**What Determines Arable Crop Farmers Climate Change Adaptation Decision? Evidence from Nigeria**

**Esiobu, Nnaemeka Successabc\*; Nwaiwu, Chinatu Juana;Okoye, Benjaminb; Nwaodu, Kingsley Tobechukwua;Nzeadibe, Uchechi Ursulaa; Ubaferem-Nwaoha, Odinakachukwu Peace a;Agunanne, Uchenna Theresad*;*Osuagwu, Chizoma Oliviaeand Akanda, Ndidi Stellaf**

*a DepartmentofAgriculturalEconomics,ExtensionandRuralDevelopment,FacultyofAgriculture,*

*Imo State University, Owerri, Nigeria.*

*bNational Root Crop Research Institute (NRCRI), Umudike, Abia State, Nigeria*

*c Sustainable Impact Platform, International Rice Research Institute (IRRI), Bangkok, Thailand*

*dDepartment of Agricultural Management, Imo State Polytechnic Omuma, Imo State, Nigeria*

*eDepartment of Agricultural Economics, University of Agriculture and Environmental Sciences, Umuagwo, Imo State, Nigeria*

*fDepartmentofAgriculturalExtensionandManagement,SchoolofAgronomy,FederalCollegeof*

*Land Resources Technology, Owerri ImoState, Nigeria.*

**ABSTRACT**

Empirical evidence suggests that there has been an increasing negative impact of climate change on the production of arable crops in Sub-Saharan Africa (SSA), particularly in Nigeria. Farmers must critically evaluate and adjust to the challenges presented by climate change in order to build resilience. Global, national, and local adaptation efforts have progressed through international debate, national programs, and community-based initiatives.Adaptation has been seen as a vital component of the all-encompassing, long-term global response to climate change, protecting farmers, livelihoods, and ecosystems. However, even though there are several studies regarding the factors influencing farmers' decisions to adapt to climate change. There is still a need for the present study for a deeper understanding and new knowledge about the discourse. Therefore, it is critical to understand the factors that influence farmers' decisions about climate change adaptation in order to guarantee that the right policies are put in place to support their efforts.In light of this, our study examined the factors that influence arable crop farmers' decisions about climate change adaptation. We made use of cross-sectional data from 144 arable crop farmers who were chosen from critical farming villages in Southeast Nigeria using a standardized questionnaire. To choose farmers who farmed arable crops, we used purposive and multistage sampling techniques. The purposive sampling approach was employed in order to identify regions with a high concentration of farmers producing arable crops.Multinomial logit regression and descriptive statistics were used to analyze the gathered data. Our study found that the arable crop farmers employed a variety of adaptation strategies to manage the climate risks, including migration (Y1), changing the dates of planting and harvesting (Y2), altering tillage operations (Y3), intercropping crops (Y4), crop rotation (Y5), mixed cropping (Y6), agroforestry practices (Y7), introducing well-acclimated crop varieties (Y8), mulching (Y9), and crop and livelihood diversification (Y10). Our study also demonstrates that the following factors influenced the climate change adaptation strategies of arable crop farmers in the study area: sex (X2), age (X1), education (X3), farming experience (X4), household size (X5), farm income (X6), participation in a cooperative (X7), and extension contact (X8). We found that the high cost of climate change adaptation strategies and inadequate knowledge on adaptation strategies, among others, were the barriers facing arable crop farmers adaptation decisions to climate change in the study area. Our study recommended that the arable crop farmers should take advantage of their various cooperative societies so as to jointly pool productive resources and adapt adequately to climate change in the area. Ultimately, it is important that the government strengthen the agricultural extension service system so as to provide up-to-date modern climate change information, training, and capacity building to arable crop farmers for improved yield, income, and standard of living in the study area.

***Keywords****:* Arable Crop, Climate Change, Adaptation Strategies, Multinomial Logistic Regression, Barriers and Nigeria*.*

**1.0 INTRODUCTION**

At global level, one of the biggest challenges facing humanity is the incidence of climate change (Esiobu, 2024a; Orgu *et al.,* 2024; Munonye *et al.,* 2024). The majority of the population in developing nations relies on livelihoods that are sensitive to climate change and have limited capacity for adaptation, making climate change a substantial danger to these nations (Onyeneke *et al.,* 2023; Sinore and Wang, 2024). For example, the Intergovernmental Panel on Climate Change (IPCC) Working Group I's Sixth Assessment Report for 2023 stated that the effects of climate change are predicted to exacerbate the food insecurity that already exists in the majority of low-income nations. This is particularly true for Nigeria, the most populous nation in Africa, where millions of people experience food instability and famine (Esiobu *et al.,* 2023; Carlson *et al.,* 2024). Nigeria's agricultural system is extremely vulnerable to climate change due to its over-reliance on rain-fed agriculture (March *et al.,* 2024). The production of arable crops is being impacted by climate change, which is largely caused by anthropogenic activity (Onyeneke *et al.,* 2022a). On the other hand, the methodical exploitation of land for agricultural growth is referred to as arable crop production (Onoja, 2023). Arable crops are grown on ground that is ideal for tilling, breaking up, and getting ready for planting in this sort of agricultural production (Akinnagbe and John, 2023). In order to generate a seedbed that is suitable for planting, this sort of farming is usually done on fields that have already been cleared of trees and other vegetation. The soil is prepared using techniques like tilling and plowing. Arable crops, which are typically one-season crops, include maize, rice, beans, peas, soybeans, sunflower, potatoes, and yams, among others (Lieder and Schröter-Schlaack, 2021). Nigeria, incidentally, is well positioned to produce enough food through arable crop production to meet its needs, but the effects of climate change and her inability to adapt effectively to climate change have remained a major obstacle (Food and Agriculture Organization (FAO), 2023). Therefore, reducing the harm caused by climate change has become a concern for Nigeria, the country with the largest population in Africa. Understanding how arable crop farmers in Nigeria make decisions about climate change adaptation and what influences their decisions becomes increasingly important in this regard. Individual adaptation might take the form of changing one's behavior, while community adaptation can take the form of cooperation and knowledge exchange (Huynh *et al.,* 2024). Household level behaviour that aimed at reducing the physical and financial impacts imposed by climate exacerbated hazards is the definition of adaptation at the individual/household level (Danso-Abbeam *et al.,* 2021). Arable crop farmers must use adaptation measures to lessen the effects of climate change since they are crucial in minimizing the detrimental effects on arable crop productivity (Purwanti *et al.,* 2023). The impact of climate change will continue to drive the loss in agricultural production unless adaptation mechanisms are put into place (Amadou *et al.,* 2022). Climate change adaptation is acknowledged as a crucial strategy in the context of climate change, with the goal of mitigating effects and/or seizing possibilities brought about by present or upcoming changes (Aderinoye-Abdulwahab and Abdulbaki, 2021; Onyeneke *et al.,* 2022b). However, climate change adaptation refers to actions that help reduce vulnerability to the current or expected impacts of climate change like weather extremes and hazards, sea-level rise, biodiversity loss, or food and water insecurity (Madaki *et al.,* 2023). Also, adaptation’ is defined by the IPCC (2023) as ‘the process of adjustment to actual or expected climate and its effects’. The definition differentiates between human and natural systems, going on to say: ‘In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment’ (United Nations Development Programme, (UNDP), 2023). Hence arable crop farmers must practice adaptation strategies. According to Ma and Rahut (2024), an adaptation strategy is a broad plan of action for mitigating the effects of climate change, such as extremes and variability in the climate. Its main goal will be to lessen the vulnerability of farmers who grow arable crops to climate change through a combination of policies and actions (Nath, 2024). It is imperative to comprehend the interplay between arable crop farmers' decisions to implement climate change adaptation measure. In order to give policymakers pertinent information to help vulnerable populations develop appropriate adaptation plans, studies examining the socioeconomic factors influencing arable crop farmers' decisions to adapt to climate change should be encouraged. In addition, several empirical efforts have been made by various studies (Agba *et al.,* 2017; Sufiyan *et al.,* 2020; Opeyemi *et al.,* 2022;Tajudeen *et al.,* 2022; Alehile, 2023;Saadu *et al.,* 2024; Madaki *et al.,* 2024) in understandingthe concept of climate change and farmers adaptation strategiesin Nigeria. These studies focused on the effect of climatic variables on agricultural production, farmers’ perception of climate change, and also their adaptation strategies. Empirical findings from these studies point to the fact that climate change is evidence and has significantly impacted agricultural production inNigeria. However, none of these studies evaluated what determines arable crop farmers climate change adaptation decision in Nigeria. This presents a critical research gap. This was the background against which the study was conducted.

