Awareness, Adoption and Perceived Benefits of Agroforestry Technologies among Smallholder Farmers in Benue State, Nigeria

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Abstract: Agroforestry technologies (AFT) offer smallholder farmers the potential to improve farm productivity, diversify income, and enhance environmental sustainability. However, adoption remains uneven across farming communities. This study investigated the awareness, adoption, and perceived benefits of AFT 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 administered using "Kobo Collect". The data collected were analyzed through descriptive statistics and a *Likert scale*. The results revealed that all primary beneficiary farmers (100%, n = 60) were aware of AFT, with 86.7% receiving regular extension visits, and extension agents (68.3%) identified as the main information source. Neighbouring farmers' awareness was markedly lower, ranging from 14% to 66% across zones. Adoption duration was substantial, with 53.3% of farmers practising AFT for 16–20 years and 36.7% for 21–25 years. Primary benefits reported included staking materials (MWS = 4.6), increased farm output (MWS = 4.5), fertilizer provision (MWS = 4.4), fuelwood (MWS = 4.3), and mulching/green manure (MWS = 4.3), whereas ecological benefits, such as erosion control, were less recognized (MWS = 2.1). Integration of livestock and crops was common, with goats (44.3%) and yams (60%) most frequently combined with Leucaena species. Secondary adoption among neighbouring farmers was observed, with 78.3% reporting 1–5 secondary adopters. Constraints to adoption included traditional practices (100%) and insufficient extension follow-up. The study shows that awareness and perceived benefits motivate primary users to adopt the practices; however, the spread of these practices to the broader community is still limited. This indicates a need for targeted outreach, participatory methods, and policies that promote both the ecological and economic advantages of AFT.

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Key words: Agroforestry adoption; Benue State; smallholder farmers; Leucaena species; extension services; perceived benefits

1. Introduction

Agroforestry has been widely recognized as a sustainable land-use system that integrates trees with crops and/or livestock to enhance agricultural productivity, environmental stability, and rural livelihoods. In tropical developing countries, agroforestry technologies play a crucial role in addressing land degradation, declining soil fertility, climate variability, and food insecurity while simultaneously improving farm income and ecosystem services (Mbow *et al*., 2014; Siminski *et al*., 2016; Egwumah *et al*., 2022). As a result, agroforestry has gained increasing attention as a viable pathway for sustainable agricultural development, particularly among smallholder farming systems (Getahun, 2022; Roy *et al.,* 2025).

In sub-Saharan Africa, smallholder farmers dominate agricultural production and are highly dependent on natural resources for their livelihoods (Mgbenka and Mbah, 2016; Koroma *et al.,* 2019). However, these farmers often face multiple constraints, including declining soil fertility, limited access to agricultural inputs, and increasing pressure on land resources (Wawire *et al.,* 2021). Agroforestry technologies (such as alley cropping, improved fallow systems, scattered trees on farmland, and home gardens) have been promoted as effective strategies for improving soil fertility, enhancing crop yields, diversifying income sources, and increasing resilience to climate-related shocks (Egwumah *et al*., 2022). Despite these documented benefits, the adoption of agroforestry technologies among smallholder farmers remains uneven and generally low in many parts of Africa.

In Nigeria, agriculture remains a major source of livelihood for most of the rural population, with smallholder farmers accounting for the bulk of food production. Several studies have reported on the potential of agroforestry to improve agricultural sustainability and rural livelihoods in the country (Agera *et al.,* 2019; Egwumah *et al*., 2022; Japheth *et al.,* 2023). Nevertheless, awareness and adoption of agroforestry technologies vary considerably across regions due to differences in socioeconomic characteristics, institutional support, access to extension services, and local farming practices (Bekele *et al*., 2024; Singh *et al*., 2025). Understanding farmers' awareness levels and perceptions is therefore critical for promoting wider adoption of agroforestry interventions.

Benue State, often referred to as the "food basket of the nation," is characterized by intensive smallholder farming and increasing land-use pressure (Ojogbane Singh *et al*., 2025). The predominant farming systems are rain-fed, which are vulnerable to soil degradation and deforestation. Agroforestry technologies have been introduced in various forms within the State, yet their uptake has remained limited (Torhemen *et al*., 2024). This situation raises important questions regarding farmers' awareness of agroforestry practices, the extent of adoption, and the perceived benefits associated with their use.

Perception plays a central role in the adoption of agricultural innovations. Most farmers adopt agroforestry technologies when they perceive clear economic, environmental, and social benefits, such as increased crop yields, improved soil fertility, fuelwood availability, and enhanced household income (Kiyani *et al*., 2017; Torhemen *et al*., 2024; Bhandari *et al*., 2025; Dimobe *et al*., 2025; Gashu *et al*., 2025). Conversely, limited awareness, inadequate technical knowledge, and perceived risks can hinder adoption, even when technologies are demonstrably beneficial. Assessing farmers' perceptions alongside adoption behaviour provides valuable insights into the drivers and barriers influencing agroforestry uptake.

Against this background, this study examines the awareness, adoption, and perceived benefits of agroforestry technologies among smallholder farmers in Benue State, Nigeria. By focusing on farmers' knowledge levels, adoption patterns, and perceived outcomes, the study provides empirical evidence to inform policy formulation, extension programming, and the design of context-specific agroforestry interventions aimed at improving sustainable agricultural development in the region.

2.0 Materials and Methods

2.1 Location of the Study

The study was conducted in Benue State, Nigeria, located within the Lower River Benue Trough of the Middle Belt region. Geographically, the state lies between longitudes 7.50°E and 10.00°E and latitudes 6.25°N and 8.25°N, covering an estimated land area of 34,059 km² (Hula and Ukpong, 2013). Benue State occupies a central position in Nigeria and shares an international boundary with the Republic of Cameroon to the southeast (Figure 1). The state experiences a tropical climate characterized by distinct seasons: a rainy season from April to October and a dry season from November to March. Mean annual rainfall ranges between 1,200 mm and 2,000 mm, while mean annual temperatures vary from 23°C to 38°C. The dry season is influenced by the north-easterly Harmattan winds, particularly between November and February, whereas the south-westerly monsoon winds dominate during the rainy season (Nyagba, 1995; Hula and Ukpong, 2013).

