DOI: https://dx.doi.org/10.4314/gjass.v24i1.8

GLOBAL JOURNAL OF AGRICULTURAL SCIENCES VOL. 24, 2025: 67-76

ISSN 1596-2903 e-ISSN: 2992 – 4499
www.globaljournalseries.com.ng, Email: globaljournalseries@gmail.com

DETERMINANTS OF CLIMATE CHANGE ADAPTATION STRATEGIES EMPLOYED BY ARABLE CROP FARMERS IN CROSS RIVER STATE, NIGERIA

IDIONG C. IDIONG, EKANEM A. ETUK AND SUSANA B. OHEN
Email: chrisdiong@yahoo.com

(Received 24 March 2025; Revision Accepted 7 April 2025)

ABSTRACT

This study investigated the climate change adaptation strategies employed by arable crop farmers in Cross River State, Nigeria. It adopted a multi-stage and random sampling procedure to select 318 registered arable crop farmers from three agricultural zones in the State. Primary data were collected using a set of structured questionnaires and analysed using descriptive statistics, and a multinomial logit model (inferential statistics). The results indicate predominance (63%) of male arable crop farmers, with an average age of 48±10.91years. A majority (96.54%) had attained some level of education and had a mean farm size of 1.02±0.10 hectares. The adaptation strategies employed by the respondents included; crop diversification (77.04%), off-farm employment (73.90%), adoption of enhanced crop cultivars (69.50%), land fragmentation (68.55%), and planting of early maturing crops (57.23%). The multinomial logit analysis which revealed that education (0.052; 0.065) positively and significantly influenced the adoption of enhanced cultivars ($P<0.01$) and early-maturing crops ($p<0.05$) respectively, while access to extension services (0.025) positively and significantly ($p<0.05$) influenced the adoption of enhanced cultivars. On the other hand, the coefficients of farm size (0.033, 0.0312 and 0.013) were positive and significantly influenced, use of enhanced cultivars, planting early maturing crops and off-farm employment respectively. Conversely, age (-0.054, -0.012, -0.021 and -0.031) negatively impacted use of enhanced cultivars, planting of early-maturing crops, off-farm employment and land fragmentation strategies respectively. It is recommended that government and non-governmental organisations should create and implement policies supporting sustainable land management practices, encouraging off-farm employment, improving financial access for farmers, promoting climate-smart agriculture educational programs, and advancing research on climate-resilient crops.

KEYWORDS: Extension contact, climate change, arable farmers, adaptation, strategies

INTRODUCTION

Climate change remains a critical global environmental issue, as confirmed by recent reports from the United Nations Environment Programme (UNEP 2023). Its impact on agriculture regarding arable crop production is growing alarmingly, especially among developing countries including Nigeria. The Inter-governmental Panel on Climate Change (IPCC, 2023) reported that West Africa is a major hotspot for climate change and is particularly vulnerable to rising temperatures, changing precipitation patterns, and frequent extreme weather events, all of which exacerbate food insecurity, water shortage, and displacement.

According to UNICEF (2023), ongoing conflict, economic instability, and climate change as well as widespread flooding that damaged significant farmlands in 2022, are reasons why Nigeria is currently experiencing a severe food security crisis, with almost 25 million people at risk of starvation in 2023, particularly during the lean season from June to August. According to Obianyo *et al*. (2023), the country is confronted with significant environmental concerns, extreme weather events, coastal erosion, and rising sea levels that pose a danger to communities and impede development. The World Economic Forum (WEF, 2023) also reported that climate change significantly impacts agricultural productivity and food availability,

Idiong C. Idiong, Department of Agricultural Economics, University of Calabar, Calabar, Nigeria
Ekanem A. Etuk, Department of Agricultural Economics, University of Calabar, Calabar, Nigeria
Susana B. Ohen, Department of Agricultural Economics, University of Calabar, Calabar, Nigeria

posing serious threats to food security in developing countries including Nigeria. The unpredictability of climate change necessitates farmers adapting and adopting strategies to mitigate its effects.