## **2.0 MATERIALS AND METHODS**

From January to May of 2024, the study was conducted in Nigeria's Southeast agricultural zone. The zone is made up of the five States of Abia, Anambra, Ebonyi, Enugu, and Imo. There are 22,583,076 people living in the study area, with an estimated land mass of 32,610 km2 (Nigeria Population Commission (NPC), 2006; National Bureau of Statistics (NBS) 2016). The region is located between latitudes 6o741 and 8o151 North and longitudes 2o611 and 60.321 East of the Equator. The average yearly temperature in this area ranges from 21.6oC to 32.4oC, while the annual rainfall in the rainforest zone is between 720 mm and 1440 mm (Nigerian Meteorological Agency (NiMET), 2021). The State's climate is ideal for growing arable crops, and a sizable section of the populace is dedicated to farming arable crops. Purposive and random sample procedure with many stages were used in the study to pick respondents who grow arable crops. Purposive sampling was used to identify farmers in the area who cultivate arable crops as their primary source of income. Areas with high agricultural crop farming intensity (growing, among other things, cassava, sweet potatoes, maize, rice, melon, pepper, ginger, and yam) were chosen through the use of purposivesampling. The aggregate sample size consisted of one hundred and forty-four (144) farmers who farmed arable crops. The survey was administered by trained enumerators selected across the study area. Table 1 displays the sample proportion, whereas Figure 1 shows the map of the study area. The main tool utilized for data to data collection was a structured questionnaire. In addition, multinomial logistic regression was used to examine the collected data. When a nominal outcome variable has more than two categories without a defined rank or order, a multinomial logistic regression is used (Vera, 2022). This model can be used with any number of continuous or categorical independent variables. The multinomial logit model is an extension of the binary logit model used to model categorical dependent variables with more than two categories (Barmoudeh *et al.,* 2022). A significant number of research (Mdoda, 2020; Belachew and Ababu, 2021; Onyeneke *et al.,* 2022b; Molla *et al.,* 2023; Sadiq *et al.,* 2019) have modelled farmers' decisions on climate change adaptation in conjunction with their socioeconomic characteristics using the multinomial logit model. The following is the formula that was given for the study:

If is the probability of  falling in category  then

 ……………(1) leading to

 ……………(2)

 and

……………………………..(3)

Where P = Response Probability (*J* =0,1,2,3,---10) ……………(4)

Y = Arable Crop Farmers Climate Change Adaptation Strategies category; *J* = 1, 2, …,10;

**Y= Climate Change Adaptation Measures of the Arable Crop Farmersvariables**

Y1= Migration(dummy variable; yes = 1, no = 0)

Y2= Adjusting planting/harvesting dates (dummy variable; yes = 1, no = 0)

Y3= Changing tillage operations (dummy variable; yes = 1, no = 0)

Y4= Intercropping of crop(dummy variable; yes = 1, no = 0)

Y5= Crop rotation (dummy variable; yes = 1, no = 0)

Y6= Mixed cropping(dummy variable; yes = 1, no = 0)

Y7= Agroforestry practices (dummy variable; yes = 1, no = 0)

Y8= Introduction well acclimated crop varieties(dummy variable; yes = 1, no = 0)

Y9= Mulching (dummy variable; yes = 1, no = 0)

Y10= Crop and Livelihood diversification (dummy variable; yes = 1, no = 0)

NCCAM = No Climate Change Adaptation Measures

ei = Error term

Pij *=*Probability response jth observation of the ith arable crop farmer

k-1 = jth observation of the ith arable crop farmer

ln = Log likelihood

J = Response category

β1 = Estimated regression coefficients

The explanatory variables are defined as follows:

X1 = Age (years)

X2 = Sex (dummy variable; Male = 1, Otherwise = 0)

X3 = Education (years spent in school)

X4 = Farming experience (years)

X5 = Household size (number of persons)

X6= Farm income (Naira)

X7 = Membership of Cooperative (dummy variable; Member = 1, Otherwise = 0)

X8 = Extension Contact (Number of contact)

ei = Error term

**Table 1. Sampling proportion for the arable crop farmers**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Southeast States of Nigeria | Total number of Local Government Areas (LGAs) | Total Number of Communities Selected | Total Number of Villages  | Total Number of Arable crop Farmers  | Total Number of Arable crop Farmers per Zone |
| Ebonyi | 5 | 5  | 12 | 4 | 48 |
| Imo | 5  | 5  | 12 | 4 | 48 |
| Anambra | 5 | 5  | 12 | 4 | 48 |
| Total | 15 | 15 | 36 | 12 | 144 |

