FUDMA Journal of Earth and Environmental Sciences (FUDJEES), Vol. 2, No. 2, 2025
Print ISSN: 1595-9686
EISSN: 1595-9708

CLIMATE CHANGE ADAPTATION STRATEGIES AMONG MAIZE FARMERS TOWARDS FOOD SECURITY IN SELECTED LOCAL GOVERNMENT AREAS OF BENUE STATE, NIGERIA

Elisha Ikpe[1] and Ugbede D. Omede[2]

[1]Department of Geography, Federal College of Education, Odugbo, Benue State
[2]Department of Agricultural Science, Federal College of Education, Odugbo, Benue State

Corresponding Author's Email: elishaikpe@fceodugbo.edu.ng
Phone Number: +2348065665954
https://doi.org/10.33003/jees.2025.0202/008

ABSTRACT
This study examined maize farmers' adaptation strategies towards food security in selected Local Government Areas (LGAs) of Benue State, Nigeria. A multistage sampling technique was employed to choose six LGAs from the state. Krejcie and Morgan's sample size determination method was used to select 783 farmers, who were purposively sampled for the study. A self-structured questionnaire, titled the Crop Farmers' Perception Questionnaire (CFPQ), and an interview guide, titled the Crop Farmers' Perception Interview Guide (CFPIG), were used to elicit relevant information from respondents. Six focus group discussions were conducted, one in each LGA. A Relative Importance Index (RII) technique was used to determine the relative importance of various adaptation strategies to climate change. The socio-demographic characteristics of the respondents revealed that 75% were male, 50% were within the 30–40 years age group, the majority (39%) had attained secondary education, and 72% had lived in the area for 20–30 years. These characteristics are believed to have influenced the farmers' perceptions and their choice of adaptation strategies. Mixed cropping ranked first among the adaptation strategies used by farmers, followed by early planting, the use of organic/inorganic manure, and the planting of pest- and disease-resistant crops. To enhance food security and promote climate resilience, the study recommends scaling up successful strategies, such as mixed cropping and organic manure use, and fostering integrated farming practices, including mixed farming and crop rotation, to improve soil health, reduce pests and diseases, and enhance overall agricultural productivity.

Keywords: Adaptation Strategies; Climate Change; Food Security; Maize Farmers; Perception

INTRODUCTION

Climate change is one of the most pressing global challenges of our time, posing enormous risks to socioeconomic development and disregarding political boundaries. It threatens food security and sustainable development by impacting agricultural systems, and the Intergovernmental Panel on Climate Change (IPCC, 2022) has found that it has already caused unprecedented challenges worldwide. The IPCC's reports underscore the seriousness of this challenge, emphasising the need for strengthened mitigation and adaptation measures to address worsening climate impacts. These impacts will be more damaging in the future, severely compromising agricultural production and food security, and potentially rendering marginal agricultural regions unproductive, affecting ecosystems, economies, and human health worldwide (IPCC, 2021).

Increasing weather and climate extremes have exposed millions to acute food insecurity and reduced water security, with devastating impacts in Africa and worldwide. Climate change will intensify pressure on food production systems, undermining food security (GreenFacts, 2022). Africa, highly vulnerable to climate change and variability, will see agriculture affected by rising temperatures, altered growing seasons, and extreme weather events, leading to disruptions in harvests, drought, flooding, water scarcity, increased disease transmission, and heat stress (Ariko et al., 2024). While Nigerian agriculture may benefit from increased harvests and new crop cultivation in the short term, the changing climate poses significant long-term risks, emphasising the need for agriculture to adapt to ensure sustainable food production (Iornongo, 2021).

Adaptation in human systems involves adjusting to actual or expected climate change and its effects to moderate harm or exploit beneficial opportunities, facilitated by human intervention. It plays a crucial role in reducing exposure and vulnerability to climate change in natural systems, encompassing autonomous adjustments in ecological systems and anticipatory or reactive, incremental, and/or transformational strategies in human systems. Adaptation strategies involve identifying and evaluating options to address climate change, considering factors such as availability, benefits, and feasibility (IPCC, 2021). Climate change adaptation through improved agricultural practices is essential to meet growing food demands, helping farmers achieve food, income, and livelihood security objectives despite changing climatic and socioeconomic conditions (Ikpe, 2021), and directly impacting productivity (Food and Agriculture Organisation, 2016).