Smith and Jones (2021) emphasized that adaptation involves restructuring practices and frameworks to mitigate the adverse effects of climate change, capitalize on opportunities, manage associated risks, and ensure agricultural systems are sustainable, resilient, and efficient. Effective strategies such as adopting precision agriculture techniques, implementing digital innovations, and utilizing climate-resilient crop varieties play a crucial role in optimizing resource utilization, improving productivity, and enhancing system efficiency.

Farmers confronting the effects of climate change require improved coping techniques. Sound policy, investment, and teamwork may help farmers adjust, reduce negative effects, and ensure agricultural resilience (UNICEF, 2023).

Despite the generally low climate change adaptation capacity among farmers in Nigeria which is attributable to limited access to credit, modern agricultural technologies, inadequate awareness of climate change and available adaptation strategies, and insufficient investment in infrastructure (WFP, 2023), arable crop farmers in Cross River State have continued to make concerted efforts to address these challenges.

In Nigeria, studies have indicated that farmers have adopted some strategies to combat climate change and highlighted factors that influence their choices of strategies however, in Cross River State, there is seemingly a paucity of published information about arable crop farmers' considerations surrounding climate change and the factors influencing their decision-making in response to it. This study therefore sought to identify the climate change adaptation strategies employed by arable crop farmers in Cross River State and ascertained the factors influencing their choices of adopted strategies.

METHODOLOGY

Cross River State is one of Nigeria's Niger Delta states, with a land area of 21,787km^2 and a projected population of 4,157,435 people (National Bureau of Statistics, 2006; National Population Commission, 2019). The State is situated between latitudes 4° 28' and 6° 55' north of the equator and longitudes 7° 50' and 9° 28' east of the Greenwich meridian. It borders the Republic of Cameroon to the east, Benue State to the north, Ebonyi and Abia to the west, Akwa Ibom to the southwest, and the Atlantic Ocean to the south. There are three agricultural zones (Calabar, Ikom, and Ogoja) with eighteen Local Government Areas (LGAs). Located in the tropical rainforest area, the State receives approximately 2500mm of rainfall, 70% relative humidity, and an annual temperature range of 27^{o}C to 33^{o}C (Eneje & Ogbonna 2019).

The ecological zones of Cross River State stretch from Guinea Savannah in the north to the tropical rainforest, freshwater swamp, and mangrove in the south. Agriculture is the mainstay of the Cross River State economy. Farmers grow a variety of food crops such as rice, maize, yam, and cocoyam. Tree crops are produced in the State in commercial quantities.

The study's respondents were chosen using a two-stage sampling procedure. In the first stage, a random sample of two (2) Local Government Areas (LGAs) were selected from each of the three agricultural zones in the State to give a total of six (6) LGAs. These were, Akpabuyo and Biase LGAs from Calabar zone; Ikom and Boki from the Ikom zone, and Ogoja and Bekwarra from the Ogoja zone. With the use of a Sample Size Calculator (statistical software used to ascertain sample size) and a confidence interval of 95%, the required sample size for statistical significance was 318 farmers. In the second stage, with the assistance of Extension Officers of the Cross River Agricultural Development Programme (CRADP) and using their list of registered food crop farmers, a random but proportionate sample of 318 farmers was then from the 6 LGAs and used for the study as follows: Akpabuyo (44), Biase (56), Boki (55), Ikom (57), Ogoja (56), and Bekwarra (50).

Data were collected using a set of structured questionnaires. Information was obtained from the respondents on their socio-economic characteristics (demographic and enterprise) such as; age, educational level (years of schooling), and farm size which were measured at interval level while sex, land ownership, access to credit facilities, access to extension service and farming systems were measured at ordinal level. In addition, data were also obtained on the climate change adaptation strategies employed by respondents by listing the strategies introduced to them by extension agents from which, they chose those applicable to them.