***Source: Field survey data, 2024***

****

**Figure 1. Map of Southeast Nigeria showing the five various States (Nigerian Geological Survey Agency (NGSA), 2020).**

**3.0 Climate Change Adaptation Strategies of the Arable Crop Farmers**

Figure 2 shows the various climate change climate change adaptation strategies of the arable crop farmers in the area. It shows that 97.22% of the farmers identified adjusting planting/harvesting dates as amongst their climate change adaptation strategies in the area.Specific humidity and temperature ranges are ideal for the growth of some plant diseases. These peak disease periods can be avoided by modifying the planting date. The study supports the findings of Han *et al.* (2022); Madaki *et al.* (2024), who suggested that, in light of the growing effects of climate change, making optimal modifications to planting and harvesting dates could be a very good method to improve arable crop output. In the same way, changing tillage operations (83.33%) and mixed cropping (70.14%) were stated by the farmers as amongst their climate change adaptation strategies in the area. Enhancing tillage practices could increase water infiltration and decrease runoff, which would support soil moisture retention. According to Teklewold and Mekonnen (2017), excessive tillage contributes to losses of soil and water, plant nutrients, and organic matter. It is also a major source of high levels of surface runoff and soil erosion from arable fields. Moreover, producing a variety of crops lowers the chance of a harvest failing entirely because of severe weather, pests, or diseases. The diversity of crops ensures a certain degree of productivity even in the event of crop failure. A within-field diversification technique based on ecological intensification is mixed cropping (Sawe, 2022; Esiobu, 2024b). It seeks to minimize the effects of climate change while increasing production per land area with little external inputs (Adeboa and Anang, 2024). More so, the farmers stated that crop rotation (65.28%), mulching (61.81%), agroforestry practices (54.86%) and introduction well acclimated crop varieties (49.31%) were among to climate change adaptation strategies of the arable crop farmers in the area. various crops require various amounts of water and root depths while rotating crops. Farmers can minimize soil erosion and maximize water consumption by rotating their crops. Mulch functions as a barrier to lessen moisture evaporation from the soil's surface. This keeps soil moisture levels stable, especially in dry spells, which increases crop resistance to drought. Agroforestry systems foster biodiversity by establishing habitats and supporting a variety of plant and animal species. The resilience of ecosystems to climate extremes is improved by this diversification. Crops that can withstand these new dangers are essential as climate change modifies the dynamics of pests and diseases. The result is in line with the study of Singh *et al.,* (2020); Williams *et al.,* (2021); Patel *et al.,* (2024)found similar study as arable crop farmers adaptation strategies to climate change. In the similar way, crop and livelihood diversification (43.06%) was identify by the farmers as among their climate change adaptation strategies. Weather patterns become far more variable and unpredictable due to climate change, which might cause crop failures for farmers who depend on a single source of revenue. By distributing the risk over several revenue streams, diversifying one's means of subsistence lessens the effect of unfavorable weather events on a household's total income. According to a number of empirical research (Onyeneke *et al.,* 2022a; Ola, 2022; Beyene *et al.,* 2023; Khan et al., 2024), one of the most important strategies for farmers to adapt to climate change is diversifying their sources of income.Also, intercropping (38.89%) and migration (30.56%) were identified by the farmers as among other various climate change adaptation strategies in the area.The possibility of a crop failing entirely because to unfavorable weather is decreased by intercropping. The degree to which crops can withstand pests, diseases, temperature swings, and drought varies. Growing many crops at once raises the chances that at least one will resist unfavorable conditions and ensures a sizeable harvest. The outcome is in line with research by Ndiritu *et al.* (2022); Mligo *et al.* (2022); and Zobeidi *et al.* (2024), which suggested that intercropping could help mitigate climate change by enhancing farms' ability to adapt, which could result in multi-beneficial climate-smart solutions for arable crops. Lastly, farmers can diversify their sources of revenue thanks to migration. Family members frequently send money home through remittances when they relocate to cities. According to Gemenne and Blocher (2017) and Sobczak-Szelc and Fekih (2020), these financial transfers can assist families in climate-affected areas in investing in adaptation measures, such as enhanced agricultural methods, weather-resistant crop varieties and other inputs.

**4.0 Socio-economic Determinants of Arable Crop Farmers Decision to Practices Climate Change Adaptation Measures**

Table 1 displays the findings of the socioeconomic factors that influence farmers of arable crops' decisions to implement climate change adaptation strategies. In order to estimate the multinomial logit model for this study, one category often referred to as the "reference or base category"—was normalized. The reference category in this analysis is the final category, " no climate change adaptation measures." Using the Hausman test for IIA, the model was run to verify the validity of the independence of the irrelevant alternatives (IIA) assumption.The multinomial logit specification is suitable and a good fit to describe the climate change adaptation tactics of arable crop farmers, according to the test, which accepted the null hypothesis of independence of the farmers' activities. Eight (8) significant socioeconomic factors that affect arable crop farmers' decisions about climate change adaptation were found in the study. They covered factors including age, household size, income, sex, education level, farming experience, cooperative membership, and extension contact. The logit regression's Likelihood Ratio Chi Square (χ2) values (94.00%) are statistically significant at 1% (P<0.00001), according to the results, indicating that the model has a good explanatory power.This suggests that, in multinomial logistic regression, all of the models fit well. The significance of this likelihood ratio statistics test suggests that the socioeconomic features of farmers who grow arable crops have a substantial impact on their decision to utilize different climate change adaptation strategies in the region. As a result, the multinomial logit result's interpretation and discussion are shown below:

**Age (X1):** Age of the farmers was negative across some of the climate change adaptation strategies practiced by the arable crop farmers but still significant. The coefficient of age, significantly decreased the probability of uptake of migration, changing tillage operations, intercropping of crop, mixed cropping, agroforestry practices, mulching, crop and livelihood diversification. This implies that younger farmers migrated more to other cities in search of greener pastures as well as practiced more of labour and time demanding climate change adaptation measures in the area. Generally, younger farmers are more innovative with full of energy to attempt any labour demanding climate change adaptation measures than their older counterpart who are always reluctant to practice modern and more advanced climate change adaptation measures. It is quite reasonable that this group would rather settle for conventional adaptation measure used in the study area. A year increase in the coefficient of age of the arable crop farmers resulted in a 5.92% increase in migration, 7.14% increase in changing tillage operations, 3.60% increase in intercropping of crop, 3.22% increase in mixed cropping, 2.79% increase in agroforestry practices, 4.02 increase in mulching, and 5.02% increase crop and livelihood diversification in the study area.The result tallies with the study of Onyeneke *et al.,* (2022b); Adeboa, and Anang (2024) who found that younger farmers are more energetic, innovative, full of enthusiasm to practice more labour intensive and time consuming climate change adaptation measures than their older counterpart who may be conscious of their health situation and benefit of the adaptation measures which may not be immediate.

**Sex (X2):** Sex had a negative and but significant coefficient with Changing tillage operations, intercropping of crop, mixed cropping, agroforestry practices and mulching. This is an indication that the female arable crop farmers practices less of the above adaptation measures. Therefore, the finding implies that been a female arable crop farmer decreases the likelihood of practicing changing tillage operations by 3.52%, intercropping of crop by 2.37%, mixed cropping by 2.69%, agroforestry practices by 2.18%, and mulching by 2.90%. This could be attributed to the less energy demand and labour intensive of the above practices. This implies that different sexes react differently to various climate change adaptation strategies. This study shows that male farmers are expected to adapt to climate change better and faster than female ones due to their enhanced access to productive resources such as farmland, credit and pooled labour which may help them to overcome climate change much better. The finding is in line with the study of Mdoda (2020); Abbass *et al.,* (2022) who asserted that female farmers were more involved in the climate change practices that are less labour and economic demanding than their male counterparts.

**Education (X3):**All of the modeled climate change adaptation indicators showed statistically significant and favorable effects from the farmers' education on arable crops. This outcome is consistent with the model's a priori expectation. This suggests that more people adopted different ways for adapting to climate change as a result of education. Farmers with higher levels of education are better able to comprehend and apply adaptation strategies that can lessen the effects of climate change on the production of arable crops. Thus, an additional year spent in education is expected to result in a 3.36% increase in the practice of migration, a 3.55% adjustment in planting/harvesting dates, a 2.53% change in tillage operations, a 2.59% increase in crop intercropping, a 3,62% increase in crop rotation, a 3.32% increase in mixed cropping, a 2.56% increase in agroforestry practices, a 3.83% introduction of well-acclimated crop varieties, a 2,68% increase in mulching, and a 2.93% increase in crop and livelihood diversification. The most likely explanation is that farmers may adopt sustainable techniques that preserve natural resources because of education.As a result, this finding emphasizes how crucial education is to arable crop farming in Southeast Nigeria's resilience to climate change. The findings support the findings of Madaki*et al.* (2024) and Mugisho*et al.* (2024), who found that education gives farmers the tools they need to lessen the negative effects of climate change, maintain economic stability, and encourage environmental stewardship, all of which eventually increase farmers' income and yield while also improving the well-being of rural communities and society at large.

