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WHAT DETERMINES ARABLE CROP FARMERS CLIMATE CHANGE ADAPTATION DECISION? EVIDENCE FROM NIGERIA

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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 (Y_1), changing the dates of planting and harvesting (Y_2), altering tillage operations (Y_3), intercropping crops (Y_4), crop rotation (Y_5), mixed cropping (Y_6), agroforestry practices (Y_7), introducing well-acclimated crop varieties (Y_8), mulching (Y_9), and crop and livelihood diversification (Y_{10}). Our study also demonstrates that the following factors influenced the climate change adaptation strategies of arable crop farmers in the study area: sex (X_2), age (X_1), education (X_3), farming experience (X_4), household size (X_5), farm income (X_6), participation in a cooperative (X_7), and extension contact (X_8). We found that the high cost of climate change adaptation strategies and inadequate knowledge of 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.

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INTRODUCTION

At the global level, one of the biggest challenges facing humanity is the incidence of climate change **[1, 2].** 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 **[3].** 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 **[4, 5].** Nigeria's agricultural system is extremely vulnerable to climate change due to its over-reliance on rain-fed agriculture **[6].** The production of arable crops is being impacted by climate change, which is largely caused by anthropogenic activity **[2].** On the other hand, the methodical exploitation of land for agricultural growth is referred to as arable crop production **[7]**. Arable crops are grown on ground that is ideal for tilling, breaking up, and getting ready for planting in this sort of agricultural production **[8]**. 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 **[9]**. Nigeria, incidentally, is well positioned to produce enough food through arable crop production to meet its needs, but the effects of climate change and its inability to adapt effectively to climate change have remained a major obstacle **[10]**. 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 **[11]**. Household-level behavior that is aimed at reducing the physical and financial impacts imposed by climate exacerbated hazards is the definition of adaptation at the individual/household level **[12]**. 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 **[13]**. The impact of climate change will continue to drive the loss in agricultural production unless adaptation mechanisms are put into place **[14]**. 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 **[15]**. 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 **[16]**. Also, adaptation' is defined by the **[17]** 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' **[18]**, hence arable crop farmers must practice adaptation strategies. According to **[19]**, 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 **[20]**. It is imperative to comprehend the interplay between arable crop farmers'

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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 **[21, 22, 23, 24, 25, 26]**, in understanding the concept of climate change and farmers adaptation strategies in 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 in Nigeria. However, none of these studies evaluated what determines arable crop farmers climate change adaptation decisions in Nigeria. This presents a critical research gap. This was the background against which the study was conducted.

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 km^2 **[27]**. The region is located between latitudes 6^o74^1 and 8^o15^1 North and longitudes 2^o61^1 and $6^0.32^1$ East of the Equator. The average yearly temperature in this area ranges from 21.6^oC to 32.4^oC, while the annual rainfall in the rainforest zone is between 720 mm and 1440 mm **[28]**. 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 procedures 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 purposive sampling. 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 **[29]**. 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 **[30]**. A significant number of researches **[31, 32, 33, 34]** have modeled 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:

It p_{ij} is the probability of y_i falling in category $j, j = 1, 2, ..., J,$ then

$$\ln\left(\frac{p_{ij}}{p_{iJ}}\right) = \alpha_j + \beta_j X_i, \quad j = 1, 2, ..., J-1 \quad ....(1)$$ leading to

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$$p_{ij} = \frac{e^{\alpha_j + \beta_j X_i}}{1 + \sum_{k=1}^{J-1} e^{\alpha_k + \beta_k X_i}}, \quad j = 1, \ldots, J-1 \ldots\ldots\ldots\ldots\ldots(2)$$

and

$$p_{iJ} = \frac{1}{1 + \sum_{k=1}^{J-1} e^{\alpha_k + \beta_k X_i}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

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 Farmers variables

Y_1= Migration(dummy variable; yes = 1, no = 0)

Y_2= Adjusting planting/harvesting dates (dummy variable; yes = 1, no = 0)

Y_3= Changing tillage operations (dummy variable; yes = 1, no = 0)

Y_4= Intercropping of crop(dummy variable; yes = 1, no = 0)

Y_5= Crop rotation (dummy variable; yes = 1, no = 0)

Y_6= Mixed cropping(dummy variable; yes = 1, no = 0)

Y_7= Agroforestry practices (dummy variable; yes = 1, no = 0)

Y_8= Introduction well acclimated crop varieties(dummy variable; yes = 1, no = 0)