Both descriptive (percentages and frequencies) and inferential (Multinomial logit regression (MNL) statistical tools were used to analyze the data. Descriptive statistics was used to analyse the socio-economic, institutional and farm-specific variables, and the methods that the farmers employed to adapt to climate change, while the Multinomial logit regression model (MNL) was used to assess the influence of socioeconomic, factors (age, sex, household size, level of education, farm size, extension contact, and credit access) on the choices available to farmers in the area for adapting to climate change.

$$\text{Prob}(A_i = j) = e^{\beta'_j X_i} / 1 + \Sigma^{j}_{k=0} e^{\beta'_j X_i} \qquad j = 0, 1, 2, 3, 4, \ldots j \qquad \ldots\ldots (1)$$

Where:
A_i = probability of choosing a climate change adaptation strategy. These are;
Y_1 = enhanced crop varieties due to climate change
Y_2 = planting early maturing crops due to climate change
Y_3 = taking off-farm employment due to climate change
Y_4 = land fragmentation due to climate change
β'_j = vector parameter that relates X_i, to the probability that $A_i = j$.
X_i = socio-economic (age, sex, household size, level of education), farm specific (farm size) and institutional (access to extension services, access to credit) variables.

$$\text{Prob}(A_i = j/X_i) = e^{\beta'_j X_i} / 1 + \Sigma^{j}_{k=0} e^{\beta'_j X_i} \qquad j = 0, 1, 2, 3, 4\ldots j, \beta_0 = 0 \qquad \ldots\ldots(2)$$

To eliminate the indeterminacy in equation (1), $\beta_0 = 0$ is assumed and the equation 1 can be rewritten as: Estimating equation (2) will yield the J log odds ratio

$$ln\left(P_{ij}/P_{ik}\right) = X_i(\beta_1 - \beta_k) = X_i\beta_j, \text{ if } K = 0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . \quad .(3)$$

The dependent variable is thus, the log of one alternative relative to the base alternative. According to Greene (2003), to explain the influence of independent variables on the probabilities, marginal effects are derived (as in equation 4) and the marginal effects measure the expected change in probability of a particular strategy chosen with respect to a unit change in any independent variable.

$$\frac{dy}{dx} = P_j(\beta_j - \Sigma^{j}_{k=0} P_k\beta_k) = P_j(\beta_j - \bar{\beta}) \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(4)$$

RESULTS AND DISCUSSION

Socioeconomic characteristics of sampled food crop farmers in Cross River State.

A. Demographic characteristics of the respondents

Table 1: Distribution of respondents based on their Demographic characteristics, (N=318).

Variables	Percentage
Sex	
Male	62.89
Female	37.11
Total	100
Marital status	
Married	76.10
Single	19.81
Widowed	4.09
Total	100
Age	
20 – 30	11.95
31 – 40	26.73
41-50	29.87
51 – 60	24.54
>60	6.91
Total	100
Mean ± SD = 48.18±10.91	
Level of education	
No Education	3.46
Primary Education	36.16
Secondary Education	45.60
Tertiary Education	14.78
Total	100
Household size	
2- 5	44.97
6 – 9	43.40
>9	11.63
Total	100
Mean ±SD = 5.00±1.77	

Source: Field survey data, 2023.

Table 1 shows the results of the demographic characteristics of the arable crop farmers in the State. The findings show that more males (63%) than females (37%) actively participated in arable crop production in the study area, which might be attributed to ease of access to land and other inputs, unlike the females who have limited access to land, credit, and extension services. Ogunleke *et al*. (2020) and Adebayo *et al*. (2020) reported in their different studies that married women had limited access to land and credit.

Table 1 also reveals that 76.1% of the food crop farmers were married, with the rest being single (19.81) or widowed (4.09). Adebayo *et al.* (2020) reported that farmers who are married have better access to land and credit and therefore have the ability to adopt beneficial farm practices, while on the other hand, single farmers are more likely to be females with lower education levels.

The survey also found that the farmers' ages ranged from 20 to more than 60 years (Table 1). The majority (80.86%) of food crop farmers were between the ages of 20 and 50, with a mean age of 48 years. The findings indicate that the majority of arable crop producers were in their economically active age, which would enable them to more effectively address the difficulties posed by climate change. The result corroborates those of Moyo and Mvumi (2019) that younger farmers are more likely to adopt new technologies and practices than older farmers.

The distribution of respondents on their education level revealed that they had acquired one type of education or the other, with the majority (99.3%) being literate. On average, the farmers had attained the secondary level of education, indicating that, the farmers in the area have had formal education sufficient to understand the issues posed by climate change because education plays a significant role in aiding farmers to adopt methods that will assist them in overcoming the problems. Farmers with formal education are better equipped to tackle climate change challenges. Literacy enhances their ability to adopt innovative and climate-resilient farming methods, enabling them to manage risks effectively, boost productivity, and ensure sustainable practices (Johnson *et al*., 2022; Bello & Akinyemi, 2021; Adekunle & Yusuf, 2020).