To mitigate the adverse effects of climate change, various adaptation strategies can be employed across different contexts. The effectiveness of these strategies is directly proportional to the degree of adaptation, resulting in reduced exposure to damage risks and enhanced preparedness. Adaptation objectives encompass reducing exposure to damage risks, developing coping capacities for unavoidable damages, and capitalising on emerging opportunities (IPCC, 2014). Notably, preparatory adaptation can significantly reduce the impacts of climate change. Adaptation strategies complement mitigation approaches, particularly in agriculture, where farmers' ability to update their climate expectations in response to unusual weather patterns is crucial (Ikpe, 2014).

Food security is achieved when all individuals have consistent physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and preferences, enabling an active and healthy life. The concept of food security is built on four pillars: availability, access, utilisation, and stability, with nutrition being an integral dimension (CWFS, 2014). The focus on food security has shifted from a global and national perspective to a household and individual level (GreenFact, 2022), as disparities in food intake have been observed despite adequate overall supply. This issue is underscored by its inclusion as a target in the first Millennium Development Goal (MDG), with the Food and Agriculture Organisation (FAO) emphasising that food security requires physical and economic access to sufficient, safe, and nutritious food (FAO, 2016).

Climate change has significantly impacted food supply for the growing population, altering climatic conditions and leading to declines in crops cultivated in northern Nigeria (Odjugo, 2010). Consequently, production of major crops like rice, maize, soybeans, and yams has declined over the past few decades, despite an increasing population (Adamgbe & Ujoh, 2013). This exacerbates hunger and food insecurity, relying heavily on food aid nationally and domestically. To address climate change's negative impacts on Nigerian agriculture, particularly on crop production in the Guinea savanna region, drastic increases in the productivity of staple crops such as maize are

necessary (Iornongo, 2021). However, the yield has declined, especially in Benue State, highlighting the need for adaptation strategies to unlock the state's crop production potential (Terseer et al., 2019).

STATEMENT OF THE RESEARCH PROBLEM

Nigeria's food production, particularly in Benue State, has failed to keep pace with its rapid population growth. To address this disparity, successive governments have implemented policies and programs to boost agricultural productivity and efficiency (Boko & Iheanacho, 2021). However, Benue State's crop farmers continue to face challenges, including crop failures, reduced productivity, hunger, and drought. Therefore, adopting reliable farming strategies is crucial to mitigate the negative impacts of climate change on crop yields, enhance food production, and improve food security in Benue State. As the mainstay of the state's economy, employing over 80% of the population, agriculture plays a vital role in sustaining human existence and improving the quality of life (Enokela & Seini, 2013). This underscores the need to investigate the effects of climate change on crop yields in Benue State.

Benue State was selected for this research because of its large population of crop farmers, who constitute over 80% of the state's farmers (Jande & Amonjenu, 2018). The study focused on rice, soybeans, cassava, and yams, which are the primary food crops in Benue State (Iornongo, 2021). The state's climatic conditions favour the cultivation of grain and tuber crops, and these crops, including rice and soybeans, are among the most widely cultivated in Africa, particularly in the Savannah areas (FAO, 2016). This research aimed to investigate farmers' adaptation strategies in Benue State, Nigeria, to address existing gaps and provide recommendations to enhance food security.

This research aims to investigate the viable adaptation strategies adopted by maize farmers in selected LGAs in Benue State. To achieve this aim, the study pursued the following objectives:

i. Evaluate the farmers' adaptation strategies to climate change.
ii. Identify the most effective adaptation strategies employed by maize farmers in the areas.

STUDY AREA

Benue State, created on February 3, 1976, is situated in the lower River Benue trough within Nigeria's middle belt region and is renowned as the "Food Basket of Nigeria." The state lies between Latitudes 6°25'59"N and 8°8'06"N and Longitudes 7°30'14"E and 10°00'53"E " E, covering 34,059 square kilometres (Terdoo et al., 2016; National Bureau of Statistics, 2018). Benue State shares boundaries with five states (Nassarawa, Kogi, Taraba, Ebonyi, and Cross River) and the Republic of Cameroon, with a vegetation characteristic of the southern Guinea Savanna biome (Hula, 2010; Nigerian Investment Promotion Commission [NIPC], 2020).