**Farming experience (X4):** Farming experience was statistically positive and significant across all the climate change adaptation measures modelled. This result is in line with the *a priori* expectation of the model. This is an indication that farming experience increased the uptake of the climate change adaptation measures by the arable crop farmers. This implies that experienced arable crop farmers practiced these climate change adaptation strategies to increase their yield, income, and standard of living in the area.Arable crop farmers with extensive experience have likely encountered various climatic challenges and have developed adaptive capacities. They can draw from past experiences to devise strategies for managing new and evolving climate-related risks. Hence, a 1-year increase in the farming experience is likely to increase the practice ofmigration by 4.12%, adjusting planting/harvesting dates by 3.53%, changing tillage operations by 2.92%, intercropping of crop by 3.75% crop rotation by 4.72%, mixed cropping by 2.58%, agroforestry practices by 2.52%, introduction well acclimated crop varieties by 2.93% mulching by 4.26% and crop and livelihood diversification by 3.44%.Years of farming experience foster innovation and problem-solving skills. Experienced farmers are often adept at experimenting with new techniques, and technologies in arable crop farming to find solutions that work best under changing climatic conditions (Sinore and Wang, 2024).

**Household size (X5):** Household size regarded as a proxy for family labour in farming was statistically positive and increased the likelihood of practicing migration by 3.26%, adjusting planting/harvesting dates by 3.00%, changing tillage operations by 3.44%, intercropping of crop by 4.72% crop rotation by 3.47%, mixed cropping by 3.77%, agroforestry practices by 3.64%, introduction well acclimated crop varieties by 3.64% mulching by 2.51% and crop and livelihood diversification by 3.81%.Similarly, labour is required to implement climate change adaptation strategies which in most instances are provided by the farm family members. Household labor often extends to building and maintaining social networks within the farming community. These networks are essential for sharing resources, information, and support during times of climate stress. The study of Dzalbe *et al.,* (2024) observed that household labour is indispensable for climate change adaptation among arable farmers. It ensures the implementation of diversified and sustainable practices, promotes knowledge sharing, enhances flexibility, and strengthens arable crop farmers resilience to climate change (Orgu *et al.,* 2024).

**Farm Income (X6**): The income of farmers had a positive and significant effect on the likelihood of practicing all the climate change adaptation strategies modelled. This is an indication that arable crop farmers with higher farm income practiced these climate change adaptation strategies to increase their yield, income and standard of living than their counterpart with low income. A significant increase in farm income is likely to increase the practice ofmigration by 2.82%, adjusting planting/harvesting dates by 2.91%, changing tillage operations by 4.77%, intercropping of crop by 3.69% crop rotation by 2.58%, mixed cropping by 3.61%, agroforestry practices by 3.31%, introduction well acclimated crop varieties by 3.52% mulching by2.91% and crop and livelihood diversification by 3.03%.Farm income enables arable crop farmers to invest in infrastructure and inputs that can mitigate the effects of climate change. The finding is in line with the study of Belachew and Ababu (2021) who asserted that with adequate farm income, arable farmers crop can adopt modern technologies and innovations that enhance climate resilience.

**Membership of Cooperative Society (X7):** Membership of cooperative had a positive and significant influence across all the climate change adaptation strategies measured. The finding shows that been a member of cooperative increases the likelihood of practicing migration by 3.91%, adjusting planting/harvesting dates by 2.60%, changing tillage operations by 4.79%, intercropping of crop by 4.01% crop rotation by 2.96%, mixed cropping by 2.71%, agroforestry practices by 2.71%, introduction well acclimated crop varieties by 4.61% mulching by 3.68% and crop and livelihood diversification by 3.14%. Membership of cooperatives can significantly bolster the capacity of arablecrop farmers to adapt to climate change. It provides access to resources, financial support, knowledge, collective bargaining power, shared infrastructure, risk management tools and sustainable practices (Esiobu *et al.,* 2023). The study is in line with the result of Oyelere *et al.,* (2020); Onoja(2023)who reported that membership of cooperatives is vital for climate change adaptation among arable farmers, offering numerous benefits that enhance resilience and adaptive capacity. Cooperatives often provide members with access to essential resources and inputs that are crucial for climate change adaptation.

**Extension Contact (X8):**Across all modeled techniques for adapting to climate change, extension contact showed a favorable and significant influence. The findings suggest that farmers who received regular visits from extension agents were more likely to use all of the measures for adapting to climate change than their counterparts who did not have access to extension agents in their area. According to the results, the likelihood of practicing migration increased by 2.59%, planting/harvesting date adjustments by 3.72%, tillage operations changes by 3.10%, crop intercropping by 3.62%, crop rotation by 2.33%, mixed cropping by 3.27%, agroforestry practices by 3.02%, introduction of well-acclimated crop varieties by 2.50%, mulching by 3.81%, and crop and livelihood diversification by 3.64% for every unit increase in the number of extension visits to farmers who grow arable crops.Extension contacts give farmers access to essential knowledge, resources, and support networks, they play a critical role in helping farmers adapt to climate change. Farmers of arable crops with connections to extension agencies are more likely to use contemporary techniques for adapting to climate change in order to raise their farm's output, revenue, and standard of life. The results are consistent with the research of Ifeanyi-obi and Ekere (2021); Antwi-Agyei and Stringer (2021), who suggested that extension agents help farmers improve their overall farm management practices to better adapt to climate change, thereby promoting sustainable agricultural practices that are critical for long-term climate resilience.