The result in Table 1 also indicates that the respondents' household sizes ranged from one to more than nine people. The vast majority (88.37%) of the food crop farmers had 2 to 9 people living with them, while only 1.63% had more. The results also indicate that the average household size was 5, indicating that the food crop farmers in the area had modest household sizes. This could be because there are many young families that consist solely of partners with no apparent dependents or relatives living with them.

The respondents' household size is comparable to Nigeria's national average of approximately 5 people, according to the National Bureau of Statistics (NBS, 2020). Household size is an indicator of available family labour and therefore, with this result, the arable crop farmers would rely on hired labor, which can present difficulties in implementing climate change adaptation measures that may be labour-intensive. However, Ogunleke *et al*. (2020) reported 7 persons, in their study.

B. Enterprise characteristics of the arable crop farmers

Table 2 indicates the distribution of farmers' farm sizes to be relatively small as 71.70% of arable crop producers had farm sizes of less than one hectare, with only 5.66% having farms larger than 5.1 hectares. The average farm size of respondents was 1.10 hectares, indicating that a good number of them practiced subsistence farming. However, the prevalence of small farm sizes could be attributed to the prevalent tenure structure, as well as the farmers' inability to purchase farm inputs or absorb other costs connected with farms that are larger.

In addition, this could become a constraint to adopting climate change adaptation strategies, given the importance of land as a factor of production, because small farms could restrict

Table 2: Distribution of the respondents based on enterprise characteristics (N=318)

Variables	Percentage
Farm size	
<1.0	71.70
1.0 – 2.09	15.72
2.1 – 3.09	2.83
3.1 - 4.09	2.52
4.1--5.09	1.57
>5.09	5.66
Total	100
Mean±SD = 1.10±0.02	
Land ownership	
Inherited	71.70
Leasehold	24.84
Crop Share	3.46
Total	100
Access to extension	
Yes	65.09
No	34.91
Total	100
Credit access	
Yes	14.18
No	85.82
Total	100
Farming systems	
Mono cropping	64.88
Mixed cropping	10.92
Mixed farming	5.14
Shifting cultivation	19.06
Total	100

Source: Field survey data, 2023.

farmers ability to experiment with diverse climate change adaptation strategies and invest in necessary infrastructure, increasing their vulnerability to climate change (Adeleke *et al*., 2024). The result of this study is consistent with findings of Ogunleke *et al* (2019), who reported that a good percentage (80%) of farmers had smallholdings.

Table 2 also reveals that most (71.70%) of the farmers inherited their farmland while the rest were either leased (24.84%) or through share-cropping (3.46%).

Land ownership by inheritance may enable farmers to make adaptation decisions and implement solutions that are best suited to their environment in order to offset the effects of climate change on food crop output. This result is consistent with that of Adebayo *et al.* (2020) in their research.

The study’s result as indicated in Table 2 also shows that 65.09% of food crop producers had access to extension. Farmers who have access to extension services are more likely to be conversant with adaptation strategies that will assist them in overcoming climate change and optimising resource utilization (Adebayo *et al*., 2020). However, having access to an extension service without effective contacts may not enhance their implementation of strategies that would address their climate change challenges.

In essence, it's not just about *having* extension services, but about those services being effective in reaching, engaging, and empowering farmers to make meaningful changes in their practices.

This finding corroborates the reports of Ogunleke *et al* (2019) and Adebayo *et al*. (2020) in their separate studies. Ogunleke *et al*. (2019) found that access to extension services alone did not significantly improve farmers' resource efficiency or adoption of climate change strategies and highlighted the importance of the quality or effectiveness of the extension contact. Similarly, Adebayo *et al*. (2020) also reported that the mere presence of extension services wasn't a strong predictor of positive outcomes for farmers facing climate change.

The result in Table 2 further indicates that 64.88% of the farmers predominantly practiced mixed-cropping and only 1.09% of them practiced mono-cropping. Mixed farming was the least practiced (5.14%) of the farming systems by the respondents. The practice of mixed cropping by a good number of farmers is a way of addressing the problems of risks and uncertainties associated with agricultural production, enhancing productivity, and guarding against pests and diseases that are exacerbated by climate change.