According to the Köppen climate classification, Benue State falls within the AW climate, characterised by two distinct seasons: a wet and a dry season. The state typically experiences 8-10 months of rainfall (Hula, 2010), with the rainy season spanning from April to October and annual rainfall ranging from 1000 to 2000 mm. The dry season runs from November to March. Temperatures fluctuate between 21°C and 37°C throughout the year. However, the south-eastern part of the state, adjacent to the Obudu-Cameroun Mountain range, has a cooler climate, similar to that of Plateau State (Ologunorisa & Tersoo, 2006). Notably, temperatures in Makurdi, the state headquarters, are consistently high, averaging 28°C to 32°C and sometimes reaching 37°C (Hula, 2010).

FUDMA Journal of Earth and Environmental Sciences (FUDJEES), Vol. 2, No. 2, 2025
Print ISSN: 1595-9686
EISSN: 1595-9708

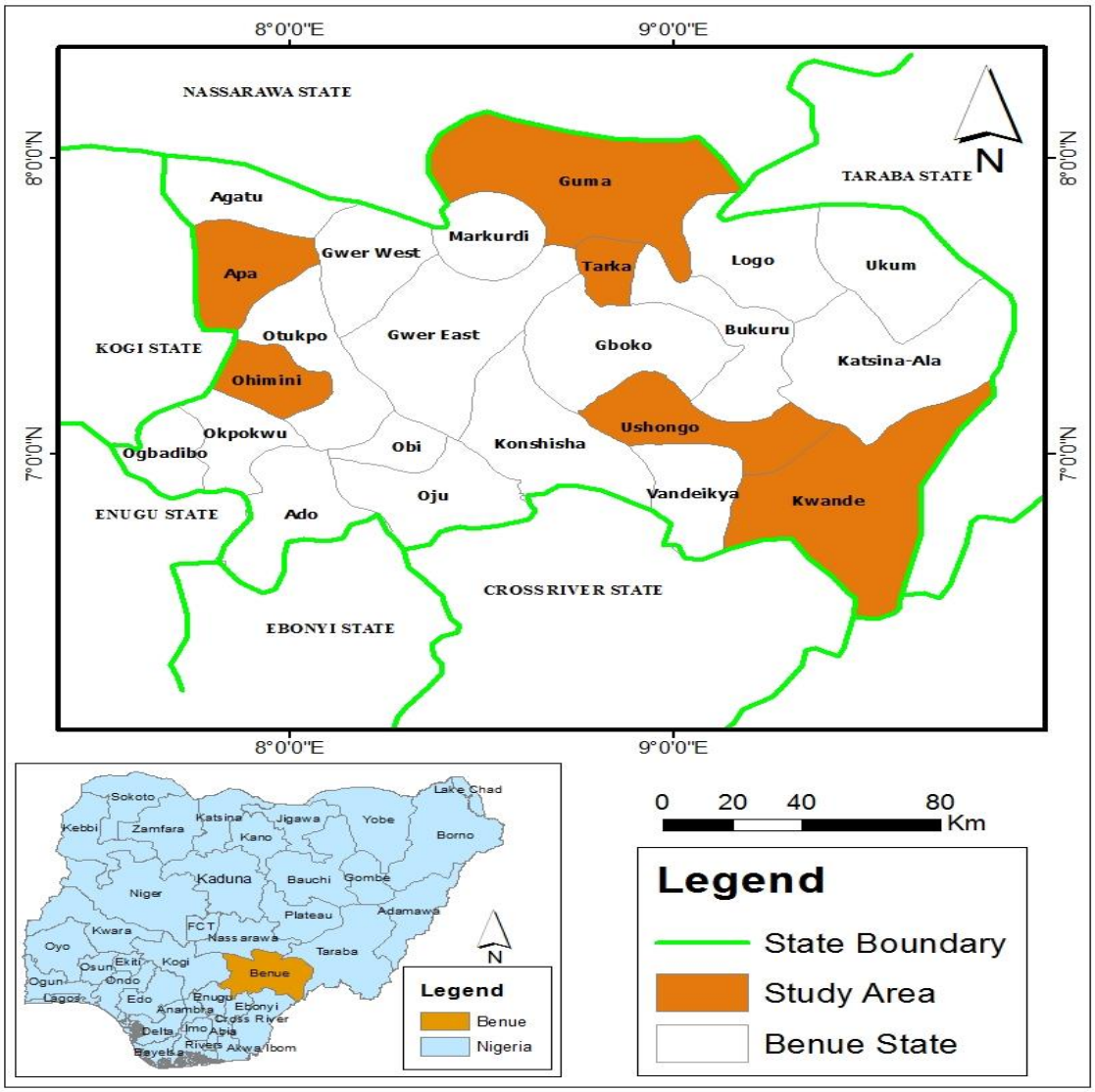

Fig. 1: Benue State (Study Area)
Modified by GIS Lab Department of Geography, A.B.U. Zaria.