Y_9= Mulching (dummy variable; yes = 1, no = 0)

Y_{10}= Crop and Livelihood diversification (dummy variable; yes = 1, no = 0)

NCCAM = No Climate Change Adaptation Measures

e_i = Error term

P_{ij} =Probability response j^{th} observation of the i^{th} arable crop farmer

k-1 = j^{th} observation of the i^{th} arable crop farmer

l_n = Log likelihood

J = Response category

β_1 = Estimated regression coefficients

The explanatory variables are defined as follows:

X_1 = Age (years)

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X_2 = Sex (dummy variable; Male = 1, Otherwise = 0)

X_3 = Education (years spent in school)

X_4 = Farming experience (years)

X_5 = Household size (number of persons)

X_6= Farm income (Naira)

X_7 = Membership of Cooperative (dummy variable; Member = 1, Otherwise = 0)

X_8 = Extension Contact (Number of contact)

e_i = 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*

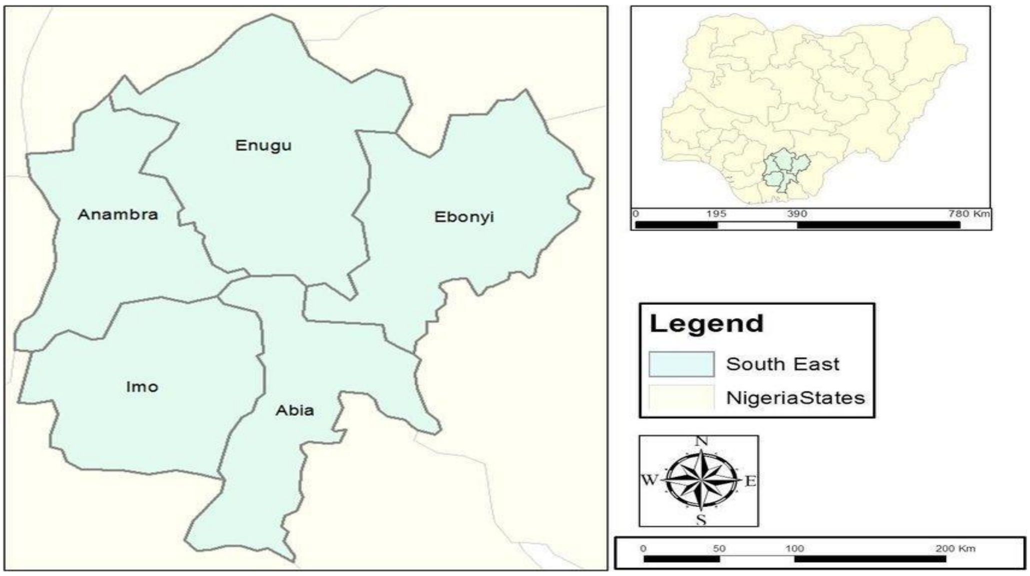

Figure 1. Map of Southeast Nigeria showing the five various States [35]

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Climate Change Adaptation Strategies of the Arable Crop Farmers

Figure 2 shows the various 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 **[36]** 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 **[37]**, 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 **[38, 39]**. It seeks to minimize the effects of climate change while increasing production per land area with little external inputs **[40]**. More so, the farmers stated that crop rotation (65.28%), mulching (61.81%), agroforestry practices (54.86%) and introduction of 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 **[41, 42, 43]** found similar study as arable crop farmers adaptation strategies to climate change. In the similar way, crop and livelihood diversification (43.06%) was identified 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 **[44, 45, 46]**, 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 **[47, 48, 49]**, 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