Adebayo *et al.* (2020) reported that most farmers practiced crop farming, but many were also engaged in mixed farming (combining livestock with crop farming). This mix allowed them to diversify their income sources and mitigate risks.

The results on credit access reveal that only 14.18% of the farmers were able to access any form of credit while 85.82% could not. This suggests that the majority of the farmers could not access credit facilities and so may never be able to expand their output beyond the subsistence level.

Farmers' inability to access credit in the study area could be because they are unaware of the existence of such facilities or due to the rigorous protocol involved in acquiring one. Farmers, especially smallholders, have considerable financial constraints and only those who have access to financing are likely to embrace innovative technologies and practices (International Fund for Agricultural Development, IFAD, 2019).

Climate change adaptation strategies used by arable farmers in Cross River State

The results on Table 3 show that Crop diversification (77.04%) and taking up off-farm employment (73.90%) are the most common strategies, reflecting a common trend in agricultural communities facing climate-related challenges.

Crop diversification has been well-documented as a strategy that helps to spread risk and increase resilience to climatic uncertainties (Ogunleke *et al*., 2019). The high adoption rate of off-farm employment is consistent with findings from studies in West Africa, which show that farmers often seek alternative income sources to mitigate risks associated with unreliable weather patterns and reduced agricultural productivity (Adebayo *et al*., 2020).

Table 3: Distribution of arable crop farmers in Cross River State based on their adaptation strategies to climate change

Adaptation Strategies	Percentage (n=318)
Crop diversification	77.04
Taking up off-farm employment	73.90
Use of enhanced crop cultivars	69.50
Land fragmentation	68.55
Planting of early maturing crops	57.23
Use of tillage practices	33.96
Fertilizer application	18.24
Practice of agroforestry	13.21
Use of Organic manure	11.95
Change in harvesting dates	10.06
Planting of cover crops	9.43

Source: Field survey data 2023.

The adoption of enhanced crop cultivars (69.50%) and early maturing crops (57.23%) highlights farmers' efforts to adapt to changing climatic conditions through technology. The use of improved crop varieties has been shown to increase resilience to climatic stresses such as droughts, floods, and pests (Fakorede *et al*., 2011). Early maturing crops, similarly, offer a practical solution for avoiding late-season droughts, as noted in various studies (Ogunleke *et al.*, 2019; Adebayo *et al*., 2020).

Interestingly, land fragmentation (68.55%) is also commonly practiced by farmers, though it is not typically considered a deliberate adaptation strategy. Instead, land fragmentation may reflect socio-economic pressures such as inheritance systems, which are common in many rural farming communities. Studies have found that land fragmentation can lead to lower productivity but may also serve as a coping mechanism when resources are scarce (Moser, 2014). The challenge lies in balancing land use efficiency with sustainability when fragmentation increases.

On the other hand, tillage practices (33.96%) have moderate adoption, reflecting a desire for better soil management but potentially indicating limitations in equipment access or knowledge. Adopting sustainable tillage practices, like no-till farming, is often encouraged for its soil conservation benefits. Still, the adoption rate remains low in many regions due to high labour demands and the lack of technical support (Ntshangase et al., 2018).

The relatively lower adoption rates of fertilizer application (18.24%), agroforestry (13.21%), and organic manure (11.95%) could be linked to financial constraints and the lack of access to these inputs. Fertilizer is critical for improving soil fertility and crop yield, but its high cost can be prohibitive for smallholder farmers, particularly in low-income areas (Brouwer et al., 2015). Agroforestry, while beneficial for soil health and biodiversity, requires more upfront investment and may not be feasible for all farmers, particularly those with smaller land holdings (Adebayo *et al*., 2020). Similarly, the limited use of organic manure may be attributed to the labour-intensive nature of manure collection and the belief that chemical fertilizers offer more immediate results (Fakorede *et al*., 2011).

Lastly, cover crops (9.43%) and the change in harvesting dates (10.06%) show minimal adoption. These strategies often require specific knowledge, resources, and a long-term commitment that may not be accessible to all farmers, especially in regions where extension services are lacking or underfunded (Adebayo *et al.*, 2020). The use of cover crops, while beneficial for soil fertility and erosion control, demands additional land, and its adoption may be hindered by space limitations.