The state's dominant geographical feature is the River Benue, with numerous tributaries, including the Katsina-Ala River. Benue State has a population of approximately 6,096,869 (2006 Population Census), with the Tiv, Idoma, and Igede peoples being the predominant ethnic groups. Agriculture is the backbone of the state's economy, employing over 70% of the population, with significant cash crops including soybeans, rice, and peanuts, as well as food crops such as yams, cassava, and maize (Terdoo et al., 2016).

METHODOLOGY

This study employed a quantitative research approach, collecting primary data through structured questionnaires administered in the study area. A multistage sampling technique was utilised. Specifically, the 23 Local Government Areas (LGAs) of the state were alphabetised and systematically sampled, with every third ward selected. The sample size was determined using Krejcie and Morgan's (1970) formula, which recommends a sample size of 783 for a population

FUDMA Journal of Earth and Environmental Sciences (FUDJEES), Vol. 2, No. 2, 2025
Print ISSN: 1595-9686
EISSN: 1595-9708

ranging from 500,000 to 10,000,000 at a 95% confidence level and a 3.5% margin of error. A 3.5% margin of error was chosen to minimise errors, as smaller sample sizes typically yield larger margins of error.

Primary and secondary data were used, including structured questionnaires, interviews, FGDs, rainfall, temperature, and yield data. The instruments used for data collection were the self-structured Crop Farmers' Perception Questionnaire (CFPQ) and the interview guide titled Crop Farmers' Perception Interview Guide (CFPIG). Six multiple FGDs were designed for the six selected LGAs, each comprising eight experienced crop farmers and two extension workers. These participants were selected by the Heads of farmers in each LGA to explore pertinent issues affecting crop production in their areas. The reliability of the instruments was determined using Cronbach's alpha, with values of 0.76 for CFPQ and 0.82 for CFPIG.

The 2006 census figures were projected to 2023 using Newman's (2001) population projection method. The population of the sampled localities was projected using Benue State's annual population growth rate of 3%. The formula applied was:

$$Pn = Po + ((1+R)/100 \times Po) \times n \quad \text{---------- (1)}$$

Where:

Pn = Population in the recent year;
Po = Population in the base year;
R = annual growth rate;
n = number of intermediary years.

The sampling frame and sample size for each selected LGA are presented in Table 1.

Table 1: Sample Frame and Size for the study

	LGAs	2006 Population	2023 Projected Population	Sample Size
1.	Apa	96,765	154,591	69
2.	Ohimini	71,482	113,819	52
3.	Guma	191,599	299,511	135
4.	Tarka	297,398	477,419	215
5.	Ushongo	188,341	294,191	133
6.	Kwande	248,697	397,311	179
	Total	**1,250,149**	**1,736,842**	**783**

Source: Authors' Compilation, 2024

The sampling frame and size by political wards for the study are presented in Table 2. The political wards in each LGA were arranged alphabetically, and every third ward was selected. The population was sampled proportionally, and questionnaires were administered accordingly.

FUDMA Journal of Earth and Environmental Sciences (FUDJEES), Vol. 2, No. 2, 2025
Print ISSN: 1595-9686
EISSN: 1595-9708

Table 2: Sample Frame and Size by Political Wards for the study

LGAs	Political Wards	Sampled Population by Political Wards
	Edikwu 1	21
Apa	Ikobi	22
	Ugbokpo	25
	Awume-Icho	18
Ohimini	Ichobo	15
	Onyagede-Ehaje	19
	Mbabai	41
Guma	Mbayar/Yandev	44
	Saghev	50
	Mbac	67
Tarka	Mbaikyo	75
	Mbanyaber	73
	Mbaaka	45
Ushongo	Mbagba	47
	Mbayegh	41
	Mbaketsa	60
Kwande	Tondov	60
	Mbadura	59
Total	**18**	**783**

Source: Authors' Compilation, 2024

The Relative Importance Index Technique (RII) was used to determine the relative importance of various adaptation strategies to climate change in the study area. The RII formula used was:

$RII = \Sigma W / (A \times N)$ ---------- (2)

Where:

W = Weight given to each factor by the respondents;
A = Highest weight (i.e., 3 in this case);
N = Total number of respondents.

