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Impacts of Climate Variability on Agricultural Activities and Availability of Agroforestry Practices in Southeast Nigeria

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Climate variability poses a significant challenge for smallholder farmers globally, including those in Southeast Nigeria. The purpose of this study is to explore farmers' perceptions of the impact of climate variability and agroforestry practices available in the region. Specifically, the study evaluates the availability of agroforestry practices for adoption by farmers and the extent of climate variability effects on agricultural activities in Southeast Nigeria. The study employed primary data, which were collected from 350 registered farmers in the study region using a validated and well-structured questionnaire. The study employed a structured questionnaire to gather data on the availability of agroforestry practices among farmers in Southeast Nigeria as well as utilized a seven-item scale to assess the perceived impacts of climate variability on agricultural activities in Southeast Nigeria. Findings revealed that home gardening emerged as the most prevalent agroforestry practice among respondents, while multipurpose wood lots were the least common. The mean ratings for all thirteen agroforestry practices were below the critical threshold of 3.00, indicating a lack of widespread availability. Thus, there is a limited adoption of these practices among farmers in the region. Irregular rainfall and rising temperatures were identified as the most significant climate variability impacts on farming operations. However, extreme events like storms, hailstorms, and thunderstorms had the least impact according to respondents, indicating that farmers perceive these impacts as significant and pressing concerns. The study concludes that there is a high level of climate variability impacts on agricultural practices in Southeast Nigeria, coupled with a low availability of agroforestry practices for farmers to mitigate these impacts. The study suggests enhancing agricultural extension services, developing tailored extension programs, advocating for governmental support and investment, providing technical support and capacity-building assistance to farmers, investing in research and innovation, and fostering collaboration among stakeholders to promote the adoption of agroforestry practices as a climate-resilient agricultural approach.
Keywords: Agroforestry practices, climate variability impacts, Southeast, Nigeria.

INTRODUCTION

Nigeria is the most populated nation and richest nation in Africa and a leader in development. The current population of Nigeria is 227,749,665 as of Wednesday, March 27, 2024, based on Worldometer elaboration of the latest United Nations data. Groundnut exports from Nigeria accounted for 42% of global production. In addition, the nation was the largest exporter of cotton in West Africa, accounting for 1.4% of global exports, 18% of cocoa, and 27% of the world's palm oil shipments. Nigeria's GDP (gross domestic product) and most of its export earnings came from agriculture until the early 1970s. Nigeria's abundant petroleum and fertile land resources allow the nation to become self-sufficient in food and other necessities. The country also boasts an internal market for the production of a wide range of consumer products. The administration does, in fact, want to take Nigeria back to the prosperous 1960s, when it was a net exporter of a wide range of goods. But as oil began to flow freely in the 1970s, the nation lost its boom. The environmental effects of climate variability have decreased agricultural productivity. Considering adaptation to climate variability, agroforestry has the potential to moderate climate extremes in particular high temperatures as well as intra-

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annual climatic fluctuations. For millions of African farmers whose livelihoods are in jeopardy due to land degradation and climatic unpredictability, agroforestry offers a route towards more resilient livelihoods. Prehistoric land use practices were also called agroforestry which is a combination of agriculture and forestry (Okonkwo, 2016). It started with hunting and gathering lifestyle and culture inclusive. Human has developed a strategy for sustainable survival (Bryah *et al.*, 2009). Agroforestry is a type of farm forestry that motivates a planned combination of woody perennials with crops and animals on the same platform to improve soil fertility and grow the farmer's income from the proceeds of the economic trees (Uyigue and Agbo, 2007). Agroforestry improves the local climate and soil fertility while generating income and assets from carbon and wood energy. It reduces the impact of humans on natural forests while providing ecological benefits. While impacting the global atmospheric greenhouse gas concentrations, the majority of these advantages have first-hand local adaptation (Adejuwon, 2002). The main objective of this study is to assess the impact of climate variability on agricultural activities of farmers practicing agroforestry in Southeast Nigeria. Specifically, the study assessed agroforestry practices available for farmers to adopt in the region and investigated the scale of climate variability Impacts on agricultural practices in the region.

***Agriculture and Agroforestry in Nigeria*:** Nigeria has the local market to produce several retailer's goods also because of rich resources in crude oil and fruitful lands the country can depend on itself for food production and other needs (FAO, 2017). The goal of the administration is to return Nigeria to its heyday in the 1960s when it was a net exporter of several items. Numerous areas are impacted by monocropping or deforestation. By enhancing soil fertility, fortifying water retention, and raising crop yield, agroforestry techniques helped restore the biological productivity of the land (Ekpe and Ukpong, 2015). The sustainability of agricultural development is a major challenge faced at the international policy levels considering the rapid depletion of natural resources which leads to the development of agroforestry (Bryah *et al.*, 2009). According to (Nunes and Seixas, 2003), a greater percentage of Nigeria's Gross Domestic Product is from agriculture, and many people living in rural areas are employed in this sector. The slight role of agriculture can contribute a major impact on climate deterioration and can lead to destructive socioeconomic outcomes.