**Table 2: Estimated Multinomial Logit Regression of the Socio-economic Determinants of Arable Crop Farmers Climate Change Adaptation Decisions**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| EV | Y1 | Y2 | Y3 | Y4 | Y5 | Y6 | Y7 | Y8 | Y9 | Y10 |
| Age (X1) | -0.040e-06  (-5.92)\*\*\* | 0.053 (4.02)\*\*\* | -0.095 (-7.14)\*\*\* | -0.059 (-3.60)\*\* | -0.042 (-3.22)\*\*\* | -0.065(-2.53)\*\*\* | -0.094 (-2.79)\*\*\* | 0.072 (2.50)\*\*\* | -0.036 (-4.02)\*\*\* | -0.060 (-5.01)\*\*\* |
| Sex (X2) | 0.057e-01  (2.42)\*\* | -0.093 (-2.11)\*\* | -0.036 (-3.52)\*\*\* | -0.033 (-2.37)\*\* | 0.050 (2.09)\*\* | -0.075 (-2.69)\*\*\* | -0.062 (-2.18)\*\* | 0.011 (2.03)\*\* | 0.071 (2.90)\*\*\* | -0.071 (-2.33)\*\* |
| Education (X3) | 0.095e-03 (3.26)\*\*\* | 0.064 (3.55)\*\*\* | 0.009 (2.53)\*\*\* | 0.048 (2.59)\*\*\* | 0.055 (3.62)\*\*\* | 0.094 (3.32)\*\*\* | 0.046 (2.56)\*\*\* | 0.069 (3.83)\*\*\* | 0.091(2.68)\*\*\* | 0.083 (2.93)\*\*\* |
| Farming Experience (X4) | 0.064e-05 (4.12)\*\*\* | 0.083 (3.53)\*\*\* | 0.021 (2.92)\*\*\* | 0.081 (3.75)\*\*\* | 0.039(4.72)\*\*\* | 0.052(2.58)\*\*\* | 0.082 (2.52)\*\*\* | 0.071 (2.93)\*\*\* | 0.041 (4.26)\*\*\* | 0.092 (3.44)\*\*\* |
| Household Size (X5) | 0.051e-02 (3.25)\*\*\* | 0.055 (3.00)\*\*\* | 0.066 (3.44)\*\*\* | 0.093 (4.72)\*\*\* | 0.059 (3.47)\*\*\* | 0.084 (3.77)\*\*\* | 0.067 (3.64)\*\*\* | 0.052 (2.56)\*\*\* | 0.051 (2.51)\*\*\* | 0.031 (3.81)\*\*\* |
| Farm Income (X6) | 0.008e-04 (2.82)\*\*\* | 0.056e-01 (2.91)\*\*\* | 0.062e-09 (4.77)\*\*\* | 0.059e-01 (3.69)\*\*\* | 0.081e-05 (2.58)\*\*\* | 0.073e-04 (3.61)\*\*\* | 0.047e-07(-3.31)\*\*\* | 0.063e-02 (3.52)\*\*\* | 0.051e-06 (2.91)\*\*\* | 0.0084e-02 (3.03)\*\*\* |
| Membership of Cooperative (X7) | 0.081e-01 (3.91)\*\*\* | 0.065 (2.60)\*\*\* | 0.088 (4.79)\*\*\* | 0.83 (4.01)\*\*\* | 0.058 (2.96)\*\*\* | 0.083 (2.71)\*\*\* | 0.061 (4.61)\*\*\* | 0.072 (3.68)\*\*\* | 0.056 (3.14)\*\*\* | 0.071 (2.82)\*\*\* |
| Extension Contact (X8) | 0.053e-01 (2.59)\*\*\* | 0.058 (3.72)\*\*\* | 0.068 (3.10)\*\*\* | 0.077(3.62)\*\*\* | 0.090 (2.33)\*\* | 0.062(3.27)\*\*\* | 0.099 (3.02)\*\*\* | 0.082 (2.50)\*\*\* | 0.072 (3.81)\*\*\* | 0.056 (3.64)\*\* |
| Pseudo R2 | 0.73 (73.00%) |  |  |  |  |  |  |  |  |  |
| Likelihood Chi square | 94.00\*\*\* |  |  |  |  |  |  |  |  |  |
| Sample Size (n) | 144 |  |  |  |  |  |  |  |  |  |
| Reference / Base Category | NCCAM |  |  |  |  |  |  |  |  |  |

**Computer Printout of SPSS; Values in parenthesis are Z-Values; \*\*\* Significant at 1% level, \*\* Significant at 5% level, \* Significant at 10% level; Field Survey, 2024**

**KEYS:**

|  |  |
| --- | --- |
| **Y1:**Migration | **Y8:**Introduction well acclimated crop varieties |
| **Y2:**Adjusting planting/harvesting dates  | **Y9:**Mulching |
| **Y3:**Changing tillage operations | **Y10:**Crop and Livelihood diversification |
| **Y4:**Intercropping of crop | **EV:** Explanatory variables |
| **Y5:**Crop rotation | **NCCAM:** No Climate Change Adaptation Measures |
| **Y6:**Mixed cropping |  |
| **Y7:**Agroforestry practices |  |

**5.0Barriers of Arable Crop Farmer’s Adaptation Decisions to Climate Change**

Figure 3 illustrates the outcome of farmers' hurdles to climate change adaptation when it comes to arable crops. It demonstrates that the farmers of arable crops highlighted two barriers to their adaptation to climate change: the high expense of adaption measures and a lack of knowledge about them. A major obstacle for farmers is the high expense of adapting to climate change. As a result, most arable crop producers are unable to use more effective adaptation measures in their region. Furthermore, the majority of farmers who cultivate arable crops in the region lack access to precise, localized climate projections that may guide the development of tailored adaptation strategies.The study concurs with the findings of Orgu et al. (2024), who identified two of the major obstacles facing farmers who grow arable crops as being the high expense of adapting to climate change and a lack of expertise. The farmers who grow arable crops also mentioned that other factors limiting their ability to adjust to climate change included high labor costs, a lack of effective adaptation tactics, a shortage of farmland available to extend adaptation strategies, and inadequate government support. Due to these limitations, the majority of farmers that cultivate arable crops were unable to better adapt to climate change. According to Okoronkwo et al. (2024), low labor costs and a lack of better adaption tactics can result in low crop yields, which can lower prices and sales.Similarly, farmers of arable crops identified insufficient extension contact, limited knowledge of early warning indications of climate change, and limited access to financial facilities as barriers impeding their ability to adapt to climate change. According to a similar study by Molla et al. (2023) and Onoja (2023), farmers of arable crops are particularly less able to adapt to climate change when they have limited access to farm loans and extension services. Without a doubt, farmers in the region have managed to adapt to climate change over time because to these limits. In addition to improving farmers' ability to adapt to climate change, addressing these issues will be essential for raising local farmers' yields, incomes, and standards of living.

**6.0 Conclusions and Recommendations**

Our research has empirically demonstrated that climate change is still evident and arable crop farmers are adapting several adaptation strategies to reduce the negative effect of climate change in their production. Some of the climate change adaptation measure farmers used were adjusting planting/harvesting dates; changing tillage operations; mixed cropping; crop rotation; mulching; agroforestry practices; introduction well acclimated crop varieties; crop and livelihood diversification; intercropping and migration. Our study also found how different socioeconomic factors affected arable crop farmers' decisions to adapt to climate change in the area. The findings further indicate that the following factors influenced the climate change adaptation strategies of arable crop farmers in the research area: household size (X5), farm income (X6), sex (X2), education (X3), farming experience (X4), age (X1), farm income (X6), participation in a cooperative (X7), and extension contact (X8). Therefore, these factors are crucial when formulating policies meant to increase the adaptive capacity of producers of arable crops. Additionally, the following adaptation strategies were used: migration (Y1), shifting the dates of planting and harvesting (Y2), altering tillage operations (Y3), crop intercropping (Y4), crop rotation (Y5), mixed cropping (Y6), agroforestry practices (Y7), introducing crop varieties that have acclimated well (Y8), mulching (Y9), and crop and livelihood diversification (Y10) were the adaptation strategies used by the arable crop farmers to manage the climate risks. Farmers of arable crops also had to deal with a number of obstacles that prevented them from implementing climate adaptation techniques. These limitations include, but are not limited to, the high cost of adapting to climate change, the lack of understanding about these tactics, the high cost of labor, the scarcity of farmland needed to increase adaption measures, and the poor extension contact. The different conclusions have significant policy ramifications for both farmers who grow arable crops and legislators. The goal of the awareness-raising strategy should be to make education and agricultural extension services more widely accessible. Farmers who grow arable crops need to develop their ability to adapt by strengthening the extension service system and providing government support. This is essential for increasing mitigation and adaptation tactics in the production of arable crops. In order to ensure that small-scale farmers benefit from their forecasts and minimize farm losses due to unfavorable weather events, meteorological agencies like the Nigerian Meteorological Agency (NiMet) need to broaden their scope and improve their methodology. Farmers that grow arable crops will now be able to plan ahead for the crops and when to plant and harvest them. Increased endowments could be attained, for example, by crop diversification, access to services and alternative livelihoods, and support for poorer arable crop farmers in particular. These are some of the ways that policy on improving the accessibility of climate risk adaption measures should be focused on. In order to give farmers in the study area with current, cutting-edge training on climate change adaptation and maintained capability, it is imperative that the government fortify the agricultural extension service system. Our study's findings are essential for raising the output of arable crops in southeast Nigeria and throughout Sub-Saharan Africa. In the end, more research ought to concentrate on examining the effects of climate change on a particular arable crop, like rice, over a 40-year period using meteorological variables like temperature, humidity, sunshine duration, and rainfall, among others, as well as what influences farmers' decisions regarding adaptation and mitigation in Nigeria and elsewhere.

