.13	1	0.13	2.23	0.14
Age	0.19	1	0.19	3.28	0.08
Family size	0.24	1	0.24	4.25	0.05
Distance_from farm	0.03	1	0.03	0.46	0.50
Income	0.66	1	0.66	11.54	0.00
Years_exp	0.33	1	0.33	5.77	0.02
Farmsize	0.48	1	0.48	8.42	0.01
Residuals	2.68	47	0.06		

DISCUSSION

Socioeconomic Characteristics of Smallholder Farmers on Agroforestry (AF) in Benue State, Nigeria

The study recorded a higher number of male respondents who were involved in the adoption and practice of AF technology in the study area than females. This could be because agricultural practice in the area is dominated by males, which is influenced by the land tenure system practised by the people (Idoma and Isma'il, 2014). Ivande *et al.* (2014) also reported more males in their study on technological challenges in farming among the Tiv people. Also, Adedotun (2010) reported that in Nigeria, male are usually the head of household, which influences their control of farming activities.

Most of the respondents were young and agile people, which shows that most of them were active in farming activities. A similar result was reported by Akinwalere (2016) in Southwest, Nigeria. This revealed a promising future for agroforestry practices in the study area. The result of this study contradicts the growing evidence of an ageing farming population in most parts of rural Nigeria, as reported by Akpan (2010). The age of the smallholder farmers reported in this study was in line with the report of Ojiako and Ogbukwa (2012).

The study indicated that most of the smallholder farmers in the study area had one form of education or the other, with a good number of them attaining secondary education. Education plays a crucial role in the study area, as majority of the respondents were literate and able to understand the importance of forests, policies, and programs; education helps to liberate the mind and exposes individuals to alternative options (Reuben *et al.,* 2025). This result aligns with the report of Akinwalere (2017) in southwestern Nigeria, where most farmers were educated. Issa *et al* (2016) had a

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similar experience among Maize farmers in Ikara Local Government Area of Kaduna State, Nigeria, where most of the farmers had secondary education.

This is an indication that enlightened and educated people are embracing agriculture in the area as their means of livelihood, and with their level of education, understanding AF technology was not difficult. It is also believed that their level of enlightenment can help them make more informed decisions concerning AF technology (Jara-Rojas *et al.,* 2025). This agrees with the submission by the United States Agency for International Development, USAID (2010), that the more educated a farmer is, the more chances that the farmer will adopt innovations.

Most farmers were married; this is common among Nigerian farmers, and scholars (Ogumefun and Chike, 2015; Issa *et al*., 2016) believed that married people dominate agricultural production activities in Nigeria. This is because they rely heavily on farming activities to provide for their family members. Most respondents were farmers who were involved in farming activities as their primary occupation. This is a common attribute of rural communities in Nigeria, where most of the people are farmers (Michael and Abdulqudus, 2021; Charles *et al*., 2021).

The family size recorded in this study is an affirmation that most of the farmers used the family members as labour force for farming, so the more members in the family, the larger the size of the farm. With several household members, human labour could be easily achieved during land clearing and the cultivation of crops in the area, especially for farmers who use manual labour. Yusuf *et al*. (2011) reported that due to an increase in demand for labour in family farming, the larger the household size, the more family labour is utilized. This result aligns with the results of Ojiako and Ogbukwa (2012), who reported the average household size of farmers to be 7 persons.

The result on the distance from home to farmland of the respondents revealed the proximity of the respondents from their homes to their farms. The closer the respondents are to their farms, the frequently they visit the farms and spend more time on the farmlands. Those who must walk a long distance to their farms usually have fewer visits and time spent on their farms. This result aligned with the report of Hettige (2006).