***The Concept of Agroforestry*:** Agroforestry is an adaptive technology that can reduce soil erosion and enhance carbon storage capacity. It is a dynamic system that sustains itself through various practices adopted by farmers. These practices will have an impact on climate variability and integrate them into climate variability adaptation measures. It is important to understand the adaptive capacity of farms as they deal with changing risks in the environment. Agroforestry is also called a land use system or farming system where trees or shrubs are cultivated in combination with crops, and livestock and there is ecological and economic interaction among the components. It is made up of the environment, plant species and ordering administration, social and economic functions. According to Nair (1991), yams, maize, pumpkins, and beans were all cultivated together in Southern Nigeria beneath a canopy of scatted trees. He emphasized that the Yoruba tribe of Nigeria has long used an intense method of combining shrubs, tree crops, and herbaceous plants, and he said that this is how they save human energy by making use of the little area they have taken from the thick forest. The tribe further states that this is an inexpensive way to prevent erosion and nutrient leaking while maintaining the fertility of the soil. According to Alao and Shuaibu (2013), useful practices for adjusting to climatic variability in Ethiopia and Kenya include fodder banks, live fences, boundary planting, enhanced fallows, alley farming, rotating woodlot establishment, silvopasture, riparian forest buffers, and forest farming.

***Agroforestry and Technology Transfer*:** Agroforestry, a worldwide practice of clearing fallen woods, burning the slash, planting trees at the beginning, throughout, and finish of crop sowing, was first seen in Europe. Farmers in Central America have long followed a custom of cultivating an average of two dozen different plant species on plots larger than tenths of a hectare (Wilken, 1977). A more intricate kind of shifting farming was used in the Philippines. To prevent the land from being overexposed to the sun during the growing rice season, certain trees are purposefully left standing after the forest is cleared for agricultural use. Conklin (1957) states that the method of farming was either cultivated or shielded from the natural forest to provide food, medicine, building timber, and cosmetics. According to Nair (1991), certain crops were grown under the covered, scatted trees, including beans, yams, maize, and pumpkin. He illustrates how the Yoruba tribe has long used an intense construction that combines shrubs, trees, and herbaceous plants, proving that the structure is a way to preserve human energy by using all of the restricted space found in the dense forest. The Yoruba attested that this construction is an inexpensive means of preventing erosion and nutrient leakage in addition to preserving soil fertility. One such technique is agroforestry, which blends forestry and agriculture in a way that can enhance environmental health, lessen the consequences of climatic variability, and boost food security (FAO, 2017). Agroforestry is an adaptive technology that can reduce soil erosion and enhance carbon storage capacity. It is a dynamic system that sustains itself through various practices adopted by farmers. These practices will have an impact on climate variability and integrate them into climate variability adaptation measures. It is important to understand the adaptive capacity of farms as they deal with a changing risk environment. The technology transfer of agroforestry is defined as the process by which technology, or a set of technologies is moved from the field to the farm or farm home. To address the impacts of climate variability, the government of Nigeria has developed and implemented various adaptation strategies. These strategies include improving water management, developing drought-resistant crops, and enhancing disaster preparedness (Nigeria National Adaptation Plan of Action, 2013). The main aim is to create an ecological balance in a country. Agroforestry has been defined as an international term that came into existence in 1951, and it is understood as a bridge between crop and livestock production, providing benefits to both agriculture and the environment. Agroforestry also comprises intercropping, shelterbelt planting, and agroecosystems such as silvopasture systems integrated with crops grown under tropical rain forest trees' canopy. According to current research, agroforestry is being used by farmers and farming families, particularly in rural areas, to adjust to the adverse effects of climate change, which might have an impact on agricultural productivity (Mohammed, 2017). According to Syampungani *et al.* (2010), who investigated agroforestry's potential applications as a win-win response to climate change, agroforestry can assist farmers who have experienced droughts, floods, and unpredictable rainfall in maintaining their agricultural output and improving their standard of living. According to Verchot *et al.* (2007), agroforestry technologies are also dynamic because they can boost agricultural output in both wet and dry seasons. This is because trees cultivated on farmland can pump excess water from the soil and decrease runoff during wet seasons, and during dry spells, their deep roots can find large amounts of water as well as nutrients within the soil to boost agricultural output. Agroforestry systems are a potential solution for farmers in rural regions to adjust to climate change since they are more adaptable to extreme weather than any other agricultural method. Some farmers in Ghana have adopted agroforestry as a means of adapting to climate change (Mohammed, 2017). To better manage the challenges posed by climate change, some farmers in the Brong Ahafo Region are more willing to plant or maintain trees on their farms. This is because these farmers have recently gained some understanding of environmental and climate change management practices thanks to the activities of environmental non-governmental organizations. The implementation of agroforestry technology and the provision of appropriate extension services to farmers and farming households regarding excellent agricultural agronomic practices are critical to raising agricultural productivity. Scheir and Franzel (2002) state that one of the main obstacles to boosting the adoption of agroforestry technologies in underdeveloped countries is the lack of national extension lead services. Other related factors influencing the adoption of agroforestry include the government's weak and limited funds for extension systems, the lack of suitable training for lead agents in agroforestry change, the absence of locally organized extension content, and the ambiguity surrounding the functions and duties of forestry extension service personnel and agricultural institutions (Mohammed, 2017).