Vegetation in Benue State represents a transition between semi-rainforest and Guinea savanna, consisting mainly of tall grasses, shrubs, and scattered trees, with riparian forests occurring along riverbanks and low-lying areas. The State falls within the Guinea savanna ecological zone, one of the largest vegetation belts in Nigeria (Dau and Chenge, 2016). Common tree species include *Khaya senegalensis, Daniellia oliveri, Isoberlinia doka, Parkia biglobosa, Prosopis africana, Vitellaria paradoxa, Burkea africana, Pterocarpus erinaceus, Afzelia africana, Borassus aethiopum, Bombax costatum, Anogeissus leiocarpa,* and *Irvingia gabonensis* (Dagba *et al.,* 2017). However, continuous vegetation removal through farming, logging, and bush burning has led to widespread secondary regrowth and parkland landscapes, which increasingly attract pastoral activities into the state (Hula and Ukpong, 2013). Topographically, Benue State is characterized by undulating plains with occasional elevations of about 150–300 m above sea level. The geology is dominated by shale, sand, silt, and clay derived from the basement complex, giving rise to rolling hills, residual mountains, inselbergs, valleys, and plains. These physical characteristics, combined with favourable rainfall conditions and ecological transition features, support a wide range of crop and livestock production systems.

Agriculture constitutes the backbone of the state's economy, engaging over 70% of the working population and earning Benue State its reputation as one of Nigeria's major food baskets. Despite this agricultural potential, production systems remain largely traditional, with limited adoption of modern technologies. Mechanization, plantation agriculture, and agroforestry practices are still at relatively early stages of development. Although the use of farm inputs such as fertilizers, improved seeds, and agrochemicals is increasing, high costs and limited accessibility remain major constraints. Major cash crops include soybeans, rice, groundnuts, mango, and citrus, while other crops such as oil palm, melon, African pear, chilli pepper, and tomatoes are also cultivated. Staple food crops include yams, cassava, sweet potatoes, maize, beans, millet, guinea corn, and vegetables. Irrigation agriculture is minimally practised, with limited application of modern irrigation technologies.

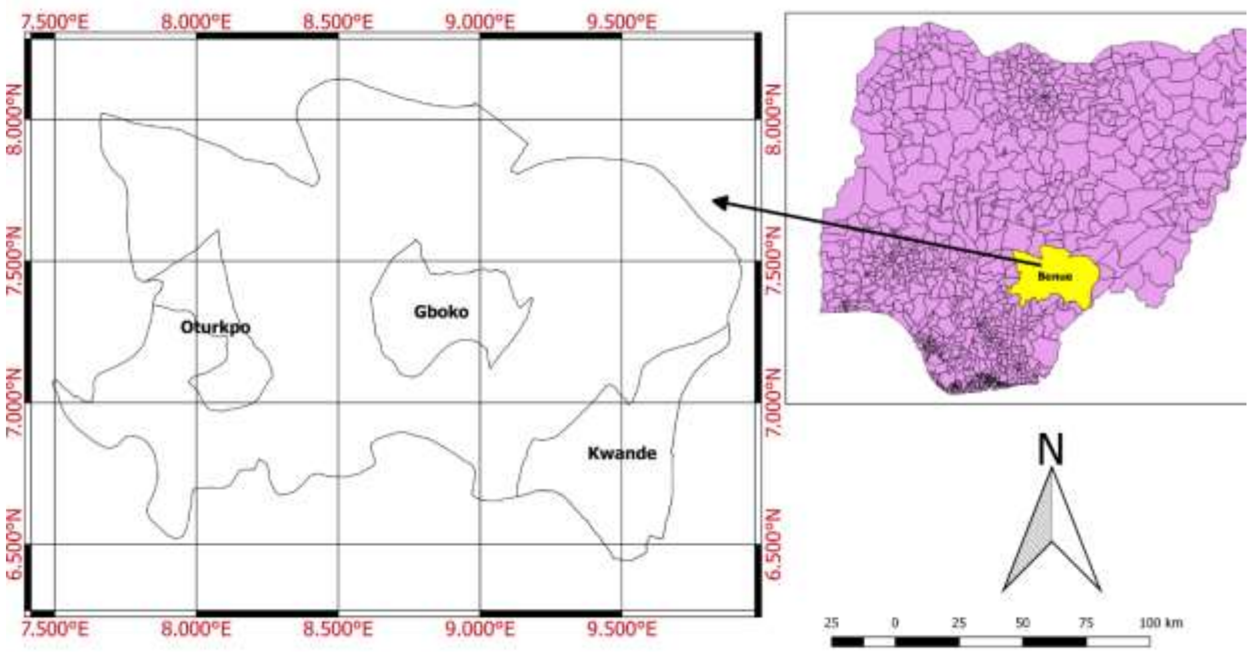

Figure 1: Map of Benue State showing the Study Area
Source: Mapped with QGIS Desktop (version 3.18.3) (2021).

2.2 Data Collection and Analysis

This study adopted a mixed-methods approach, utilizing both primary and secondary data to examine the awareness, adoption, and perceived benefits of agroforestry technologies among smallholder farmers in the study area. Primary data on AF technologies were collected from 60 direct beneficiaries, 300 secondary beneficiaries/neighbouring farmers, and 10 extension agents using semi-structured questionnaires. Data collection was conducted using the *KoboCollect* Toolbox, which facilitated efficient data capture and management.

The questionnaires collected information on farmers' socioeconomic characteristics, levels of awareness, levels of adoption, and perceived benefits of agroforestry technologies. The collected data were coded, cleaned, and screened for outliers before analysis in the Statistical Package for Social Sciences (SPSS version 11.5) and Microsoft Excel.