The three-point scale ranged from 1 (Not at all) to 3 (Always). A higher RII value indicated that the adaptation strategy was more important or effective in addressing climate change in the study area. Of the 783 questionnaires administered, 780 were returned, analysed, discussed, and presented for the study.

RESULTS AND DISCUSSION

The socio-demographic characteristics of the farmers in the selected LGAs were identified, analysed, and presented in Table 3. The demographic characteristics of the respondents provide valuable insights into their backgrounds and potential influences on their responses. The majority of respondents are male (586, 75%), while females constitute a smaller proportion (194, 25%). This imbalance may affect the generalizability of the findings, particularly if there are significant gender differences in the variables under study.

The age distribution of respondents is skewed towards the middle-aged group, with 50% (389) falling within the 30-40 years range (Table 3). The 41-50 years age group constitutes 27% (213) of

FUDMA Journal of Earth and Environmental Sciences (FUDJEES), Vol. 2, No. 2, 2025
Print ISSN: 1595-9686
EISSN: 1595-9708

respondents, followed by 15% (114) in the 51-60 years range. The oldest age groups (>61 years) make up a smaller proportion of respondents, with 7% (56) in the 61-70 years range and 1% (8) in the 71+ years range. This age distribution may influence respondents' perspectives, experiences, and attitudes, particularly if age-related factors are relevant to the research topic.

Christianity is the dominant religion among respondents, with 93% (724) identifying as Christians (Table 3). Islam and traditional beliefs account for more petite proportions, with 4% (30) and 3% (26) of respondents, respectively. This religious distribution may impact respondents' values, beliefs, and practices, particularly if the research topic is sensitive to religious influences. The majority of respondents are married (401, 51%), followed by singles (315, 40%). Widowed individuals constitute a smaller proportion of respondents (64, 8%) (Table 3). Marital status may influence respondents' experiences, attitudes, and perspectives, particularly if family-related factors are relevant to the research topic. The level of education among respondents is relatively balanced, with 37% (289) having primary education, 39% (301) having secondary education, and 23% (180) having tertiary education (Table 3). A small proportion of respondents (10, 1%) have no formal education. Education level may affect respondents' knowledge, attitudes, and practices, particularly when the research topic requires a specific educational background.

Table 3: Socio-demographic Characteristics of the Farmers

Parameters	Options	Respondents(N=780)	Percentages
Sex	Male	586	75
	Female	194	25
Age	30 – 40 years	389	50
	41 – 50 years	213	27
	51 – 60 years	114	15
	61 – 70 years	56	7
	>71	8	1
Religious Belief	Christianity	724	93
	Islam	30	4
	Traditional	26	3
Marital Status	Single	315	40
	Married	401	52
	Widowed	64	8
Level of Education	Primary	289	37
	Secondary	301	39
	Tertiary	180	23
	Others	10	1
Respondents' years of residency in the study area	20 – 30 years	564	72
	31 – 40 years	189	24
	>41 years	27	3

Source: Field Survey, 2024

FUDMA Journal of Earth and Environmental Sciences (FUDJEES), Vol. 2, No. 2, 2025
Print ISSN: 1595-9686
EISSN: 1595-9708

The majority of respondents (72%, 564) have lived in the study area for 20-30 years, indicating a relatively stable and long-term resident population. Smaller proportions of respondents have lived in the area for 31-40 years (24%, 189) or more than 41 years (3%, 27). Length of residency may influence respondents' familiarity with the area, their social networks, and their experiences with local services or issues.

Adaptation strategies

Climate change adaptation refers to the proactive process of preparing for and adjusting to the impacts of climate change, including both negative consequences and potential opportunities (World Bank, 2011). Enhancing local farmers' adaptive capacities in the study area can strengthen their resilience to climate-related shocks. While planned adaptation offers a strategic approach to addressing climate change, identifying and integrating local adaptation strategies is crucial. As Adeshina and Odekunle (2011) pointed out, proposed adaptation strategies may be entirely new to an area or build upon existing community knowledge and practices. Farmers in Benue State adopt adaptation strategies to cope with the effects of climate change.