Climate Variability**:** Climate variability is a current issue around the globe. The rise in carbon dioxide (CO_2) by industrialization, fossil fuel burning, etc can cause a subtle climate variability. Greenhouse gases including CO_2, N_2O, CH_2, CFC, etc are the foremost region behind global warming leading to changing climate. Carbon dioxide (CO_2) is the main heat-trapping gas that has been responsible for average warming for several decades (Toppo and Raj, 2008). Earth's biodiversity is greatly influenced by unusual climates leading to the degradation of natural resources and the environment. Variability in weather such as rainfall patterns causes floods and drought not only affects agricultural production but also influences the emergence of several infectious diseases. Agroforestry is an important component in the fight against climate variability. However, its impact on the ecosystem has not been fully understood because of a lack of operational research/experimentation. The paper investigates how agroforestry affects climate variability using disturbance and natural experiment approaches, and then discusses some potential implications of agroforestry on climate variability impact through planting mangrove trees (Rhizophora mangle). Climate variability affects the livelihoods of the farmers, eventually leading to their displacement from their land. Through the adoption of agroforestry technology, farmers can create income opportunities, increase sustainability, and improve climate resilience. The positive impacts this technology has on the environment and its benefits to modern farming practices must be understood by policymakers and farmers so that they can use this method to adapt to climate variability.

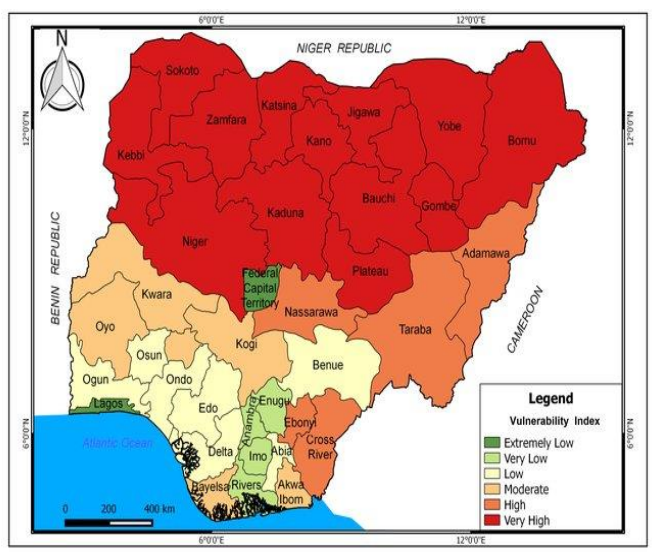

Figure 1. The Pattern of Climate Variability Vulnerability in Nigeria uploaded by Ignatius Ani Madu.

***Climate Variability Impact on Agriculture*:** In Yobe State Nigeria, a study conducted shows that dunes and desert encroachment have covered from 25,000 hectares to more than 30,000 hectares with its attendant negative impact on food and livestock production. In 2008, the Nigerian Environmental research/Action Team (NEST) did research on climate variability in Nigeria and found that the people living in coastal regions were negatively impacted by climate variability in several sections of the country's southern region. Numerous factors, such as unknowns and fluctuations in rainfall patterns, floods, and devastated farmlands, contribute to climate variability and its effects on agricultural productivity. Additionally, pests and illnesses spread due to climatic variability. The country's northern regions are notably prone to significant drought and flooding, which have an impact on agriculture, and animal production the majority of which is fed by crops and harvests.

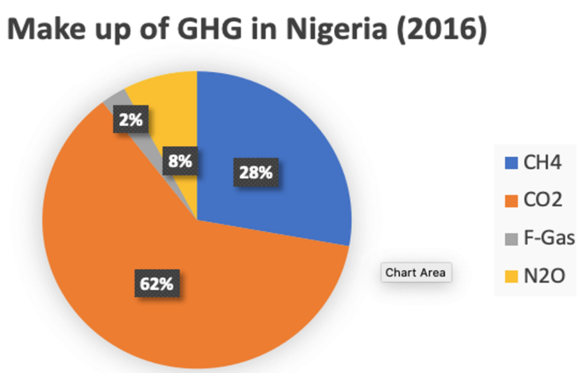

Figure 2. Recently reported Greenhouse Gas Emissions Level by Peter Hanson 2020.

***Environmental Impact of Climate Variability*:** Challenges associated with climatic variability are more likely to arise in coastal and desert regions than in other areas. The rising sea level may cause social unrest, hinder the development of the economy, and put the region's residents at risk. Oladipo (2010) states that a sea level rise of 0.5im is anticipated for the Nigerian coastline, which will have an impact on the socioeconomic and ecological activities occurring in those areas. The increased frequency of floods that are devastating the coastal cities of Warri, Port Harcourt, and Calabar is due to an increase in rainfall in those locations. Houses have been uprooted and some oil wells have been lost to the water as a result of erosion in certain coastal areas of the Niger Delta region (Odjugo, 2010).