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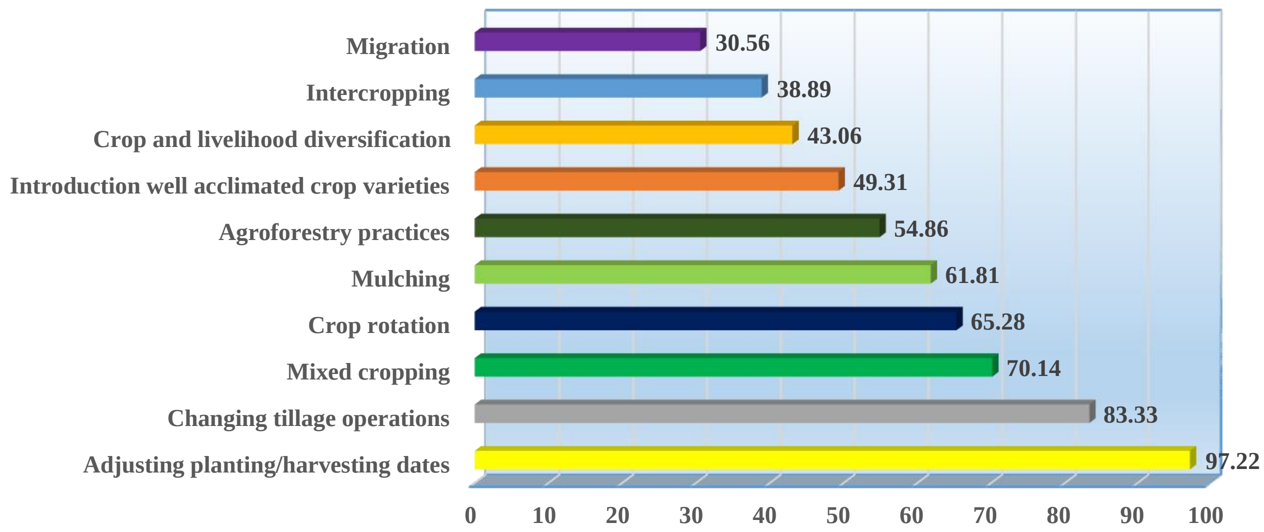
migration. Family members frequently send money home through remittances when they relocate to cities. According to **[50]**, these financial transfers can assist families in climate-affected areas in investing in adaptation measures, such as enhanced agricultural methods, weather-resistant crop varieties and other inputs.

Figure 2: Adaptation Strategies of the Arable Crop Farmers



Socio-economic Determinants of Arable Crop Farmers Decision to Practice 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 ($\chi 2$) values (94.00%) are statistically significant at 1% ($P<0.00001$), according to the results, indicating that the model has 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 (X_1): The 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,

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significantly decreased the probability of uptake of migration, changing tillage operations, intercropping of crops, 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 labor and time-demanding climate change adaptation measures in the area. Generally, younger farmers are more innovative with full of energy to attempt any labor demanding climate change adaptation measures than their older counterparts 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 **[40]**, who found that younger farmers are more energetic, innovative and full of enthusiasm to practice more labor-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 (X_2): Sex had a negative 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 being a female arable crop farmer decreases the likelihood of practicing changing tillage operations by 3.52%, intercropping of crops by 2.37%, mixed cropping by 2.69%, agroforestry practices by 2.18%, and mulching by 2.90%. This could be attributed to the lower energy demand and labour intensity 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 **[51, 52]** who asserted that female farmers were more involved in climate change practices that are less labour and economically demanding than their male counterparts.

Education (X_3): 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 of 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 **[16, 53]**, who found that education

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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 (X_4): Farming experience was statistically positive and significant across all the climate change adaptation measures modeled. 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 of migration 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 of 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 crops farming to find solutions that work best under changing climatic conditions **[54]**.

Household size (X_5): Household size regarded as a proxy for family labor 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 the crops 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 **[55]** observed that household labor 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 **[1]**.

Farm Income (X_6): The income of farmers had a positive and significant effect on the likelihood of practicing all the climate change adaptation strategies modeled. 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 of migration 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 by 2.91% 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 **[32]** who

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asserted that with adequate farm income, arable farmers' crops can adopt modern technologies and innovations that enhance climate resilience.

Membership of Cooperative Society (X_7): Membership of a cooperative had a positive and significant influence across all the climate change adaptation strategies measured. The finding shows that being 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 the crops by 4.01% crop rotation by 2.96%, mixed cropping by 2.71%, agroforestry practices by 2.71%, the introduction well-acclimated crop varieties by 4.61% mulching by 3.68% and crop and livelihood diversification by 3.14%. Membership in cooperatives can significantly bolster the capacity of arable crop 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 **[4]**. The study is in line with the result of **[7, 56]** 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 (X_8): 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 **[57, 58]** 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.