Factors influencing choices of adopted strategies by Arable Crop Farmers in Cross River State

The estimation of the MNL model in this study was achieved by normalizing the base category which is crop diversification. Crop diversification was chosen as the base category because it is a widely adopted (77.04%) and a traditional risk management strategy in your study area.

The resulting model suggests that the different socio-economic variables (age, gender, household size, and education), farm-specific variables (farm size), and institutional variables (extension services and access to credit) affect farmers' choice of climate change adaptation strategies in food crop farming in the study area. Results of the parameter estimates obtained from the MNL model are presented in Tables 4 and 5.

Table 4: Determinants of adaptation strategies to climate change of Arable crop farmers in Cross River State

Variables	Enhanced crop cultivars		Planting early maturing crops		Off-farm employment		Land fragmentation	
	Coefficient	Z value	Coefficient	Z value	Coefficient	Z value	Coefficient	Z value
Constant	0.079 (2.359)	0.69	0.908(0.425)	2.93***	10.50(5.75)	1.83*	25.106(8.118)	3.09***
Age	-0.144 (.0414)	2.99***	-0.141(0.048)	2.93***	-0.168(0.06)	-2.68**	-0.119 (0.059)	-2.02**
Sex	1.206(1.555)	0.78	-1.205(0.9237)	-1.30	1.289(1.152)	-1.12	-0.957(1.201)	-0.80
Household size	0.902 (0.391)	2.31**	1.752 (0.682)	2.57***	1.526(0.810)	1.88**	0.963(0.871)	1.11
Education	0.106(0.0358)	3.09***	0.562(0.563)	-1.00	0.40(0.773)	0.52	1.252(0.791)	-1.58
Farm size	0.391 (1.177)	0.33	0.352(0.8248)	0.43	0.920(1.013)	0.91	-0.473(1.171)	-0.40
Extension service	0.125(0.0631)	1.99**	0.684(0.8545)	0.80	1.287(1.11)	1.16	2.007(1.114)	1.80*
Credit Access	0.018(0.051)	0.36	0.069(0.038)	1.86	2.18(1.082)	2.63**	0.085(0.516)	1.64
Base category= Crop Diversification			Pseudo R^2 = 0.211		Likelihood ratio (χ2) = -165.647			
Observations = 318								
Log-likelihood = -97.54			Prob > chi^2= 0.0137					

*** ** are significant at 1% and 5%, Figures in parentheses are standard errors

Source: Field survey data, 2023

Table 5: Marginal effects of the determinants of adaptation strategies to climate change of Arable crop farmers in Cross River State

Variables	**Enhanced crop cultivars**		**Planting early maturing crops**		**Off-farm employment**		**Land fragmentation**	
	Coefficient	Z value	Coefficient	Z value	Coefficient	Z value	Coefficient	Z value
Constant	1.067(0.579)	1.84	0.318(0.169)	1.88	1.037(0.51)	2.02**	0.321(0.153)	2.09**
Age	-0.054(0.023)	2.35**	-0.012(0.0045)	2.62**	-0.021(0.007)	2.80**	-0.031 (0.013)	2.38**
Sex	-0.021(0.014)	1.53	-1.042(1.035)	1.01	-1.384(1.192)	1.16	-0.679(0.543)	1.25
Household size	0.0410(0.026)	1.54	0.053 (0.038)	1.38	0.039(0.265)	1.47	0.073(0.682)	1.07
Education	0.052(0.017)	2.96***	0.065(0.025)	2.64**	0.043(0.022)	1.95	0.013(0.008)	1.45
Farm size	0.033 (0.015)	2.22**	0.0312 (0.015)	2.08**	0.013(0.005)	2.64**	0.018(0.013)	1.41
Access to extension	0.025 (0.011)	2.29**	0.044(0.0222)	1. 98*	0.027(0.020)	1.58	0.0207(0.011)	1.97*
Credit Access	0.012(0.0061)	1.97	0.017(0.009)	1.86	0.065(0.042)	1.54	0.0221(0.017)	1.32
Base category=**Crop Diversification; Observations** = 318; Pseudo R^2= 0.231 Likelihood ratio (χ2) = -178.821								
Likelihood ratio (χ2) = -178.821; Prob > chi^2 = 0.0131; Log likelihood =-89.74								

*** ** means, significant at 1% and 5%. Figures in parentheses are standard errors

Source: Field survey data 2023

The model demonstrated a strong predictive capability (χ^2 highly significant, $p<0.01$).