***Economic Impact of Climate Variability*:** In both urban and rural locations, agriculture has provided a means of subsistence and revenue. Yet this source of sustenance and livelihood is threatened by climate unpredictability. Furthermore, programs aiming at ending poverty and ensuring food security are jeopardized (Onyenechere and Igbozurike, 2008). Nigerian agriculture is rainfed and subject to the effects of climatic fluctuation. Due to fluctuations in rainfall patterns that result in low harvest, the establishment of agribusiness is determined by the unpredictability of the commencement of rainfall in recent times. Future rainfall amounts and timing will vary due to the nation's rain-fed agriculture, which is causing climate change. Due to desertification, climate unpredictability will inevitably result in less productivity in dry places. According to Onyenechere (2008), climatic variability can disrupt ocean currents, causing periodic disruptions to coastal districts that rely on fishing. The frequency of pests and diseases that attack and kill forest trees also rises with climate variability. Climate variability is also contributing to an increase in agricultural diseases and pests in dry zones. Climate variability also affects food supplies thereby increasing malnutrition. Flooding also affects the lives and activities of the individual. If a flood encroaches on an apartment, it will lead to damage to the properties in the home, and the prevalence of malaria, and other diseases because of stagnant water surrounding it (Onojole, 2010). At the community level, it causes a poor road network due to damaged roads. Extreme weather events such as thunderstorms, heavy winds, and floods, destroy farmlands and crops (Adekunle 2011). Some industries in the arid zones are also likely to be affected by climate variability. It is worth noting that industries that are in the coastal region such as oil and gas industries, construction industries, etc are most largely to affected by climate variability challenges because of flooding and torrents. This may also experience a reduction in their revenue generation.

***Erosion and Impoverishment*:** Rainfall-induced soil erosion is more common when there is a reduction in plant cover due to land clearance. Water erosion, resulting in sheet, rill, and gully erosion, is most common on steep soils. According to (Agbamu, 2005), shifting agriculture in an untidy region promotes gully erosion and topsoil losses that can reach 10-120 tons/ha year. In the past, thick forests surrounding farmlands exposed to shifting cultivation helped to control erosion. Nowadays, deforestation and soil erosion has become increasingly challenging. The loss of soil from surfaces due to erosion is a global problem that has a negative effect on all natural ecosystems, including agricultural, forest, and grazing land ecosystems. This results in a major reduction in the availability of water, energy, and biodiversity worldwide. Reduced soil productivity results from runoff and soil erosion, which also lowers rainfall water infiltration and water-storage capacity. Given their numerous environmental advantages, plant cover's impact on soil is a sustainable method of raising production. Since soil water availability for agriculture is the primary factor limiting output in all terrestrial ecosystems, productivity declines when it is reduced. According to Duran Zuazo and Rodriguez (2008), vegetation in semiarid regions experiences prolonged periods of water deficit, which delays the development of vegetation structure and complexity and, therefore, soil protection and water conservation. According to (Nunes and Seixas, 2003; Nearing *et al.*, 2005), there is evidence to imply that global warming will lead to increased climatic variability, which in turn may increase the frequency and severity of extreme weather events, ultimately exacerbating erosion.

***Technology in Relation to Climate Variability*:** The relationship between technology and climate variability can be understood in two (2) major ways; from the adaptation perspective, technological interventions are made in response to current and predicted impacts of climate variability to reduce the vulnerability and limit the loss and damage from climate variability impacts while from the development perspective, it is major socio-economic impacts.

Three (3) major categories may be used to organize technology related to climate variability: observation and monitoring technologies, adaptation technologies, and mitigation technologies. The results indicate a statistically significant mediating effect of county location on the link between these patents and real GDP growth, according to the study on technology transfer and climate variability mitigation patents on real GDP growth. This indicates that there is a statistically significant positive correlation between GDP growth and patents related to mitigating climate variability in both Eurozone member states and the rest of Europe. Thus, it suggests that technology for mitigating climatic variability has a favorable effect on economic growth. According to (Ajayi, 2020), the farmer's choices, attitudes, goals for conservation, and risk tolerance all influence the adoption pattern of agroforestry methods. Agroforestry technology adoption is determined by a variety of factors since farmer preference varies and is an extremely difficult and inappropriate metric to assess. A farmer's propensity to implement agroforestry technological methods is influenced by several demographic factors, including age, gender, and level of education. Numerous studies indicate that the acceptance of new agroforestry technologies by farmers is negatively correlated with their age, with older farmers seeing a reduction in production and adoption decisions. Nonetheless, several studies have shown that the adoption of agroforestry techniques is significantly positively impacted by the educational attainment of farmers and agricultural households. Agroforestry has gained widespread acceptance among certain farmers as a means of adapting to climatic fluctuation. According to (Aturamu and Daramola, 2005), some farmers in the Brong Ahafo Region have become more knowledgeable about environmental and climate variability management strategies in recent years as a result of environmental non-governmental organizations' activities. As a result, these farmers are more inclined to plant or maintain trees on their farms to better address the challenges presented by climate variability.