The study has shown that most of the respondents earned below $000 a year from farming activities. This is an indicator of the poverty level of rural farmers in Nigeria (Azeez *et al*, 2015). This means that most of them had acquired capital formation through other avenues of income to support their income farming activities (Jamala *et al.,* 2013). Results on extension agents implied more males (60%) than females (40%) extension agents. Out of which most (60%) of the agents were within the age bracket of 61 – 70 years, with a few (40%) of the agents falling between the age brackets of 51 – 60 years. The agents in the area were mostly (80%) tertiary education certificate holders who were mostly (40%) retired from active service. The extension agents were Directors and senior staff, with a few (10%) of the agents serving as block supervisors. This result implied that all the extension agents involved in *L. Leucocephala* AF technology in the study area were well-trained and educated, with vast experience over a long period, having retired from active service at the time they were assessed for this research work (Timothy, 2014; Ngango *et al.,* 2023).

Farmers' Knowledge and Awareness of Agroforestry Technology in Benue State

The study reveals a low level of knowledge of AF technology among smallholder farmers in Benue State, as most farmers were not aware of the selected AF technology in the State. This low knowledge of AF technology among the neighbouring smallholder farmers in Benue State could be because the technology was still under trial, and only pilot farmers' extension agents concentrated on giving information on the technology.

The result also revealed that the knowledgeable farmers, who had ever practised AF technology, had done so with fewer tree species. Based on this result, it can be deduced that most of these smallholder farmers in the study area lack knowledge of economic tree species, usually combined with crops to boost soil fertility and other benefits associated with AF technology in this contemporary farming system in the study area. However, as widely said, "knowledge is power"; it brings innovation and vast benefits, both monetary and otherwise. This agrees with the report by the United States Agency for International Development, USAID (2010), that the more knowledgeable (educative) a farmer is, the more likely the farmer is to adopt innovations.

The lack of knowledge on economic tree species, usually combined with crops to boost soil fertility and other benefits associated with AF in the study area, could be due to ineffective communication between the change agents and other farmers on the types of economic tree species suitable for AF, coupled with the long-term benefits of agro-forestry technologies. This agrees with Govere (2003), who reported that, although agro-forestry is an age-old practice, many farmers have yet to receive communication about the technologies and the economic tree species that are combined with the practices of AF. This could be linked to ineffective communication about the long-term benefits of agro-forestry technologies between the change agents and other farmers. A similar result was reported by Owooh (2013) in North Carolina, USA, Parwada *et al.* (2010) in Zimbabwe and Tokede *et al.* (2025) in Ibadan, Oyo State, Nigeria. The ineffectiveness in communication could have been due to farmers' attitudes towards agro-forestry technologies. They tend to seek information on technologies with immediate benefits, which could not be agro-forestry technologies.

All the respondents who were sampled as agents had vast knowledge of AF technology in the area. The OFAR trial of AF technology in the area has been in existence for about 26 years, with a wider coverage in all three ecological zones of Benue State. Most smallholder farmers who belong to a group received AF technology seedlings, which were distributed by extension agents to encourage and boost the growth and development of AF technology in the whole of Benue state. According to the findings and reports from extension agents, a considerable period has elapsed since this farming system was introduced in the study area in 1995. Yet, most of the farmers in Benue State have not completely or fully acquired better knowledge of AF technology and other related practices in Benue State. This problem could be linked to poor dissemination of information and inadequate sensitization in the area.

It could also be due to poor funding and follow-up to the project in the study area. Such is common among developing countries, where projects are established, and huge amounts of capital are spent, but such projects are easily abandoned or poorly monitored and evaluated. Also, lack of interest or skepticism that comes with innovation among rural farmers in the state could be another factor which limited the smallholder farmers from having a better knowledge of the AF technology system and other related AF practices, which have many benefits to them and their environment at large. The high awareness level could also be because of the educational level of the respondents. This result aligns with the report of Sulaiman *et al.* (2015), titled Awareness and Use of Information and Communication Technologies among Extension Agents in Kaduna State, Nigeria. According to Ibrahim *et al*. (2018), farmers who were involved in hunting and gathering minor forest produce in the nearby forest for their livelihood stopped at the introduction of agroforestry and concentrated only on farming, as agroforestry ensured good and cheap food for them, which in turn increased the number of livestock. Sales from livestock and tree crops produced on home garden agroforestry systems in Southeastern Nigeria accounted for over 60% of family cash income (Robert and Tim, 2004).