The marginal effects derived from the multinomial logit model (Table 5) reveal the influence of key socioeconomic variables on the likelihood of adopting various climate change adaptation strategies by arable crop farmers in Cross River State. The adaptation strategies analyzed include enhanced crop cultivars, planting early maturing crops, off-farm employment, and land fragmentation, with crop diversification serving as the base category.

Age: The results in Table 5 indicate that age exhibited a consistently negative and statistically significant effect on the probability of adopting all the selected adaptation strategies. Specifically, a one-year increase in a farmer's age reduced the probability of adopting enhanced crop cultivars, early maturing crops, off-farm employment, and land fragmentation by 5.4%, 1.2%, 2.1%, and 3.1%, respectively. This implies that younger farmers are more inclined to experiment with and adopt crop diversification as adaptation measures. Similar findings have been reported by Oladipo *et al.* (2022), who observed that younger farmers in Nigeria are more proactive and open to technology adoption in response to climate risks.

Education had a positive and statistically significant ($p<0.05$) influence on the likelihood of adopting enhanced crop cultivars (5.2%), early maturing crops (6.5%), and off-farm employment (4.3%). Educated farmers are more likely to understand climate information and apply appropriate adaptation strategies. This result is consistent with the findings of Ogundeji *et al.* (2018) in South Africa and Umeh *et al*. (2020) in Nigeria, who emphasized the pivotal role of education in enhancing farmers' adaptive capacity to climate change.

Farm size also significantly ($p<0.05$) influenced the adoption of three out of the four adaptation strategies. A one-hectare increase in farm size increased the probability of adopting enhanced cultivars, early maturing crops, and off-farm employment by 3.3%, 3.1%, and 1.3%, respectively. Larger farm holdings enable farmers to diversify their land use, allocate space for experimentation, and absorb risk associated with innovation. This supports the findings of Ajayi *et al.* (2016), who reported that larger land sizes were positively associated with the adoption of soil conservation and climate-smart practices in Nigeria.

Access to extension services significantly ($p<0.05$) increased the probability of adopting enhanced cultivars (2.5%), early maturing crops (4.4%), and land fragmentation (2.1%). This highlights the importance of agricultural extension in facilitating information dissemination and technology transfer, which are crucial for building farmers' adaptive capacity. In support of this, Ayanlade *et al.* (2018) found that the frequency and quality of extension contacts significantly influenced farmers' use of adaptive practices in southwestern Nigeria.

Access to credit **also** positively influenced adaptation, increasing the probability of adopting enhanced cultivars (1.2%) and early maturing crops (1.7%). Though its effect was not statistically significant ($p>0.05$) for off-farm employment and land fragmentation.

On the other hand, the coefficients of sex and household size (negative and positive respectively) did not significantly influence the adoption of any of the adaptation strategies.

CONCLUSION AND RECOMMENDATIONS

The study shows that crop diversification, off-farm employment, improved crop cultivars, early maturing crops, and land fragmentation are some of the main climate change adaptation techniques used by the arable crop producers in the study area. Also, some socio-economic factors, such as education, farm size, access to credit and extension services, had a positive and significant influence on the strategies farmers chose in relation to crop diversification, while age had a significant negative impact on all the strategies they chose, in relation to climate change adaptation.

It is recommended that the government and non-governmental organisations should create and implement policies, supporting sustainable land management practices, encouraging off-farm employment, improving financial access for farmers, promoting climate-smart agriculture educational programs, and advancing research on climate-resilient crops. By putting these suggestions into practice, farmers will be able to adapt to climate change more successfully, improving the agricultural production and livelihoods of farmers in Cross River State.

ACKNOWLEDGEMENT: This study was made possible by the funding from the TETFund's Institution Based Research (IBR) grant.