MATERIALS AND METHOD

This study was conducted in the South-East agro-ecological zone of Nigeria. The South-East zone comprises five states namely: Abia, Anambra, Ebonyi, Enugu, and Imo States. The states are within the South-East rainforest zone of Nigeria. The area has an estimated population of 30,178,499 and this comprises Abia State 5,107,635 people, Imo State 6,005,348, Anambra State 9,006,321 people, Enugu State 6,023,463 people while Ebonyi State 4,035,732 people (NPC, 2023). Imo and Anambra are the most populous states of the zone and have a high concentration of economic activities. At an average population density of 247 people per square kilometer, the South-East states are among the most densely populated regions in the nation, with 96 people per square kilometer being the national average (NPC, 2023). The zone is on the Equator between latitudes 5006'N and 6034'N, and on the Greenwich (Prime) Meridian between longitudes 6038'E and 8008'E (Microsoft Corporation, 2023). It has a tropical humid climate with two distinct seasons per year namely, the rainy and dry seasons. Within the two (2) seasons, the temperature range varies from about 18^{o} C to 34^{o} C. The study population consists of farmers in the three selected states in the Southeast zone, Nigeria. The study employed a purposive sampling technique in selecting three states out of five (5) states in the Southeast of Nigeria. The reason is to select the state where climate change impact is prominent. The population of the study consists of 8,991,430 registered farmers from three States in Southeast Nigeria. A sample was collected from these numbers and the result would be generalized on the entire population. A sample size of 350 registered farmers was randomly selected from the population of 2850 registered farmers using Taro Yamane formula. The Taro Yamane formula is used for determining finite populations (Egboka and Osiname, 2018). The sample obtained through this method is representative of the entire population. Taro Yamane formula and how it was used to determine the sample size for this study is specified below:

n=N/(1+ N (e)2)

N=The Final Population

e=Level of Significance

1=Unity or Constant

Substituting the value from the formula

n=2,850/(1+2,850(0.05)2) = 350

Therefore, sample size for the study is 350. Multistage sampling technique was thereafter used to sample the 350 registered farmers from the three selected states used for the study area. The three selected states were Abia, Ebonyi and Imo states. Four steps of multistage sampling techniques:

1. Purposive sampling of one agricultural zone from each of the three (3) selected states that have records of predominant practice of agroforestry was done. The Umuahia agricultural zones was selected from Abia State, Orlu agricultural zone was selected from Imo State

while Ebonyi North agricultural zone was selected from Ebonyi State.

2. Two (2) local government areas were selected from each of the selected agricultural zones comprising of Umuahia North Local Government Area (L.G.A) and Ikwuano L.G.A in Abia state; Oru East L.G.A and Nwangele L.G.A form Imo State and Ebonyi L.G.A. and Izzi L.G.A. in Ebonyi State. This gave a total of six (6) local government areas used for the study.
3. Two (2) communities were selected from each of the Local Government Areas selected for the study. This gave a total of twelve (12) communities used for the study. The communities used for the study include Umuariaga and Ibere communities from Ikwuano L.G.A. of Abia State; Old Umuahia and Ubakala communities from Umuahia North L.G.A of Abia State; Awommama and Omuma communities from Oru East L.G.A of Imo State.; Agbaje and Amaigbo communities from Nwangele L.G.A of Imo State; Ishieke and Nkaleke communities from Ebonyi North L.G.A of Ebonyi State and Iboko and Igbeagu communities from Izzi L.G.A of Ebonyi State.
4. Based on the percentage of registered farmers in each rural community, farmers were chosen. At this point, farmers were chosen for the research using proportional sampling approaches. When there may be differences in the number of groups within a population, proportionate sampling is used to choose samples; random selection is likely to represent an inaccurate population in these situations (Ayuba *et al.*, 2007).

The breakdown of the proportions of farmers selected from each rural community is presented in Table 1 below.

Table 1. Proportionate Sampling of Farmers from The Selected Communities for The Study.

State	Local Govt. area	Rural comm-unities	Population of the Farmers	Percentage obtained from the population	Sample size
Ebonyi	Ebonyi	Ishieke	300	10.5	30
		Nkaleke	350	12.2	36
	Izzi	Iboko	220	7.7	27
		Igbeagu	200	7.1	25
Imo	Oru East	Awommama	280	9.8	32
		Omuma	230	8.1	27
	Nwangele	Agbaje	150	5.2	28
		Amaigbo	180	6.3	24
Abia	Ikwuano	Ibere	300	10.5	29
		Umuariaga	250	8.8	37
	Umuahia North	Old umuahia	150	5.2	28
		Ubakala	240	8.4	27
	Total		2,850	100	350

Source: Researchers' compilation form ADP office desks in Abia, Imo, and Ebonyi States