The data was analyzed using descriptive statistics and based on a *Likert* scale. Descriptive statistics such as means, frequencies, percentages, and tables were used to summarize respondents' characteristics and responses. A five-point Likert scale was used to evaluate the level of awareness and knowledge of smallholder farmers regarding agroforestry technologies (Dagba, 2017). The scale was structured as follows: Strongly Agree (5), Agree (4), Undecided (3), Disagree (2), and Strongly Disagree (1).

The Mean Score (MS) for farmers' awareness was calculated as:

$$MS = \frac{\sum f}{n}$$

$$MS = \frac{1+2+3+4+5}{5}$$

$$MS = 3.0$$

where f represents the sum of the Likert scale ratings, and n is the number of scale points.

The Weighted Mean Score (WMS) was computed as:

$$WMS = \frac{\sum_{i=1}^{n} f_i x_i}{N}$$

where f is the frequency of responses, x is the Likert scale value, and N is the total number of respondents.

Using an interval scale of ±0.05, a mean score of 3.0 served as the benchmark. Scores below 2.95 were categorized as *Disagree*, scores between 2.95 and 3.05 as *Moderate*, and scores above 3.05 as *Agree*. Adoption levels of agroforestry technologies were assessed using percentage adoption categories: 0–20% (Low adoption), 21–40% (Moderate adoption), 41–60% (High adoption), 61–80% (Very high adoption), and 81–100% (Excellent adoption).

3.0 Results

3.1 Benefits Derived by Farmers from the Adoption

of AFT in the Study Area

The result of the study, as presented in Table 1, revealed that (100%) of the benefitting farmers were aware of AF Technology in the area. Across the three zones, farmers reported varying levels of contact with extension staff (Figure 2). In Zone A, 20% of respondents indicated that they had not received visits from extension personnel, while 80% reported receiving such visits. In Zone B, 23.8% of respondents stated that they had not been visited by extension staff, whereas 76.2% confirmed that they had. In Zone C, all respondents (100%) reported receiving visits from extension staff, with no respondents indicating otherwise. The majority (68.3%) of the respondents stated that their major source of information on the OFAR trial in AF technology was extension agents (Figure 3).

Table 1: Awareness of Smallholder Farmers Benefiting from the Agroforestry Technology in the Study Area

Variables		Frequency	Percent
Awareness of AF Technology	Yes	60	100.
	No	0	.0
	Total	**60**	**100.0**
Visits by extension staff	No	8	13.3
	Yes	52	86.7
	Total	**60**	**100.0**
A major source of information on Agroforestry technology	association/group meeting	7	11.5
	Extension agent	41	68.3
	Relative	2	3.3
	community meeting	17	28.3
	Total	**60**	**100.0**

The level of awareness of agroforestry technologies among neighbouring farmers varied across the three zones (Figure 3). In Zone A, 34% of respondents reported that neighbouring farmers were not aware of agroforestry technologies, while 66% indicated that they were aware. In Zone B, 86% of respondents stated that neighbouring farmers lacked awareness, whereas 14% affirmed awareness. In Zone C, 77% of respondents reported no awareness among neighbouring farmers, while 23% indicated that neighbouring farmers were aware of agroforestry technologies.

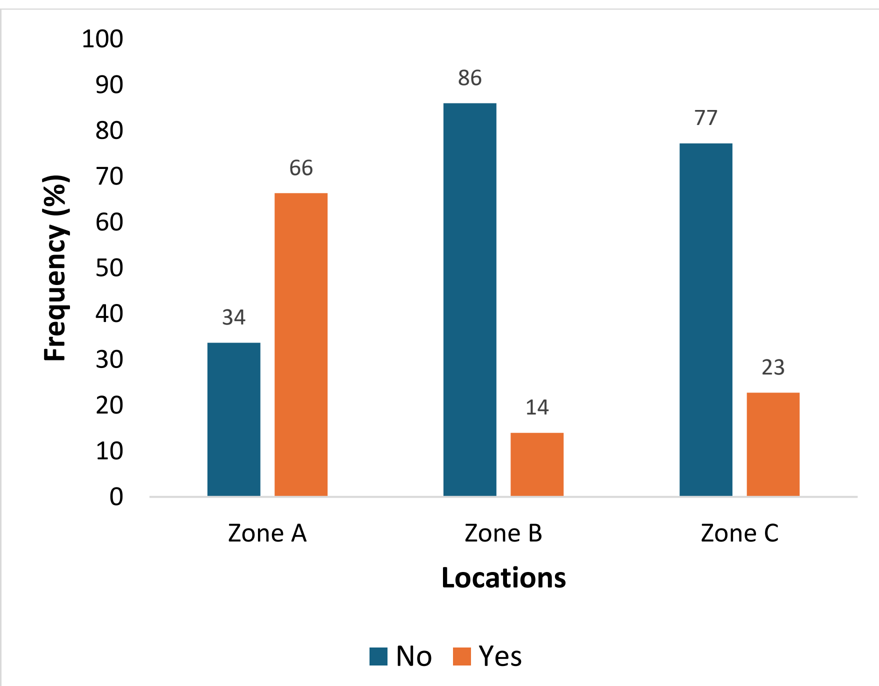

Figure 2: Neighbouring Farmers' Awareness of AFT in the Study Area

Neighbouring farmers received information on agroforestry technologies from multiple sources (Figure 5). Association and group meetings accounted for 27.1% of reported information channels, while community meetings contributed 18.6%. Extension agents were identified as the most prominent source at 28.8%. Friends provided 10.2% of the information, and relatives accounted for 6.8%. Traditional chiefs represented 1.7% of reported sources, while other unspecified channels contributed an additional 6.8%.