**Acknowledgments:**

This research team wishes to thank the arable crop farmers across the selected area for the time, patience and assistance in providing valuable feedback through the research questionnaire.

**Conflicts of Interest:**

The authors declare no conflict of interest.

**Funding:**

This study received no funding. The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest

**References**

Abbass, K., Qasim, M. Z., Song, H., Murshed, M., Mahmood, H., & Younis, I. (2022). A review of the global climate change impacts, adaptation, and sustainable mitigation measures. *Environmental Science and Pollution Research International*, *29*(28), 42539–42559. <https://doi.org/10.1007/s11356-022-19718-6>

Adeboa, J., & Anang, B. T. (2024). Perceptions and adaptation strategies of smallholder farmers to climate change in Builsa South district of Ghana. *Cogent Social Sciences*, *10*(1). <https://doi.org/10.1080/23311886.2024.2358151>

Aderinoye-Abdulwahab, S. A., & Abdulbaki, T. A. (2021). Climate change adaptation strategies among cereal farmers in Kwara State, Nigeria. In *Springer eBooks* (09–522). <https://doi.org/10.1007/978-3-030-45106-6_228>

Agba, D. Z., Adewara, S. O., Adama, J. I., Adzer, K. T., & Atoyebi, G. O. (2017). Analysis of the effects of climate change on crop output in Nigeria. *American Journal of Climate Change*, *06*(03), 554–571. <https://doi.org/10.4236/ajcc.2017.63028>

Akinnagbe, O.M., & John, A.M. (2023). Use of Conservation Practices among Arable Crop Farmers in Oyo State, Nigeria. *Journal of Agricultural Extension,* 27(2), 104-113 <https://dx.doi.org/10.4314/jae.v27i2.11>

Alehile, K. S. (2023). Climate change effects on employment in the Nigeria’s agricultural sector. *Chinese Journal of Urban and Environmental Studies*. https://doi.org/10.1142/s2345748123500185

Amadou, T., Mamoutou, K., Georges, S., Alassane, B., François, A., Michel, G., & Benjamin, S. (2022). Farmers’ perception and adaptation strategies to climate change in central Mali. *Weather, Climate, and Society*, *14*(1), 95–112. <https://doi.org/10.1175/wcas-d-21-0003.1>

Antwi-Agyei, P., & Stringer, L. C. (2021). Improving the effectiveness of agricultural extension services in supporting farmers to adapt to climate change: Insights from northeastern Ghana. *Climate Risk Management*, *32*, 100304. <https://doi.org/10.1016/j.crm.2021.100304>

Barmoudeh, L., Baghishani, H., & Martino, S. (2022). Bayesian spatial analysis of crash severity data with the INLA approach: Assessment of different identification constraints. *Accident; analysis and prevention*, *167*, 106570. <https://doi.org/10.1016/j.aap.2022.106570>

Belachew, T. A., & Ababu, D. G. (2021). Statistical modeling of farmers’ preference for adaptation strategies for climate change: the case of Dera District, Oromia, Ethiopia. *Applied and Environmental Soil Science*, *2021*, 1–12. <https://doi.org/10.1155/2021/6659859>

Beyene, B., Tilahun, M., &Alemu, M. (2023). The impact of livelihood diversification as a climate change adaptation strategy on poverty level of pastoral households in southeastern and southern Ethiopia. *Cogent Social Sciences*, *9*(2). https://doi.org/10.1080/23311886.2023.2277349

Carlson, B., Kohon, J. N., Carder, P. C., Himes, D., Toda, E., & Tanaka, K. (2024). Climate Change Policies and Older Adults: An Analysis of States' Climate Adaptation Plans. *The Gerontologist*, *64*(3), gnad077. <https://doi.org/10.1093/geront/gnad077>

Danso-Abbeam, G., Ojo, T. O., Baiyegunhi, L. J. S., &Ogundeji, A. A. (2021). Climate change adaptation strategies by smallholder farmers in Nigeria: does non-farm employment play any role?.*Heliyon*, *7*(6), e07162. <https://doi.org/10.1016/j.heliyon.2021.e07162>

Dzalbe, S., Eriksson, R. H., & Hane-Weijman, E. (2024). Jumping scales and producing peripheries: Farmers’ adaptation strategies in crises. *Geoforum*, *148*, 103910. <https://doi.org/10.1016/j.geoforum.2023.103910>

Esiobu, N.S. (2024a). Are Rice Production Sustainable in Nigeria, Paper Presented at the “International Research Symposium on Agricultural Greenhouse Gas Mitigation: From Research to Implementation” from 21 to 23 October 2024 in Berlin, Germany, <https://www.agrighg-2024.de/>

Esiobu, N.S. (2024b). Quantifying the Intensity of Greenhouse Gas (GHG) Emissions Using Inbred and Hybrid Rice, Paper Presented at the “International Research Symposium on Agricultural Greenhouse Gas Mitigation: From Research to Implementation” from 21 to 23 October 2024 in Berlin, Germany, <https://www.agrighg-2024.de/>

Esiobu, N. S., Sander, B. O., Ali, J., Romasanta, R. R., Murugaiyan, V., Khatibi, S. M., Noel, O. K., Chikaodi, C. V., Theresa, O. U., Ndidi, A. S., & Chimeriri, A. D. (2023). Do Rice Farmers Have Knowledge of Greenhouse Gas (GHG) Emission Mitigation Strategies? New Evidence from Nigeria. *Asian Journal of Agricultural Extension, Economics and Sociology*, *41*(9), 541–552. <https://doi.org/10.9734/ajaees/2023/v41i92073>

Food and Agriculture Organization (FAO) (2023). Crop prospects and food situation. Global reports. Food and agriculture Organisation of the United Nations. https://www. fao. org/3/ cc086 8en/ cc086 8en. Pd

Gebru, G. W., Ichoku, H. E., & Phil-Eze, P. O. (2020). Determinants of smallholder farmers' adoption of adaptation strategies to climate change in Eastern Tigray National Regional State of Ethiopia. *Heliyon*, *6*(7), e04356. <https://doi.org/10.1016/j.heliyon.2020.e04356>

Gemenne, F., & Blocher, J. (2017). How can migration serve adaptation to climate change? Challenges to fleshing out a policy ideal. *Geographical Journal*, *183*(4), 336–347. https://doi.org/10.1111/geoj.12205