The research made use of primary data. Mixed approaches were used to obtain data for this investigation. The primary tool used to collect data was a structured questionnaire. The questionnaire was divided into two sections A and B. Section A measures climate variability impacts, while section B measures the various agroforestry practices available for farmers to practice in the study area. To get the information, a self-administered questionnaire was used. It was suggested for the responder to seek clarification. When collecting data, the drop-off and pick-up approach was employed to make sure that every respondent was contacted throughout the questionnaire distribution and collection process. Additionally, it gives the responders plenty of time to address the questions. With the help of three research assistants that the researcher trained, a total of 350 questionnaires were delivered and recovered. The data was cleaned and coded by the researcher following the successful gathering process. The data obtained were analyzed using IBM Statistical Product and Service Solutions (SPSS) version 26. Descriptive statistics such as mean score, frequency table and percentages were used in the analysis of the data obtained for the study. The item statements bordering on the available agroforestry practices for the farmers as well as the scale of climate variability impacts were rated on a five-point Likert rating scale. The item statements bordering on the available agroforestry practices for the farmers was rated as Never available = 1, Seldomly available = 2, Occasionally available =3, Often available = 4, and Always available = 5. The item statements bordering on the scale of climate variability impacts on agricultural activities of the farmers in the Southeast Nigeria was rated as Never = 1, Slightly = 2, Mild = 3, Bad = 4, and Too Bad = 5. In using the five-point rating scale to obtain the mean score, a midpoint was obtained by adding the weights of the rating scales of 5+4+3+2+1 which gave 15 points, and we shall divide the total point of 15 by 5 to obtain a mean score of 3.00. This implies that any mean score response above 3.00 implies acceptance of the statement item, while any mean score response lower than 3.00 implies rejection of the statement item. The mean score for agroforestry practices available to the farmers was derived as shown in equation (1) while the mean score for scale of climate variability impacts on agricultural activities of the farmers leading to the need for agroforestry practices as an adaptive practice to climate variability was derived as shown in equation (2) below:

$$\bar{X} = \frac{\sum NA\,x\,(1) + SA\,x\,(2) + OCA\,x\,(3) + OFA\,x\,(4) + AA\,x\,(5)}{n} \ldots\ldots(1)$$

$$\bar{X} = \frac{\sum N\,x\,(1) + S\,x\,(2) + M\,x\,(3) + B\,x\,(4) + TB\,x\,(5)}{n} \ldots\ldots(2)$$

Where, $\bar{X}$ = Mean score rating of item statements; NA = Pooled frequency responses for never available rating; SA = Pooled frequency responses for seldomly available rating; OCA = Pooled frequency responses for occasionally available rating; OFA = Pooled frequency responses for often available rating; AA = Pooled frequency responses for always available rating; N = Pooled frequency responses for never (no impact) rating; S = Pooled frequency responses for slight impact rating; M = Pooled frequency responses for mild impact rating; B = Pooled frequency responses for bad impact rating; TB = Pooled frequency responses for too bad rating; X = Multiplication sign; $\sum =$ Summation sign; and n = Total number of respondents.

Furthermore, the mean scores obtained for each statement item were categorized into 3 decision rules (Low:1.00-2.33, Moderate:2.34-3.67, and High: 3.68-5.00) for levels of agroforestry practices available and levels of scale of climate variability impacts in the study area. The difference in the mean score was obtained by dividing the mean rating score of 5.00 into 3 categories (for clarity purposes there are four runs between the rating scale of 1 through 5, and dividing these 4 runs by 3 gave an interval value of 1.33, as such adding 1+1.33 gives 2.33 which is the boundary of the first category, and adding 1.33 to 2.33 gives 3.67 which is that boundary of the second category and adding 1.33 to 3.67 gives 5 which is the boundary of the category).

RESULTS AND DISCUSSION

***Agroforestry Practices Available to The Respondents*:** The result in Table 2 shows that agroforestry practices are available in the study area which was measured using thirteen (13) items while the summary of respondents' level of responses to the agroforestry practices available in the study area is presented in Table 2 below. Evidence on the average score responses from respondents regarding agroforestry techniques in the research area, as shown in Table 2, revealed that the most prevalent practice for farmers to embrace in Southeast Nigeria was home gardening (mean=2.79; SD=1.44), whereas the least common practice was Multipurpose wood lot (mean=1.75; SD=1.05). It was also observed that the mean ratings for all thirteen items assessing available agroforestry practices in the study area were below the critical threshold of 3.00. The mean score for the agroforestry practices accessible in the study area was 2.22, with a standard deviation of 1.28, indicating that none of the

Table 2. Agroforestry practices available in the study area.