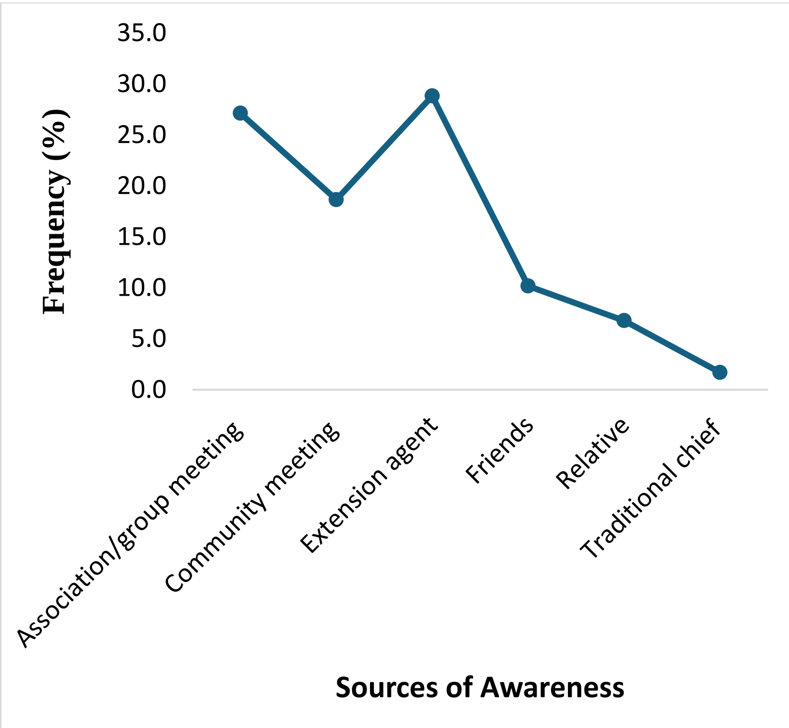

Figure 3: Neighbouring Farmers' Awareness Sources of AFT in the Study Area

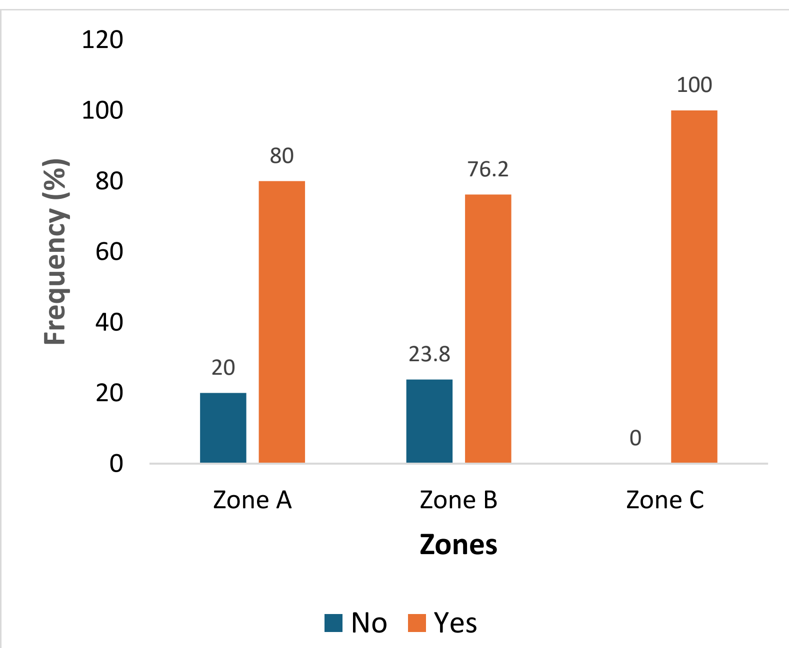

Figure 4: Smallholder Farmers' Response to Visits by Extension Staff in the Study Area

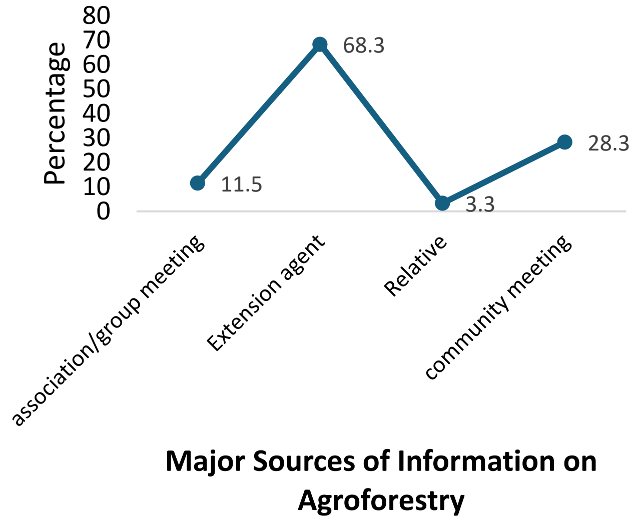

Figure 5: Smallholder and Neighbouring Farmers Major Sources of Information on Agroforestry Technology in Benue State, Nigeria

3.2 Perceived Benefits of AF Technology Experienced by the Smallholder Farmers in the Study Area

In Zone A, alley cropping and erosion control each accounted for 25.0% of the reported benefits influencing farmers' adoption of agroforestry technologies (Figure 6). This was followed by using agroforestry species as feed for animals (16.7%), while green manure, mulching, staking material, and other categorized benefits each constituted 8.3% of the adoption motivations.

In Zone B, the most frequently reported benefit was the availability of feed for animals, representing 30.8% of respondents. Alley cropping contributed 23.1%, whereas green manure, mulching, and staking material each accounted for 15.4% of the identified benefits. Erosion control and other benefits were not reported by respondents in this zone. In Zone C, erosion control overwhelmingly dominated adoption motivations, with 76.9% of respondents citing it as the primary benefit. Alley cropping accounted for 15.4%, while other benefits represented 7.7%. Benefits related to feed for animals, green manure, mulching, and staking materials were not indicated by farmers in this zone.