Han, X., Dong, L., Cao, Y., Lyu, Y., Shao, X., Wang, Y., & Wang, L. (2022). Adaptation to climate change effects by cultivar and sowing date selection for maize in the Northeast China Plain. *Agronomy*, *12*(5), 984. <https://doi.org/10.3390/agronomy12050984>

Huynh, L. T. M., Su, J., Wang, Q., Stringer, L. C., Switzer, A. D., & Gasparatos, A. (2024). Meta-analysis indicates better climate adaptation and mitigation performance of hybrid engineering-natural coastal defence measures. *Nature Communications*, *15*(1). <https://doi.org/10.1038/s41467-024-46970-w>

Ifeanyi-obi, C.C., &Ekere, K. (2021). Assessment of climate change training needs of agricultural extension agents in Abia state, Nigeria. *South African Journal of Agricultural Extension,49*(3), 76-89. <https://dx.doi.org/10.17159/2413-3221/2021/v49n3a12854>

Intergovernmental Panel on Climate Change (IPCC) (2023). AR6 Synthesis Report (AR6-SYR), Accessed on 20 March, 2023 from <https://www.ipcc.ch/report/sixth-assessment-report-cycle/>

Khan, N. A., Shah, A. A., Chowdhury, A., Wang, L., Alotaibi, B. A., & Muzamil, M. R. (2024). Rural households' livelihood adaptation strategies in the face of changing climate: A case study from Pakistan. *Heliyon*, *10*(6), e28003. https://doi.org/10.1016/j.heliyon.2024.e28003

Lieder, S., &Schröter‐Schlaack, C. (2021). Smart Farming Technologies in Arable Farming: Towards a Holistic Assessment of opportunities and Risks. *Sustainability*, *13*(12), 6783. <https://doi.org/10.3390/su13126783>

Ma, W., &Rahut, D. B. (2024). Climate-smart agriculture: adoption, impacts, and implications for sustainable development. *Mitigation and Adaptation Strategies for Global Change*, *29*(5). <https://doi.org/10.1007/s11027-024-10139-z>

Madaki, M. J., Owoade, E. O., Hassan, B. K., & Muhammed, H. K. (2024). Assessing Climate Change Perceptions and Adaptation Strategies among Sesame Farmers in Yobe State, Nigeria. *Asian Research Journal of Agriculture*, *17*(2), 309–317. <https://doi.org/10.9734/arja/2024/v17i245>

March, A., Woolley, M., & Failler, P. (2024). Integration of climate change mitigation and adaptation in Blue Economy planning in Africa. *Mitigation and Adaptation Strategies for Global Change*, *29*(5). <https://doi.org/10.1007/s11027-024-10133-5>

Mdoda, L. (2020). Factors influencing farmers’ awareness and choice of adaptation strategies to climate variability by smallholder crop farmers. *Journal of Agribusiness and Rural Development*, *58*(4). <https://doi.org/10.17306/j.jard.2020.01280>

Mligo, I., Misana, S., & Pauline, N. (2022). The effectiveness of adaptation strategies to climate change and variability in enhancing rural smallholder farmers’ food security in Mvomero district, Tanzania. *Journal of the Geographical Association of Tanzania*, *42*(1), 45–63. <https://doi.org/10.56279/jgat.v42i1.216>

Molla, E., Melka, Y., & Desta, G. (2023). Determinants of farmers’ adaptation strategies to climate change impacts in northwestern Ethiopia. *Heliyon*, *9*(8), e18514. <https://doi.org/10.1016/j.heliyon.2023.e18514>

Mugisho, G. M., Ngalo, L. M., &Lukeba, F. N. (2024). Vulnerability and adaptation of maize smallholder farmers to climate change: a Sub-Saharan African context. *Discover Agriculture*, *2*(1). <https://doi.org/10.1007/s44279-024-00023-4>

Munonye, J. O., Onyeneke, R. U., Ankrah, D. A., Agyarko, F. F., Onyeneke, C. J., Nejad, J. G., & Chikezie, C. (2024). Do climate change, access to electricity and renewable energy consumption matter in aquaculture production in Africa? *Natural Resources Forum*. <https://doi.org/10.1111/1477-8947.12427>

Nath, S. (2024). Mobilising transformative community-based climate change adaptation. *Urban Transformations*, *6*(1). <https://doi.org/10.1186/s42854-023-00059-7>

National Bureau of Statistics (NBS) (2016). National Bureau of Statistics Official Gazette (FGP 71/52007/2,500(OL24): National Population Estimates Legal Notice on Publication of the Details of the Breakdown of the National and State Provisional Totals, Census; 2007. (Access on 28 February, 2016).

Ndiritu, J. M., Kinama, J. M., & Muthama, J. N. (2022). Assessment of ecosystem services knowledge, attitudes, and practices of coffee farmers using legume cover crops. *Ecosphere*, *13*(4). <https://doi.org/10.1002/ecs2.4046>

Nigeria Population Commission (NPC) (2006). Nigeria Population Commission, *Nigeria Federal Government Initiative of individual head count by gender. Spread, State by State*, In :MOFINEWS; (accessed 28 February, 2016).Jan-Feb,2007, 6(3):Nigeria

Nigerian Geological Survey Agency (NGSA) (2020). Nigeria Geological Maps; 2020, Available:[https://www.scribd.com/document/81855420/Geological-Map-of Nigeria#](https://www.scribd.com/document/81855420/Geological-Map-of%20Nigeria) Access on 28th March, 2021.

Nigerian Meteorological Agency (NiMET) (2021). Drought and Flood Monitoring in South-East Bulletin. Retrieved from www.nimet.gov.ng 25 October, 2021

Okoronkwo, D. J., Ozioko, R. I., Ugwoke, R. U., Nwagbo, U. V., Nwobodo, C., Ugwu, C. H., Okoro, G. G., & Mbah, E. C. (2024). Climate smart agriculture? Adaptation strategies of traditional agriculture to climate change in sub-Saharan Africa. *Frontiers in Climate*, *6*. <https://doi.org/10.3389/fclim.2024.1272320>

Ola, A. (2022). Climate change effects and livelihood-adaptation strategies by the urban poor in Ibadan, Nigeria. *Town and Regional Planning/Stads- EnStreekbeplanninq*, *81*. <https://doi.org/10.18820/2415-0495/trp81i1.3>

Onoja, A. O. (2023). Determinants of arable crop farmers’ decisions to adapt to climate change risks in Nigeria. *African Journal of Agricultural and Resource Economics*, *18*(2), 1–13. [https://doi.org/10.53936/afjare.2023.18(1).1](https://doi.org/10.53936/afjare.2023.18%281%29.1)

Onyeneke, R. U., Agyarko, F. F., Onyeneke, C. J., Osuji, E. E., Ibeneme, P. A., & Esfahani, I. J. (2023). How Does Climate Change Affect Tomato and Okra Production? Evidence from Nigeria. *Plants*, *12*(19), 3477. <https://doi.org/10.3390/plants12193477>

Onyeneke, R. U., Amadi, M. U., & Njoku, C. L. (2022a). Climate change adaptation strategies by rice processors in Ebonyi State, Nigeria. *OchranaPríRodySlovenska/EkolóGia*, *41*(3), 283–290. <https://doi.org/10.2478/eko-2022-0029>