Table 4: Presents the adaptation strategies adopted by maize farmers in the study area.

S/N	Adaptation Strategies	Always Used	Rarely Used	Not at all	RII	Rank
1	Early Planting	635	125	20	0.9	2
2	Use of organic manure	672	78	30	0.9	2
3	Use of inorganic manure	575	145	60	0.9	2
4	Planting of pest and disease-resistant crops	555	172	53	0.9	2
5	Increase in the number of weedings	362	262	156	0.7	6
6	Mixed farming practices	299	289	192	0.7	6
7	Loans, grants, and subsidies	257	307	216	0.6	7
8	Mixed cropping	744	16	2	1.0	1

Source: Field Work 2024

The result revealed that, of the eight adaptive strategies, five were “highly adopted” by the farmers, as reflected in their RII scores of 0.9 and 1.0.

Most Frequently Used Strategies

i. Mixed cropping: This strategy is used by almost all respondents (744), indicating its widespread adoption and potential effectiveness.
ii. Use of organic manure: A large majority of respondents (672) always use organic manure, highlighting its importance in maintaining soil health and fertility.

The data (Table 4) indicates that mixed cropping and the use of organic manure are the two most frequently adopted climate change adaptation strategies among the surveyed farmers. Mixed cropping reduces the risk of total crop failure due to climate-related hazards (e.g., drought, pest outbreaks, or erratic rainfall). If one crop fails, others may survive, ensuring some level of harvest. It also contributes to food security, diversified income sources, and more efficient land use, especially in regions with unpredictable climatic patterns (Nnaji et al., 2013; FAO, 2020). Its widespread use suggests that farmers are consciously adopting low-cost, knowledge-driven strategies to adapt to

FUDMA Journal of Earth and Environmental Sciences (FUDJEES), Vol. 2, No. 2, 2025
Print ISSN: 1595-9686
EISSN: 1595-9708

climate change, possibly due to limited access to capital-intensive options such as irrigation or mechanised systems (Ozor & Cynthia, 2011; Adebayo & Mubi, 2022).

A large proportion of respondents indicated regular use of organic manure, showing its perceived value in enhancing soil productivity. Organic manure, derived from plant or animal waste, is rich in nutrients and improves soil structure, water retention, and microbial activity (Nkonya et al., 2011). Compared with chemical fertilisers, organic manure is cheaper, more environmentally friendly, and more sustainable in the long term (World Bank, 2021). Its usage reflects farmers' awareness of the need to build soil health, especially in areas where soil degradation and nutrient depletion are significant challenges. The popularity of this strategy suggests a gradual shift toward sustainable agricultural practices, possibly influenced by awareness campaigns from extension services or NGOs (Sani & Adebayo, 2020).

Highly Adopted Strategies

The following strategies have a high adoption rate (RII = 0.9) and are used by a significant proportion of respondents:

i. Early planting (635 respondents)
ii. Use of inorganic manure (575 respondents)
iii. Planting of pest and disease-resistant crops (555 respondents)

These strategies were consistently rated as "always used" by a large proportion of farmers. This aligns with the findings of Ikpe et al. (2023), who noted similar coping strategies among farmers in Kaduna State. The high ranking of early planting and use of inorganic manures suggests that farmers rely heavily on external inputs to maintain soil fertility and protect crops from pests and diseases. These methods are likely perceived as immediate and effective responses to declining soil productivity and increased pest pressure due to climate change (Sani & Adebayo, 2020).

Moderately Adopted Strategies

The following strategies have a moderate adoption rate (RII = 0.6-0.7) and are used by a smaller proportion of respondents:

i. Increase in the number of weeding (362 respondents)
ii. Mixed farming practices (299 respondents)
iii. Loans, grants, and subsidies (257 respondents)

The ranking of mixed cropping as the top adaptation strategy aligns with existing research. For instance, a study by Ikpe et al. (2018) found that most farmers in Goronyo LGA of Sokoto State, Nigeria, adopted mixed cropping as a primary strategy to cope with climate change. This result aligns with the findings of Isaac and Ikpe (2024), who reported that maize yield is increasing in Kaduna State due to the adoption of effective adaptation strategies. This result also resonates with the findings of Ikpe et al. (2018), who identified mixed cropping, crop diversification, and varied planting dates as key farm-level adaptation strategies in Sokoto State.