The result of this finding shows that most of the farmers (95.1%) were aware of the program before adopting and practising AF technology in the area. The farmers were visited by extension staff in the area to educate them on AF technology and its benefits to smallholder farmers and their environment. They sourced the information on AF technology from extension agents, community meetings and associations. This finding is an indication that associations, group meetings and community meetings played vital roles in awareness and sensitization of rural farmers on the need to embrace AF practice. In situations where there is little or no visitation by extension agents to farmers, associations, groups, and community meetings can still play a role in sensitization, as revealed by this finding. There is a need to encourage more associations and community meetings to boost sustainable crop and tree production for global warming mitigation in the study area.

Factors Influencing the Adoption of *AF* Technology among the Smallholder Farmers in Benue State

The findings on the factors influencing the adoption of agroforestry (AF) technology by farmers in the study reveal several key elements that impact this decision. Among these, farm size, the availability of animal feed, manure, fuelwood, staking materials, and income stand out as significant determinants. Farm size is the primary factor influencing farmers' choices to engage in agroforestry. This indicates that the respondents typically represent smallholder farmers, who tend to have relatively small landholdings primarily utilized to meet their family’s needs, with only a limited surplus available for sale. In the study area, factors such as staking materials, green manure, mulching, animal feed, manure, fuelwood, and erosion control were identified as influential in the adoption of agroforestry practices. Similar findings have been reported in other studies, including those by Parwada et al. (2010) and Owooh (2013). Additionally, Parwada et al. (2010) identified other important factors, such as gender, land tenure practices, and labour availability.

The agroforestry system is generally known for its numerous benefits, which determine the type of tree species that can be combined with crops or plants. This result proved that farmers plant or retain trees on their farmland for various purposes, including food, income, soil improvement, environmental amelioration, and shade during harsh weather periods. In the case of *Leucaena* AF technology in Benue state, the species (*Leucaena*) is a tropical tree legume plant that has been used worldwide to control land degradation and maintain or increase soil fertility.

Its ability to control land degradation is attributed to its extensive, dense rooting and depth of penetration that could provide superficial as well as deep-seated soil erosion control (Osman *et al.,* 2008). Its aggressive taproot system helps break up compacted subsoil layers, improving penetration of water into the deep soil, which allows it to grow in dry conditions because of its ability to extract water from the deep soil strata that are not accessible to most herbaceous plants such as grasses (Anonymous, 2019). Its lateral roots that grow horizontally and profusely enable *Leucaena* to control run off and soil erosion (Saifuddin and Normaniza, 2016). *Leucaena* also aids in recycling leached essential nutrients, including P and K from the subsoil to the surface (Otsyina and Dwozela, 1995). *Leucaena* can grow on steep slopes and in marginal lands with long dry seasons, making it a prime plant for restoring forest cover, watersheds and grasslands (Anonymous, 2019). Being a drought-tolerant species, *Leucaena* also has higher water use efficiency compared with drought-resistant native grasses like *Cenchrusciliaris* (Dalzell *et al.,* 2006). Gladwin *et al*. (2002) and Keil *et al.* (2005) established that the probability of adoption increases when farmers perceive low soil fertility as their current problem.

The results on factors influencing the adoption of agroforestry (AF) technology indicate that farm size, availability of animal feed, manure, fuelwood, staking materials, and income, among others, influenced farmers' decisions to practise agroforestry. The findings further show that farmers' adoption decisions were largely influenced by farm size, implying that the respondents exhibit characteristics typical of smallholder farmers. These farmers possess

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relatively small landholdings, which are primarily used to produce food for household consumption, with only limited surplus available for sale.