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

EV	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8	Y_9	Y_{10}
Age (X_1)	-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 (X_2)	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 (X_3)	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 (X_4)	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 (X_5)	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 (X_6)	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 (X_7)	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 (X_8)	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 R^2	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:

Y_1: Migration	**Y_8:**Introduction well acclimated crop varieties
Y_2: Adjusting planting/harvesting dates	**Y_9:**Mulching
Y_3: Changing tillage operations	**Y_{10}:**Crop and Livelihood diversification
Y_4: Intercropping of crop	**EV:** Explanatory variables
Y_5: Crop rotation	**NCCAM:** No Climate Change Adaptation Measures
Y_6: Mixed cropping	
Y_7: Agroforestry practices	

Barriers 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

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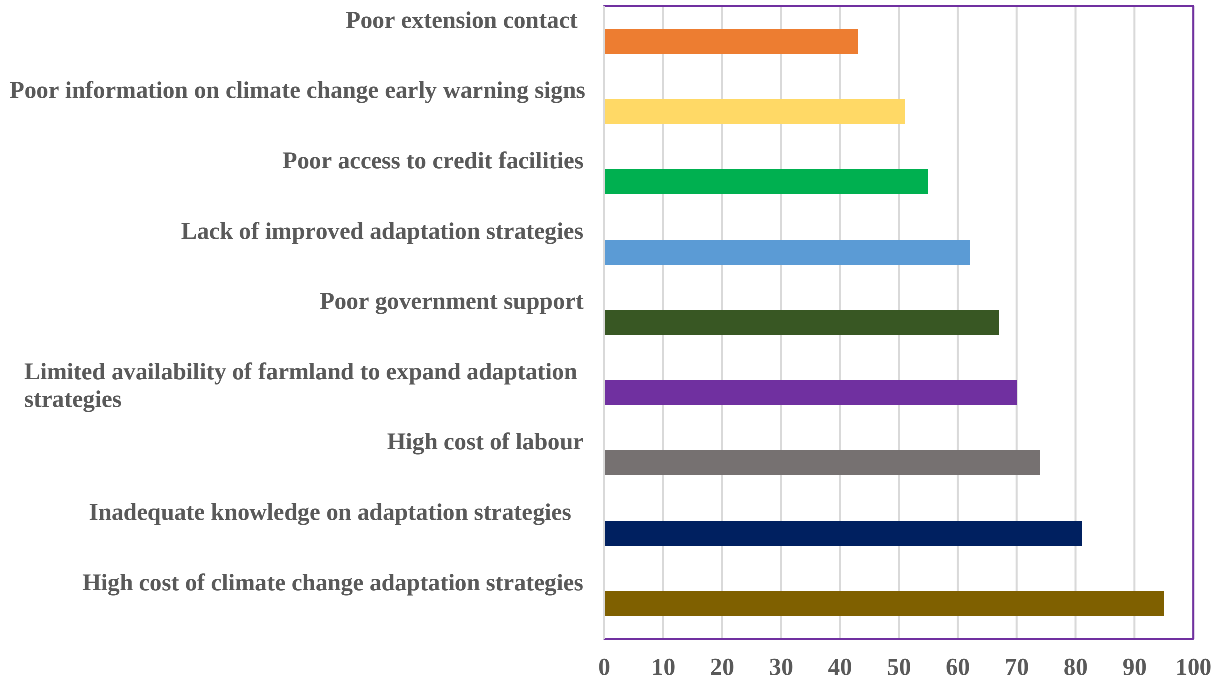
arable crops in the region lack access to precise, localized climate projections that may guide the development of tailored adaptation strategies. The study concurs with the findings of **[1, 2]**, who identified two of the major obstacles facing farmers who grow arable crops as being the high expense 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 who cultivate arable crops were unable to better adapt to climate change. According to **[59]**, 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 **[7, 33]**, 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 of 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.

Figure 3: Arable Crop Farmers Barriers to Climate Change



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CONCLUSIONS AND RECOMMENDATIONS

Our research has empirically demonstrated that climate change is still evident and arable crop farmers are adopting several adaptation strategies to reduce the negative effect of climate change on their production. Some of the climate change adaptation measures farmers used were adjusting planting/harvesting dates; changing tillage operations; mixed cropping; crop rotation; mulching; agroforestry practices; introduction of 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 (X_5), farm income (X_6), sex (X_2), education (X_3), farming experience (X_4), age (X_1), farm income (X_6), participation in a cooperative (X_7), and extension contact (X_8). 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 (Y_1), shifting the dates of planting and harvesting (Y_2), altering tillage operations (Y_3), crop intercropping (Y_4), crop rotation (Y_5), mixed cropping (Y_6), agroforestry practices (Y_7), introducing crop varieties that have acclimated well (Y_8), mulching (Y_9), and crop and livelihood diversification (Y_{10}) was 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 adaptation measures should be focused on. In order to give farmers in the study area 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.

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