A summary of the Focus Group Discussions (FGDs), comprising eight experienced crop farmers and two extension workers from each Local Government Area (LGA), was analysed. The outcomes corroborated the quantitative ranking results, with farmers in the study area emphasising the advantages of mixed cropping. They highlighted its benefits, including multiple harvests, enhanced crop security, and additional income sources. These perceived advantages underscore the relevance

of mixed cropping as a widely adopted climate change adaptation strategy among upland rice farmers in the region.

CONCLUSION

This study investigated climate change adaptation strategies among maize farmers in selected Local Government Areas of Benue State, Nigeria. Among the identified strategies, mixed cropping emerged as the most widely adopted. This practice enhances crop diversity, offers multiple harvests within a season, improves food and income security, and serves as a buffer against total crop failure due to climate variability. The study concludes that adopting effective adaptation strategies—such as exceptionally mixed cropping—is crucial for improving maize yields and ensuring the resilience of farming systems in the study area.

RECOMMENDATIONS

Based on the findings of the study, the following recommendations are made:

1. Scale up successful strategies: build on the success of mixed cropping and organic manure use by scaling up these strategies and promoting them to more farmers.
2. Improve access to credit: enhance access to loans, grants, and subsidies to help farmers adopt more adaptation strategies and improve their resilience.
3. Promote integrated farming practices: encourage farmers to adopt integrated farming practices, such as mixed farming and crop rotation, to improve soil health and reduce pests and diseases.

By adopting these recommendations, farmers in the study area can improve their resilience to climate change, enhance maize yields, and contribute to food security in Benue State, Nigeria.

REFERENCES

Adebayo, A., & Mubi, A. M. (2022). Constraints to climate change adaptation among farmers in Northeastern Nigeria. *Nigerian Journal of Agricultural Economics, 15*(1), 88–102.

Adamgbe, E. M., & Ujoh, F. (2013). Effect of variability in rainfall characteristics on maize yield in Gboko, Nigeria. *Journal of Environmental Protection, 4*, 881–887. https://doi.org/10.4236/jep.2013.49103

Adeshina, F. A., & Odekunle, T. O. (2011). Climate change and adaptation in Nigeria: Some background to Nigeria's response – III. In *International Conference on Environmental and Agriculture Engineering (IPCBEE)* (Vol. 15, pp. 146–154).

Adebayo, A., & Mubi, A. M. (2022). Constraints to climate change adaptation among farmers in Northeastern Nigeria. *Nigerian Journal of Agricultural Economics, 15*(1), 88–102.

Boko, S. N., & Iheanacho, A. C. (2021). Effects of farmers' empowerment programmes on agricultural productivity in Kwande LGA of Benue State, Nigeria [Unpublished undergraduate project]. Department of Agribusiness Management, Federal University of Agriculture, Makurdi.

Committee on World Food Security. (2014). *Global strategic framework for food security and nutrition* (3rd ed.). https://www.fao.org

Enokela, O. S., & Seini, S. A. (2013). A stochastic investigation of rainfall variability in relation to legume production in Benue State, Nigeria. *International Journal of Engineering and Science, 2*(5), 42–48.

Food and Agriculture Organisation. (2016). *The state of food and agriculture: Climate change, agriculture and food security*. http://www.fao.org/3/a-i6030e.pdf

GreenFacts. (2022). Scientific facts on IPCC climate change technical report 2022: Impacts, adaptation and vulnerability. *Intergovernmental Panel on Climate Change (IPCC)*. http://www.greenfacts.org

Hula, M. A. (2010). Population dynamics and vegetation change in Benue State, Nigeria. *Journal of Environmental Issues and Agriculture in Developing Countries, 2*(1), 53–69.

Idoma, K. (2016). Analysis of nomadic pastoralists' coping strategies to climate variability in Katsina and Zamfara States, Nigeria [Unpublished doctoral dissertation]. Ahmadu Bello University, Zaria.

Ikpe, E. (2014). Adaptation strategies to climate change among grain farmers in Goronyo Local Government Area of Sokoto State, Nigeria [Unpublished master's thesis]. Ahmadu Bello University, Zaria.

Ikpe, E. (2021). Effects of climate change on grain yield and farmers' adaptation strategies in Sokoto State, Nigeria [Doctoral dissertation, Ahmadu Bello University, Zaria].