Staking materials, green manure, mulching, animal feed, manure, fuelwood, and erosion control were identified as major factors influencing the adoption of agroforestry technology in the study area. Similar findings have been reported by Parwada *et al.* (2010) and Owooh (2013), who documented comparable drivers of agroforestry adoption. Other studies (Nkamleu and Manyong, 2005; Parwada *et al*., 2010) also identified additional influencing factors such as sex, farm size, land tenure systems, and labour availability. Agroforestry systems are generally well known for their numerous benefits, which largely determine the types of tree species that can be integrated with crops or other plants. Farmers plant or retain trees on their farmlands for multiple purposes, including food production, income generation, soil fertility improvement, environmental amelioration, and provision of shade during periods of harsh weather (Olatujoye *et al.,* 2025).

Leucaena is a tropical leguminous tree species widely used for controlling land degradation and maintaining or improving soil fertility, as perceived by the respondents (Rusdy, 2020). Its effectiveness in controlling land degradation is attributed to its extensive and dense rooting system, as well as its deep root penetration, which provides both surface and deep-seated erosion control (Osman *et al.,* 2008). The species possesses an aggressive taproot system that helps break up compacted subsoil layers, thereby improving water infiltration into deeper soil horizons. This characteristic enables Leucaena to thrive under dry conditions by accessing deep soil moisture that is unavailable to most herbaceous plants, such as grasses (Anonymous, 2019).

In addition, Leucaena develops profuse lateral roots that grow horizontally, which enhances its ability to reduce surface runoff and control soil erosion (Saifuddin and Normaniza, 2016). The species also contributes to nutrient cycling by recycling leached essential nutrients, including phosphorus (P) and potassium (K), from the subsoil to the surface layers (Otsyina and Dwozela, 1995). Leucaena is capable of growing on steep slopes and marginal lands with prolonged dry seasons, making it suitable for restoring forest cover, watersheds, and grasslands (Anonymous, 2019). As a drought-tolerant species, Leucaena exhibits higher water-use efficiency compared with drought-resistant native grasses such as *Cenchrus ciliaris* (Dalzell *et al*., 2006). Studies by Gladwin *et al*. (2002) and Keil *et al*. (2005) established that the likelihood of agroforestry adoption increases when farmers perceive declining soil fertility as a major production constraint. This perception appears to have contributed significantly to farmers' decisions to adopt agroforestry technologies in the study area.

CONCLUSION

The study revealed that smallholder farmers benefiting from agroforestry technology in Benue State are predominantly older, low-income farmers with limited formal education, small farm holdings, and complete dependence on human labour. The dominance of females among beneficiaries (58.3%) and the high proportion of married farmers (81.7%) indicate that agroforestry practices are closely tied to household livelihood strategies. Neighbouring farmers, although younger and relatively more educated, exhibited low awareness of agroforestry technology, as a majority (66.0%) had never heard of such practices. This low awareness persists despite long-standing agroforestry interventions in the state, the AF technologies-based (*Gliricidia sp, Leucaena* sp and *vertiver grass*) OFAR trials introduced as far back as 1995.

The distribution of agroforestry species (*Gliricidia sp, Leucaena* sp and *vertiver grass)* across the three zones shows a clear preference for *Gliricidia spp. and Leucaena spp*., either singly or in combination, reflecting their adaptability and multiple benefits to farming systems in the area. Adoption decisions were primarily driven by immediate production-related benefits such as staking materials (20.5%), mulching (20.1%), and green manure (20.1%), rather than direct income generation (1.8%). Statistical analysis further confirmed that education, income, family size, farming experience, and farm size significantly influenced agroforestry adoption, while demographic factors such as sex and age were less important.

Based on these findings, it is recommended that agroforestry promotion programs in Benue State should prioritize farmer education and capacity building, particularly through adult literacy programs, farmer field schools, and continuous extension services. Awareness creation should be intensified among neighbouring farmers using effective communication channels such as media and community-based platforms, given their demonstrated influence.

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