S/N	Agroforestry Practices	1	2	3	4	5	Mean	S.D.
		Frequency (percentage)						
1.	Home garden	92 (26.3)	72 (20.6)	62 (17.7)	65 (18.6)	59 (16.9)	2.79	1.44
2.	Shelter belts	191 (54.6)	75 (21.4)	58 (16.6)	21 (6.0)	5 (1.4)	1.78	1.02
3.	Windbreak line hedges	150 (42.9)	87 (24.9)	66 (18.9)	22 (6.3)	25 (7.1)	2.10	1.23
4.	Home garden involving animals	122 (34.9)	87 (24.9)	58 (16.6)	43 (12.3)	40 (11.4)	2.41	1.37
5.	Multipurpose woody hedgerows	166 (47.4)	88 (25.1)	47 (13.4)	42 (12.0)	7 (2)	1.96	1.13
6.	Apiculture with trees	157 (44.9)	57 (16.3)	62 (17.7)	38 (10.9)	36 (10.3)	2.25	1.39
7.	Tree on range land or pasture	156 (44.6)	57 (16.3)	74 (21.1)	25 (7.1)	38 (10.9)	2.23	1.37
8.	Alley cropping	193 (55.1)	56 (16.0)	54 (15.4)	40 (11.4)	7 (2.0)	1.89	1.16
9.	Multipurpose tree on cropland	118 (33.7)	39 (11.1)	84 (24)	68 (19.4)	41 (11.7)	2.64	1.41
10.	Aqua forestry	157 (44.9)	74 (21.1)	59 (16.9)	30 (8.6)	30 (8.6)	2.15	1.31
11.	Multipurpose wood lot	214 (61.1)	43 (12.3)	62 (17.7)	30 (8.6)	1 (0.3)	1.75	1.05
12.	Taungya	163 (46.6)	48 (13.7)	85 (24.3)	30 (8.6)	24 (6.9)	2.15	1.28
13.	Improved fallow practices	89 (25.4)	95 (27.1)	51 (14.6)	37 (10.6)	78 (22.3)	2.77	1.5
Overall Mean Score							2.22	1.28

Note: Scale 1 = Never, 2 = Seldomly, 3 = Occasionally, 4 = Often, and 5 = Always
Source: Field Survey Data, 2024

listed practices in Table 2 were readily and widely available for farmers to engage in within the study area.

The summary of respondents' levels of responses to the agroforestry practices available in the study area is presented in Table 3 below. Table 3 shows the overall mean score for the availability of agroforestry practices for farmers to practice in the study area. The mean score was categorized into three (3) decision rules (Low:1.00-2.33, Moderate:2.34-3.67, and High: 3.68 -5.00) for levels of agroforestry practices available in the study area. The difference in the mean score was obtained by dividing the mean rating score of 5.00 into 3 categories (Clarity to the classification of the level of responses of the respondents has been earlier provided). Therefore, for this study mean score of 2.25 with a standard deviation of 0.72 for the level of agroforestry practices available for the respondents falls within the low category, suggesting that there is a low level of agroforestry practices available for farmers in Southeast Nigeria. This study found that the availability of agroforestry practices is low among farmers in the southeast region of Nigeria.

The availability of agroforestry practices at a moderate level can have beneficial effects on farmers by offering them various advantages, such as climate change mitigation, sustainable livelihoods, and environmental sustainability. The consequences of implementing agroforestry practices at a moderate level among farmers encompass an increase in farm income, enhanced food production, improved resilience of farmer livelihoods, and the promotion of sustainable rural livelihoods. Agroforestry practices possess the potential to significantly augment food production and enhance the economic situations of farmers (Zerihun, 2021), while also positively influencing agricultural productivity, replenishing soil fertility, and increasing income (Arage, 2021). The outcome of this study on the moderate availability of agroforestry practices among farmers in the study area aligns with the findings of Oyewole *et al.* (2022), who discovered that a greater number of farmers in their study area practice agroforestry, which serves as a positive indication for climate change mitigation and environmental resource management. They further noted that the practice of agroforestry contributes to carbon sequestration, aiding in climate change mitigation, and that exposing farmers to agroforestry practices is a better approach to ensuring food security in the face of climate variabilities. The study's results are also analogous to those of Oyebamiji (2022), who observed that many farmers in their study area engage in agroforestry, and that the practice assists in achieving both mitigation and adaptation objectives while remaining pertinent to the livelihoods of smallholder farmers. The findings of this study are also in line with the findings of Falana *et al.* (2022), who

Table 3. Summary of respondents' level of agroforestry practices available in the study area.

Dimension	Level	Frequency	Percentage	Mean	S.D.
Agroforestry Practices Available	Low (1.00-2.33)	144	41.1	2.25	0.72
	Moderate (2.34-3.67)	200	57.1		
	High (3.68-5.00)	6	1.7		
Total		350	100.0		

Table 4. Scale of climate variability impacts on agricultural activities.

S/N	Statement	1	2	3	4	5	Mean	S.D.
		Frequency (Percentage)						
1.	Erratic rainfall	24 (6.9)	38 (10.9)	46 (13.1)	86 (24.6)	156 (44.6)	3.89	0.88
2.	Increased frequency of drought	15 (4.3)	68 (19.4)	31 (8.9)	115 (32.9)	121 (34.6)	3.74	0.73
3.	Land degradation	22 (6.3)	55 (15.7)	33 (9.4)	112 (32.0)	128 (36.6)	3.77	0.76
4.	Rising temperature	23 (6.6)	48 (13.7)	46 (13.1)	94 (26.9)	139 (39.7)	3.79	0.78
5.	Flooding and land erosion	19 (5.4)	57 (16.3)	38 (10.9)	111 (31.7)	125 (35.7)	3.76	0.74
6.	Desertification and land degradation	18 (5.1)	87 (24.9)	40 (11.4)	90 (25.7)	115 (32.9)	3.56	0.63
7.	Increase frequency of extreme events such as storms, hailstorms, and thunderstorms	41 (11.7)	56 (16.0)	61 (17.4)	73 (20.9)	119 (34.0)	3.49	0.62
	Overall Mean Score						3.72	0.74

Note: Scale 1 = Never, 2 = Slightly, 3 = Mild, 4 = Bad, and 5 = Too Bad

Source: Field Survey Data, 2024

Table 5. Summary of respondents' level of climate variability impacts.