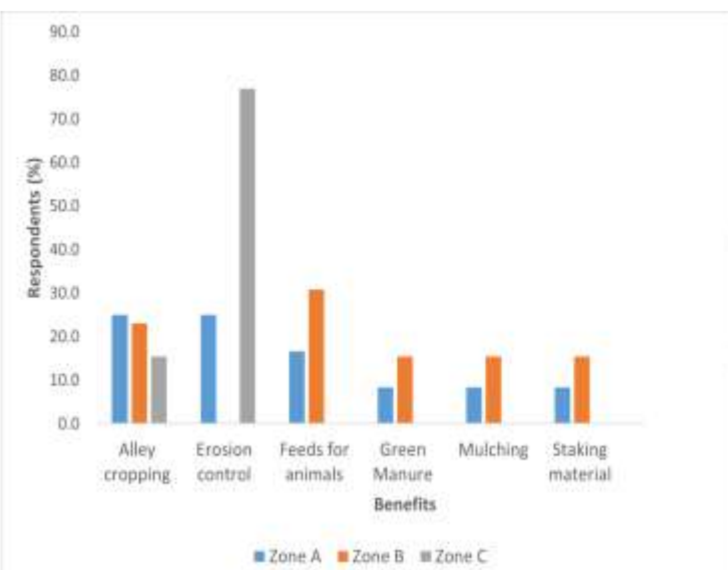

Figure 6: Benefits Influencing Farmers'

Decision to Adopt Agroforestry Technologies Across the Study Zones

Table 2 revealed that smallholder farmers in the study area adopted and practised the AF technology for an extended period. Most of the farmers (53.3%) adopted and practised the system for between 16 – 20 years, and 36.7% adopted and practised the system for between 21-25 years. However, 3.3% of the farmers adopted the system between 1-10 years.

Table 2: Period of Practising the selected Agroforestry Technology by Smallholder Farmers in the Study Area

Variables	Frequency	Percent
1-10 years	2	3.3
11-15 years	3	5.0
21-25 years	22	36.7
31 years and above	1	1.7
16-20 years	32	53.3
Total	**60**	100.0

The majority (90%) of the respondents (Figure 7) reported that *leucaena* species adoption was very high by the farmers, while 10% reported high adoption and practice of AF technology. Eighty percent (80%) of the respondents reported that *Vertiver* grass adoption was very high, 10% each reported low and very low adoption of *Vertive*r grass AF technology in the study area, respectively. Fifty percent (50%) of the respondents reported very high farmers' adoption of Gliricidia sp, (30%) of the respondents reported moderate adoption of *Gliricidia* sp, while (20%) reported high adoption and practice of Gliricidia sp AF technology in the area (Figure 7).

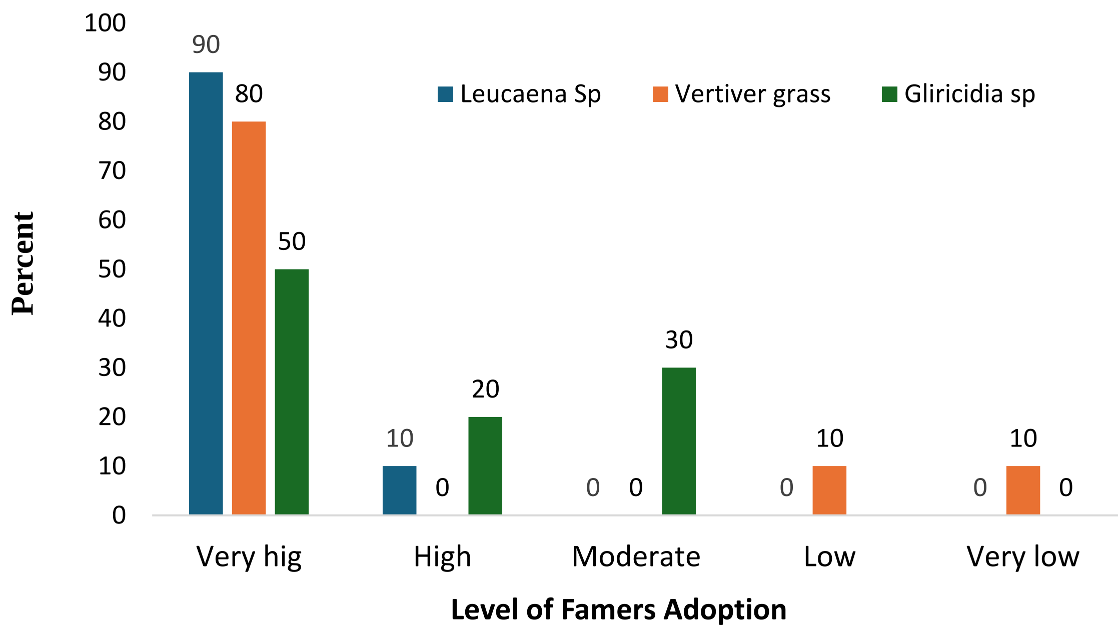

Figure 7: Rating the Level of Farmers' Adoption of AF Technology in the Study Area

Table 3 shows that the communities' adoption of AF technology was 70%; (10%) of the extension agents scored communities at 50% and 100% levels of adoption, respectively. Eighty percent (80%) of the extension agents stated that the last time the OFAR trial AF technology was assessed or evaluated in the study area was more than 4 years ago; however, (10%) of the agents stated that evaluation was done less than 4 years ago. Traditional Practice was the major (100%) resistance that was encountered during the promotion of AF extension in the area.

Table 3: Adoption of AF Technology by Community in the Study Area

Variable	Rating	Frequency	Percent
Rate the level of adoption of the technology per community/settlement	100%	1	10.0
	50%	1	10.0
	70%	8	80.0
Last assessment/evaluation of Leucaena sp agroforestry technology performance carried out	<3 years	1	10.0
	3- 4 years ago	1	10.0
	More than 4 years	8	80.0
	Total	**10**	**100.0**
Resistance encountered when trying to promote Agroforestry extension	Traditional Practice	10	100.0
	Religious believes	0	0
	Emerging technology	0	0
	Total	**10**	**100.0**

The results on the perception of smallholder farmers based on the benefits of AFT in the study area (Table 4), indicate that responding farmers perceived that agroforestry significantly increases their farm output (MWS=4.5). They agreed (MWS=4.4) that AF technology serves as fertilizer to crops on the farmland. AF as staking materials (MWS=4.6), windbreaks (MWS=3.9) to protect farmlands. Other benefits of AF stated by respondents were used as Fuel wood (MWS=4.3), treatment of disease (MWS=3.8). However, they did not agree that (MWS=2.1) it can be used for erosion control, a cheap source of fodder (MWS=2.2), making mixed farming easy and demarcation (MWS=2.7).