Ikpe, E., Ejeh, U. L., & Idoma, K. (2018). Adaptation to climate change through multiple cropping systems in Sokoto State, Nigeria. *Savannah Journal of the Environmental and Social Sciences, 24*(2), 314–322.

Ikpe, E., Kilani, M. O., Ibrahim, G. J., Shamsu, A. I., Nura, S., & Ariko, J. D. (2023). Assessment of farmers' perception of climate change issues and resilience towards food security in Kubau Local Government Area of Kaduna State, Nigeria. *Zaria Geographer, 30*(1), 29–41.

Intergovernmental Panel on Climate Change. (2014). *AR5 Climate change 2014: Impacts, adaptation and vulnerability*. Cambridge University Press.

Intergovernmental Panel on Climate Change. (2021). Summary for policymakers. In *Climate change 2021: The physical science basis*. Cambridge University Press. https://doi.org/10.1017/9781009325844.001

Intergovernmental Panel on Climate Change. (2022). Summary for policymakers. In *Climate change 2022: Impacts, adaptation and vulnerability*. Cambridge University Press. https://doi.org/10.1017/9781009325844.001

Isaac, S., & Ikpe, E. (2024). Assessing climate change adaptation strategies and challenges in maize farming: A study of Giwa LGA, Kaduna State, Nigeria. *International Journal of Scientific Research in Multidisciplinary Studies, 10*(12), 32–37.

Iornongo, T. (2021). Effect of rainfall variability on yield of selected crops in Benue State, Nigeria [Doctoral dissertation, Federal University of Technology, Minna].

Jande, J. A., & Amonjenu, I. O. (2018). Land-use/land-cover change detection mapping of Apa Local Government Area, Benue State, Nigeria. *Journal of Research in Forestry, Wildlife & Environment, 10*(3). http://www.ajol.info/index.php/jrfwe

Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. *Educational and Psychological Measurement, 30*(2), 607–610.

National Bureau of Statistics. (2018). *Federal Republic of Nigeria*. Vol. 96(2). Abuja.

Newman, J. F. (2001). *Population projection for research and development*. http://www.educationforallindia.com/New%20population-projection.pdf

Nigerian Investment Promotion Commission. (2020). *NIPC Report*. https://nipc.gov.ng

Nkonya, E., Kato, E., & Place, F. (2011). *Enhancing soil fertility through organic and inorganic inputs in Sub-Saharan Africa* (IFPRI Discussion Paper).

Nnaji, C. E., Chukwu, J. O., & Umeh, O. A. (2013). Adoption of climate change mitigation and adaptation strategies among farmers in Southeast Nigeria. *Asian Journal of Agricultural Extension, Economics & Sociology, 2*(1), 1–13.

Odjugo, P. A. O. (2010). Adaptation to climate change in the agricultural sector in the semi-arid region of Nigeria. Paper presented at the *2nd International Conference on Climate Sustainability and Development in Semi-Arid Regions*, Fortaleza, Ceará, Brazil.

Ologunorisa, T. E., & Tersoo, T. (2006). The changing rainfall pattern and its implications for flood frequency in Makurdi, Northern Nigeria. *Journal of Applied Sciences and Environmental Management, 10*(3), 26–27.

Ozor, N., & Cynthia, N. (2011). *Challenges of climate change adaptation in Nigeria: A case study of Enugu State* (Working Paper Series No. 57). African Technology Policy Studies Network.

Sani, A., & Adebayo, A. A. (2020). Agricultural adaptation to climate change in Northern Nigeria: A review. *Climate and Development, 12*(4), 367–377.

Terdoo, F., Gyang, T., & Iorlamen, T. R. (2016). Annual cropped area expansion and agricultural production: Implications for environmental management in Benue State, Nigeria. *Ethiopian Journal of Environmental Studies and Management, 9*(4), 430–442.

Terseer, I., Yahaya, T. I., Samsedeen, O., & Tsado, E. K. (2019). Assessing the effects of rainfall variability in parts of Benue State, Nigeria. *Journal of Agriculture & Agricultural Technology, 19*(1), 17–29.

World Bank. (2011). *Guide to climate change adaptation in cities*. World Bank Group. http://www.worldbank.org/urban

World Bank. (2021). *Transforming food systems under climate change: Country-level insights and policy options*. International Bank for Reconstruction and Development / The World Bank.