Dimension	Level	Frequency	Percentage	Mean	S.D.
Scale of Climate Variability Impacts	Low (1.00-2.33)	64	18.3	3.69	1.02
	Moderate (2.34-3.67)	47	13.4		
	High (3.68-5.00)	239	68.3		
Total		350	100.0		

discovered that a substantial number of farmers, as indicated by their respondents, are involved in agroforestry practices.

***Scale of Climate Variability Impact of the Respondents*:** The result in Table 4 shows that scale of the impact of climate variability in the study area which was measured using seven (7) items. Evidence derived from the average responses of farmers in southeast Nigeria reveals that irregular rainfall (M=3.89; SD=0.88) had the most notable effect on agricultural activities in the region. There was an observation of intensified temperature (m=3.79; SD= 0.78), indicating a detrimental influence on farming operations within the study area. The respondents exhibited the lowest average responses towards the heightened occurrence of extreme events like storms, hailstorms, and thunderstorms (m=3.49; SD=0.62). Despite this, the mean score of 3.49 exceeded the critical value of 3.00 on a 5-point scale, implying that the increased frequency of these extreme events had the least impact on agricultural activities in the area. The overall mean for the impacts of climate variability in the study area stood at 3.72 with a standard deviation of 0.74. This suggests that the perceived level of climate variability impacts, as reported by the respondents, surpasses what is typically considered average or expected. Consequently, it can be inferred that, on average, respondents in the study area view the impacts of climate variability as significant. The farmers in the study area perceive climate variability as a pressing concern, underscoring the necessity for interventions, policies, or adaptation strategies to mitigate the adverse consequences of climate variability on different aspects of agriculture in the region.

The summary of respondents' level of responses to the scale of impacts of climate variability in the study area is presented in Table 5 below. Table 5 shows the overall mean score for a dimension of the variable (climate variability impacts). The mean score was categorized into 3 decision rules (Low: 1.00-2.33, Moderate: 2.34-3.67, and High: 3.68 -5.00) for the level of climate variability impacts. The difference in the mean score was obtained by dividing the mean rating score of 5.00 into 3 categories (For clarity purposes there are four runs between the rating scale of 1 through 5, and dividing these 4 runs by 3 gave an interval value of 1.33, as such adding 1+1.33 gives 2.33 which is the boundary of the first category, and adding 1.33 to 2.33 gives 3.67 which is that boundary of the second category and adding 1.33 to 3.67 gives 5 which is the boundary of the category) Therefore, for this study mean score of 3.69 with standard deviation of 1.02 for level of climate variability impact fall within high category, suggesting that there is high level of climate variability impacts on agricultural practices in Southeast Nigeria. This study found that climate variability highly impacted agricultural practices in the southeast region of Nigeria.

The result of this study is in line with Chikezie *et al.* (2015), who discovered that alterations in climate significantly enhance crop production in the southeastern region of Nigeria. The result of this study corresponds with the work of Akinbobola *et al.* (2015), who determined that climate variability has a greater impact on developing countries like Nigeria than on developed countries due to their limited capacity for adaptation, absence of early warning systems, elevated temperatures, and low national income levels commonly associated with developing countries. The result of this study corresponds with the works of (Agba *et al.*, 2017; Okringbo *et al.*, 2017; Ezeaku *et al.*, 2014; Eregha *et al.*, 2014), which indicate a strong correlation between climate variability and agricultural production in Nigeria. These studies reveal that farmers in the area have experienced decreased yields of food crops because of reduced rainfall and relative humidity, land degradation, erosion, and flooding, as well as increased temperatures. This finding corroborates the assertion made by Apata (2016) that climate change has had a detrimental impact on crop production through diminished crop yields, increased pest and disease manifestation, delayed maturity of crops, and the extinction of certain crops. This finding supports the contention put forth by Nwaiwu *et al.* (2014), who argue that the impact of climate variability in southeastern Nigeria is high, pointing out that the fluctuation in climate variables has made it difficult for local farmers to accurately predict rainfall, thus rendering their traditional knowledge regarding climate unreliable. This, in turn, has an impact on their decision-making when it comes to farming activities, ultimately affecting the amount of agricultural produce they can generate.

***Conclusion*:** The study concludes that there is a high level of climate variability impacts on agricultural practices in Southeast Nigeria, coupled with a low availability of agroforestry practices for farmers to mitigate these impacts. The study suggests enhancing agricultural extension services, developing tailored extension programs, advocating for governmental support and investment, providing technical support and capacity-building assistance to farmers, investing in research and innovation, and fostering collaboration among stakeholders to promote the adoption of agroforestry practices as a climate-resilient agricultural approach. The findings of the study align with previous research indicating a strong correlation between climate variability and agricultural production in Nigeria. Similar studies have highlighted the challenges faced by farmers due to climate variability and underscored the importance of adaptive measures like agroforestry.

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