Table 4: Perception of Smallholder Farmers on Benefits of AF Technology in the Study Area

Benefits	SA	A	U	D	SD	MWS
Use it as staking material for the farm	66.7	28.3	6.7	–	–	4.6*
AF increases farm output	56.7	41.7	1.6	–	–	4.5*
Serves as fertilizer to crops	40	60	1.6	–	–	4.4*
Mulching material / green manure	43.3	50	6.7	–	–	4.3*
Fuelwood needs	50	36.7	13.3	–	–	4.3*
Windbreak to protect the farm	30	41.7	16.7	11.6	–	3.9*
Treatment of animal/bird diseases	38.3	35	10	11.7	–	3.8*
Shade/shelter for domestic animals	38.3	35	18.3	–	–	3.8*
Alternative source of income	30	41.7	13.3	15	–	3.8*
Timber/furniture materials	28.3	21.7	18.3	31.7	–	3.4*
Fencing/boundary demarcation	41.7	35	15	8.3	–	2.7*
Mixed farming easy	45	21.7	8.3	23.3	1.7	2.2ns
Cheap source of fodder	40	36.7	15	8.3	–	2.2ns
Erosion control	28.3	35	23.3	15	–	2.1ns

Where: SA=strongly agree; A=agree; u=undecided; D=disagree; SD=strongly disagree.

Figure 8 shows the result on the level of secondary adoption of AF technology. Secondary adopters are the farmers who adopted technology after observing its benefits from primary users or early adopters. The figure presents farmers' perceptions of how widely and effectively these technologies have been adopted within their communities. Most (78.3%) of the farmers reported strong awareness, acceptance, and replication of agroforestry practices among neighbouring farmers, while 3.3% reported limited spread, possibly due to factors such as inadequate extension support, lack of resources, or low awareness. This result helps to assess the diffusion and sustainability of agroforestry innovations, showing how knowledge and practices are transferred from early adopters to the wider farming population in the study area.

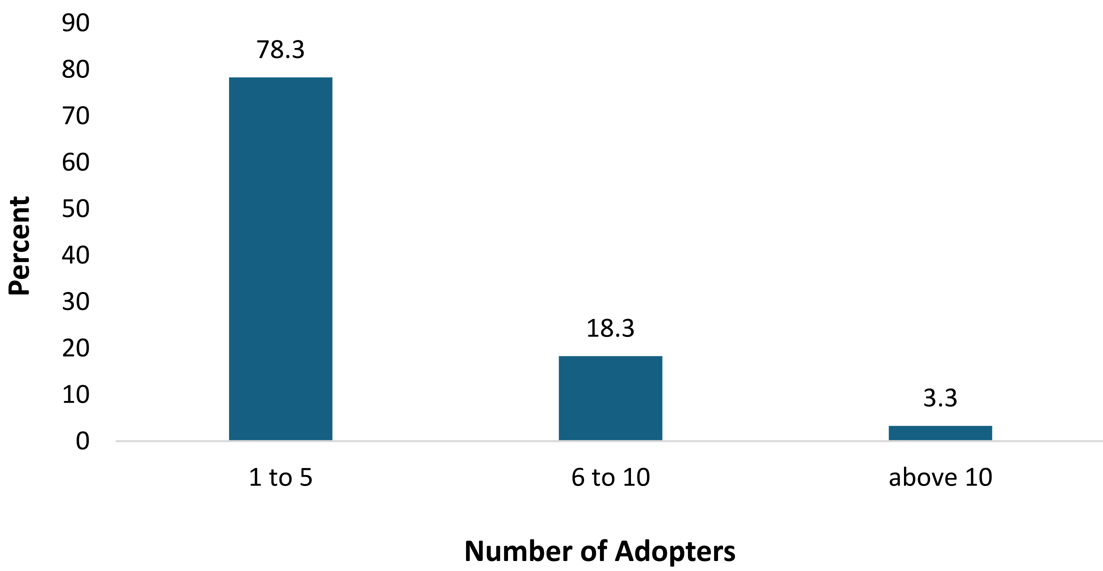

Figure 8: Rating the level of Secondary adopters of AF Technology by Smallholder Farmers in the Study Area

The results of the study, as presented in Figures 9 and 10, show the animals and crops that are combined with Leucaena sp in the study area. Goats were mostly (44.3%) combined with *Leucaena sp* as a benefit derived from the adoption of AFT in the area. The low percentage (13.1%) of the respondents reported that they combine pig alongside *Leucaena sp*, (6.6%) combined sheep and some of the respondents (3.3%) combined birds alongside *Leucaena sp* on the same land, however, (32.85) of the respondents reported other species, such as cattle and donkey in combination alongside *Leucaena species* in the area.
Results on crops cultivated alongside *Leucaena species* showed a high number (60%) of the farmers cultivating yam crops alongside *Leucaena species*, thus, was followed by 26.7% of the respondents who cultivate maize, 11.6% cultivate cassava crops, however, a few (1.7%) of the respondents reported that they cultivate soya beans alongside *Leucaena* species in the study area.