Onyeneke, R. U., Ejike, R. D., Osuji, E. E., & Chidiebere-Mark, N. M. (2022b). Does climate change affect crops differently? New evidence from Nigeria. *Environment, Development and Sustainability*, *26*(1), 393–419. <https://doi.org/10.1007/s10668-022-02714-8>

Opeyemi, G., Opaluwa, H., Adeleke, A., & Ugbaje, B. (2022). Effect of climate smart agricultural practices on farming householdsʹ food security status in Ika North East Local Government Area, Delta State, Nigeria. *Journal of Agriculture and Food Sciences*, *19*(2), 30–42. <https://doi.org/10.4314/jafs.v19i2.4>

Orgu, K. C., Esiobu, N.S., Sander, B. O., Ali, J., Romasanta, R. R., Varunseelan, M., Chinatu, N. J., Chukwunonso, A. P., Ekpereka, R. P., Mag, E. A., Ndidi, A. S., Ifeoma, C. C., Nwakaego, O. U., Patience, E., & Ifeyinwa, O. (2024). How Do Arable Crop Farmers’ Adapt to Climate Change? New Evidence from Nigeria. *Asian Journal of Agricultural Extension, Economics and Sociology*, *42*(4), 67–79. <https://doi.org/10.9734/ajaees/2024/v42i42396>

Oyelere, G. O., Sadiq, M. M., Olagoke, O. O., Adisa, J. O., &Abass, A. O. (2020). Adaptation Practices Among Arable Crop Farmers Against Perceived Effects of Climate Change in Rural Southwestern Nigeria. *International Journal of Sciences: Basic and Applied Research (IJSBAR)*, *52*(2), 191–202. Retrieved from <https://www.gssrr.org/index.php/JournalOfBasicAndApplied/article/view/11379>

Patel, S., Dey, A., Chaturvedi, A., Sharma, A., & Singh, R. (2024). Adaptation and mitigation strategies under climate change scenario. In *Springer eBooks* (pp. 213–228). <https://doi.org/10.1007/978-3-031-52708-1_11>

Purwanti, T. S., Syafrial, S., Huang, W., Hartono, B., Rahman, M. S., &Putritamara, J. A. (2023). Understanding farmers’ adaptation to climate change: A protection motivation theory application. *Cogent Social Sciences*, *9*(2). <https://doi.org/10.1080/23311886.2023.2282210>

Saadu, B., Ibrahim, H. Y., Nazifi, B., & Mudashiru, A. (2024). Adoption of climate-smart agricultural practices and its impact on smallholder farming households in some rural areas of North-Western Nigeria. *AgriculturaTropica Et Subtropica*, *57*(1), 23–34. <https://doi.org/10.2478/ats-2024-0003>

Sadiq, M. A., Kuwornu, J. K. M., Al-Hassan, R. M., &Alhassan, S. I. (2019). Assessing maize farmers’ adaptation strategies to climate change and variability in Ghana. *Agriculture*, *9*(5), 90. <https://doi.org/10.3390/agriculture9050090>

Sawe, J. (2022). Mixed cropping as a response to climate change in Manyoni District, Tanzania. *Journal of the Geographical Association of Tanzania*, *42*(1). <https://doi.org/10.56279/jgat.v42i1.217>

Singh, C., Ford, J., Ley, D., Bazaz, A., &Revi, A. (2020). Assessing the feasibility of adaptation options: methodological advancements and directions for climate adaptation research and practice. *Climatic Change*, *162*(2), 255–277. <https://doi.org/10.1007/s10584-020-02762-x>

Sinore, T., & Wang, F. (2024). Impact of climate change on agriculture and adaptation strategies in Ethiopia: A meta-analysis. *Heliyon*, *10*(4), e26103. <https://doi.org/10.1016/j.heliyon.2024.e26103>

Sobczak-Szelc, K., & Fekih, N. (2020). Migration as one of several adaptation strategies for environmental limitations in Tunisia: evidence from El Faouar. *Comparative Migration Studies*, *8*(1). <https://doi.org/10.1186/s40878-019-0163-1>

Sufiyan, I., Magaji, J., Ogah, A., Mohammed, K., & Geidam, K. (2020). Effect Of Climatic Variables On Agricultural Productivity And Distribution In Plateau State Nigeria. *Environment & Ecosystem Science*, *4*(1), 05–09. <https://doi.org/10.26480/ees.01.2020.05.09>

Tajudeen, T. T., Omotayo, A., Ogundele, F. O., & Rathbun, L. C. (2022). The Effect of Climate Change on Food Crop Production in Lagos State. *Foods (Basel, Switzerland)*, *11*(24), 3987. <https://doi.org/10.3390/foods11243987>

Teklewold, H., & Mekonnen, A. (2017). The tilling of land in a changing climate: Empirical evidence from the Nile Basin of Ethiopia. *Land Use Policy*, *67*, 449–459. <https://doi.org/10.1016/j.landusepol.2017.06.010>

United Nations Development Programme (2023). What is climate change adaptation? Accessed on 19-06-2024 from <https://climatepromise.undp.org/news-and-stories/what-climate-change-adaptation-and-why-it-crucial>

Vera, J. F. (2022). Distance-based logistic model for cross-classified categorical data. *The British journal of mathematical and statistical psychology*, *75*(3), 466–492. <https://doi.org/10.1111/bmsp.12264>

Williams, P. A., Simpson, N. P., Totin, E., North, M. A., & Trisos, C. H. (2021). Feasibility assessment of climate change adaptation options across Africa: an evidence-based review. *Environmental Research Letters*, *16*(7), 073004. <https://doi.org/10.1088/1748-9326/ac092d>

Zobeidi, T., Yazdanpanah, M., Komendantova, N., Löhr, K., & Sieber, S. (2024). Evaluating climate change adaptation options in the agriculture sector: a PROMETHEE-GAIA analysis. *Environmental and Sustainability Indicators*, 100395. <https://doi.org/10.1016/j.indic.2024.100395>

**Names, States, LGAs, Communities and Villages Selected for the Study**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No** | **States** | **LGA** | **Communities**  | **Villages** |
| 1 | Ebonyi | Ivo; Izzi; Ohaozara; Ohaukwu and Onicha (5). | Amagu; Akaeze; Ishiagu; Agbaja and Ezz-Inyi-Magu (5). | Oshugbo; Ugbodo; AkaezeUkwu; Umuimo; Umuobia; Azuda; Amachi; Amaenu; Isiege; Umuobor; Obinagu and Ogwor (12) |
| 2 | Imo | AbohMbaise; Ehime Mbano; Ideato North; Ihitte-Uboma and Ikeduru (5). | Amuzu; Ehime; Isiokpo; Amainyi and Umudim (5). | Nriukwu; Okwuta; Umuabazu; Ehime; Isieke; Amokwe/Amorji; Omulo; Amaohiara; Amuzu; Umudibia; Dimodu and Umuagwu (12). |
| 3 | Anambra | Aguata; Anambra East; Anambra West; Anaocha and Awka North (5). | Achina; Igbariam; IfiteAnam; Adazi-Enu; and Amansea (5). | Ebene; Umuezeinyi; Aniekwem; Eziafor;Abegbu; Iyiora-Anam;Akwankwo; Enugu-Adazi;Amaowelle; Egbeagu; Okikwa and Orebe (12). |