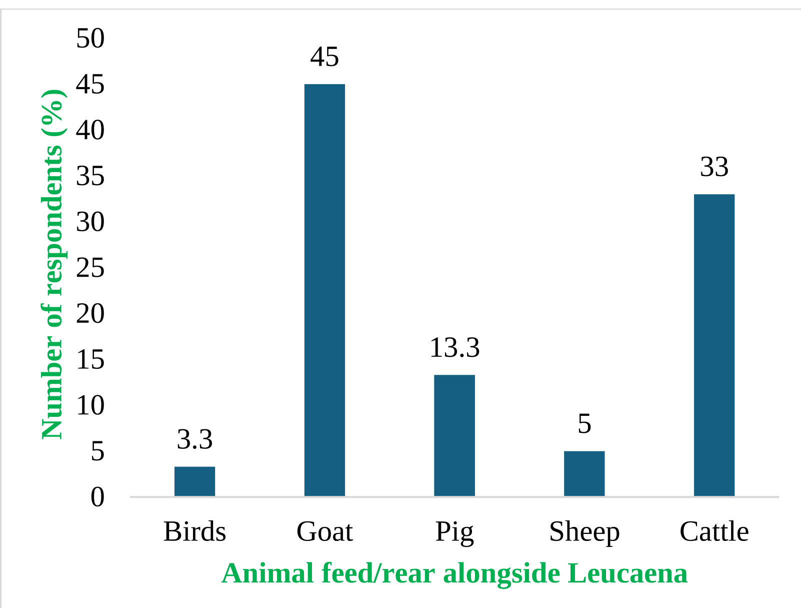

Figure 9: Agro-Pastoral by Smallholder Farmers in the Study Area

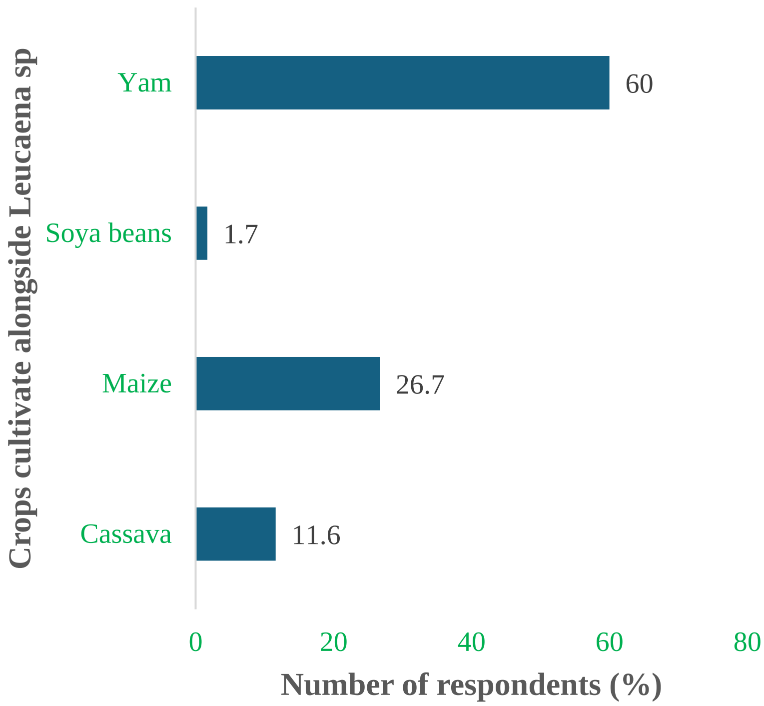

Figure 10: Agro-forestry by Smallholder Farmers in the Study Area

4.0 Discussion

4.1 Awareness and Adoption of Selected Agroforestry (AF) Technology by Smallholder Farmers in Benue State

Results on the level of adoption show that appreciable proportions of the farmers were quite knowledgeable in farming and could easily perceive new, improved ideas. This implies that with more years of AF technology farming experience, farmers tend to be more efficient in production through learning by doing. There was a higher level of adoption among the trial farmers than the neighbouring farmers. This could be because pilot farmers were exposed more to the benefits of AFT than the neighbouring farmers. A similar experience was reported by Parwada *et al.* (2010) in Zimbabwe. The study indicates that there is an increased likelihood for farmers in the area to adopt Agroforestry technologies if they are well exposed to the benefits of AFT.

Adoption occurs when one has decided to make full use of new technology as the best course of action for addressing a need (Rogers, 2003). Adoption is influenced by various factors, including socioeconomic conditions, environmental factors, and psychological processes. These are shaped by a range of intervening variables, such as individual needs, knowledge of technology, and personal perceptions regarding the methods used to fulfil those needs (Thangata and Alavalapati, 2003). Results on the level of adopting *Leucaena leucocephala* Agroforestry (AF) Technology by smallholder farmers in the study area indicate that the smallholder farmers who have adopted the practice of AF technology had also been practising the system for a long period of time, with most of the farmers being into the practice for not less than 10 years. This was an indication that AF system has been in existence for a long period of years; with the existence of this system of farming in the study area, the adoption level could be said to be too low, and the practice of AF technology is very slow and calling for urgent action to improve the rate of adoption of the system in the study area.

AF technology has numerous benefits ranging from soil nutrients improvement, environmental control/management, conserving microorganisms and improvement of crops and plants for sustainable development and global warming mitigation. The early adopters of AF technology in the study area can be encouraged to sensitize those farmers that are yet to adopt and start practising the AF system of farming in Benue state. Successful adoption depends on favourable convergence of technical, economic, institutional and policy factors (Rogers, 2003). Adekunle *et al.* (2009) reported that the level of education of farmers will directly affect their ability to adapt to change and to accept new ideas. Farmers who acquire some level of education are more likely to perceive new technologies than those who have no form of education (Jamala *et al.,* 2013).

The result of rating the level of adoption of AF technology by farmers, which was evaluated through extension agents in Benue state, indicates a very high adoption of *Leucaena species, Vertiver grass and Gliricidia* species AF technology system in the study area. This result implies that there is a clear understanding of the system of AF technology by a few smallholder farmers who have adopted and practised AF technology in the area. This result could be due to numerous benefits derived from AF technology, which the farmers have experienced or benefited from during their early stage of adoption of the system in the area. Also, the literacy level of farmers is important as it determines the rate of adoption of improved technology for increased productivity (Amaza and Tashikalma, 2003).

The result of the adoption of AF technology by communities implies that there was a high level of adoption by the communities in the study area. This report was the perception of the extension agents; though the number of smallholder farmers that indicated adoption and practice of AF technology was very low (61 farmers) out of the 300 returned copies of the questionnaire for this finding, this gave a total of 20.1% of all smallholder farmers that adopted and practised the OFAR trial technology. Therefore, the report on extension agents on the level of adoption by communities was high, while the level of adoption by individual farmers was very low (20.1%).

The difference in the level of community adoption and individual farmers' adoption of AF technology in Benue state could be due to inadequate follow-up among extension agents after sensitization of farmers on innovation. Franzel *et al.* (2001) observed high adoption of agroforestry technologies by farmers. While a separate study conducted by Ajayi (2007) shows that adoption of these technologies is low. According to Phiri *et al.* (2004) and Keil *et al*. (2005), farmers who are involved in on-farm experimentation of agroforestry technologies with the researchers are more likely to adopt than those who are not. Keil *et al*. (2005) also considered information and knowledge about a given technology as key to the adoption of agricultural practices, especially those associated with ecological benefits.

The successful adoption of Leucaena in Queensland is directly linked to the same five key factors highlighted by Shelton *et al*. (2005) in their review of the adoption of tropical forage legume technology worldwide. These are: the technology that meets the needs of farmers; relevant partnerships have been developed between farmers and rural development agencies; the socio-economic context and skills of farmers have been understood; participatory involvement with rural communities has occurred; and there has been commitment from long-term champions of the technology. Social factors also drive the adoption of *Leucaena* pastures, with many ageing farmers wanting a more relaxed lifestyle by moving away from high-risk, labour-intensive farming to become cattle managers. Some farmers have increasing concerns over frequent/persistent shortfalls of rain and the impact that global climate change might have on the future of dry land cropping (Japheth *et al.,* 2023).

4.2 Perceived Benefits of AF Technology Experienced by the Smallholder Farmers in the Study Area

The result of the perception of smallholder farmers on the benefits of AF technology indicates that the farmers perceived AF technology as playing a significant role in their livelihood in the study area. AF tree species serve the purpose of wind break, erosion control, soil stabilization, source of food, medicine and income in the study area (Parwada *et al.,* 2010, Ibrahim *et al.,* 2019). In this study, the major benefit of AFT, as reported by the farmers, was staking of yams; this could be because yams are the major crop of the farmers in the area.

Cassava, maize, yams, soybean, among others, were the most cultivated crops alongside *Leucaena* species. Agroforestry technologies offer an alternative solution to resource-constrained smallholder farmers, who, in the absence of inorganic fertilizers would otherwise grow crops without addressing nutrient requirements and harvest little or nothing for storage (Jamala *et al.*, 2013*)*. Among *Leucaena* litter components, leaf litter contributes more nutrients, especially nitrogen (N), than other litter components. The high biomass production, N content and decomposability of *Leucaena* leaves indicate its greater potential for use as green manure (Mwiinga *et al.*, 1994) to farm crops when combined alongside *Leucaena* species.

The results on the benefits of AF technology to the farmers in the study area revealed that birds, goat, pigs, and sheep, among other animals, were reared alongside *Leucaena* species. The high nutritive value of *Leucaena* species makes *it* the best forage supplement to increase animal production and feed elephant grass basal diets (Rusdy 2020). *Leucaena* in combination with grass pasture is one of the most persistent, productive and sustainable grazing systems used in north Australia (Shelton and Dalzell, 2007). For these reasons, the establishment of *Leucaena* can be a technology of choice for increasing sustainable animal production from tropical grassland (Rusdy, 2020).

Successfully grown *Leucaena* can produce sufficient nitrogen for its own needs, and intercropping with companion grass maximizes pasture production because the grass can utilize the excess fixed nitrogen to enhance its growth and create a strong ground cover, which helps prevent soil erosion and control weeds

(Shelton and Dalzell, 2007). In a grassland area where the animals cannot reach *Leucaena* leaves, litter-fall is the major pathway of nutrient cycling (Apolinario *et al.*, 2015).

Animals fed a mixture of *Leucaena* and *Megathyrsus maximus* had higher intake of crude protein, calcium, and fat and lower NDF and ADF intake than those fed *M. maximus* monoculture (Cuartas *et al.*, 2015). Inclusion of *Leucaena* at a 24% level in growing heifers fed a basal diet of *Cynodon plectostachyus* increased dry matter intake from 2.02 to 2.47% DM of animal live weight (Molina *et al*, 2016). Daily dry matter intake of goats fed basal diets of *Panicum maximum* plus 100g maize bran (control) was 229 g, but increased to 339g when the control diets were supplemented with *Leucaena* (Saha *et al.*, 2008). The higher digestibility and intake of *the Leucaena–grass* mixture over grass monoculture can be attributed to the lower ADF and NDF contents of the intercrops compared to grass monoculture, respectively.

5.0 Conclusion

The study shows that awareness and adoption of agroforestry technologies in Benue State are highly dependent on farmer exposure, extension support, and perceived immediate benefits. Primary beneficiary farmers exhibited full awareness (100%) and long-term engagement (53.3% for 16–20 years; 36.7% for 21–25 years), with key benefits including staking materials, crop yield improvement, and nutrient supplementation. Neighbouring farmers exhibited significantly lower awareness and adoption, indicating limited diffusion of knowledge and practice. Livestock and crop integration were common, reflecting the multifunctional role of AFT in smallholder systems. Barriers to adoption were primarily rooted in traditional practices and inadequate follow-up by extension agents, while benefits with longer-term ecological impacts, such as erosion control, were less recognized. Based on the results from this study, it is recommended that the frequency and quality of extension visits be improved to improve awareness and support among neighbouring farmers, promoting secondary adoption. Develop policies that incentivize adoption, including the provision of improved seedlings, technical support, and recognition of best practices to ensure the sustainable scaling of agroforestry technologies.

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