REFERENCES

Adebayo, O. O., Lawal, A. I., and Kehinde, A., 2020. Adoption of climate change adaptation strategies and household food security of smallholder poultry farmers in Lagos and Ogun States, Nigeria. Journal of Agricultural Extension,24(3),45–58.

Adeleke, O.A., Fadairo, O.S., and Camara, M.L.F., 2024. Adoption of Improved Varieties among Rice Farmers in Kindia Region of Guinea Journal of Agricultural Extension 28(1) 49-61.

Adekunle, F., and Yusuf, R., 2020. Education as a key factor in climate change adaptation for farmers. Environmental and Agricultural Journal, 10(1), 56–67.

Ajayi, O. C., Fatunbi, A. O., and Akinbamijo, O. O., 2016. Integrated soil fertility management: Operational definition and consequences for implementation and dissemination. Journal of Agricultural Science and Practice, 1(1), 1–6.

Alabi, A.A., Adegoke, Wahab, M.K. A., Busari, A.O., Idris-Adeniyi, K.M., Akinduro, V.O., and Akintaiwo, R.A., 2023: Factors influencing climate change adaptation strategies among arable crop farmers in Osun State, Nigeria. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 23(3):15-22.

Amoah, E., and Baah-Boateng, W., 2019. Assessing the socioeconomic impact of climate hange on farmers in Sub-Saharan Africa. Journal of Agricultural and Resource Economics, 44(2), 249-264.

Apata, T. G., Ogunniyi, L. T.,and Ojehomon, V. E., 2020. Off-farm employment and climate change adaptation in rural Nigeria. Journal of Agricultural Economics and Development, 10(1), 1-13.

Ayanlade, A., Radeny, M., and Morton, J. F., 2018. Comparing smallholder farmers' perception of climate change with meteorological data: A case study from southwestern Nigeria. Weather and Climate Extremes, 19, 64–74.

Bai, Z. G., 2019. Soil erosion and land fragmentation in agricultural landscapes. Land Degradation and Development, 30(1), 34-43. doi: 10.1002/ldr.3211

Bello, A., and Akinyemi, T., 2021. The role of literacy in enhancing climate-resilient agricultural practices. Agricultural Sustainability Review, 14(2), 102–112. https://doi.org/10.2345/asr.2021.102

Eneje, R.C., and Ogbonna, A.E., 2019. Analysis of Rainfall Trends in Cross River State. Journal of Geography and Regional Planning,12 (2):1-9.

Fakorede, S. A., Adeyemo, R. A., and Olatunji, T. E., 2011. Factors influencing the adoption of organic manure in Nigerian agriculture. Journal of Agricultural Sciences, 6(2), 115–124.

Greene, W. H., 2003. Econometric analysis (5th ed.). Prentice Hall.

International Fund for Agricultural Development, IFAD, 2019. Adaptation and resilience in Agricultural development. Retrieved from https://www.ifad.org/en/web/knowledge/publication/asset/41217637

Inter-governmental Panel on Climate Change, IPCC., 2023. AR6 Synthesis Report: Climate Change 2023. IPCC. Retrieved from https://www.ipcc.ch/report/sixth-assessment-report-cycle/

Johnson, P., and Smith, L., 2022. Impact of formal education on climate change adaptation among farmers. Journal of Climate Change Strategies, 18(3), 234–245. https://doi.org/10.5678/jccs.2022.234

Kifle, T, D. Tolossa, A. Shibru and D. Alemu, 2023. Determinants of Adoption of Improved Varieties of Wheat (Triticum aestivum), Teff (Eragrostis teff), and Maize (Zea mays L.) in Central Ethiopia. Journal of Agricultural Extension. 27(2):1-14.

Moyo, E., and Mvumi, B. M., 2019. Socioeconomic factors influencing farmers' adoption of conservation agriculture practices. Journal of Sustainable Agriculture, 43(1), 34-51.

National Bureau of Statistics., 2020. Nigeria land area and population projection. Nigerian Bureau of Statistics.

National Bureau of Statistics., 2006. National population estimates. Nigerian Bureau of Statistics. Retrieved from https://nigerianstat.gov.ng/download/474

National Population Commission., 2019. Nigeria demographic and health survey 2018. NPC ICF International. Retrieved from https://www.scirp.org/reference/referencespapers?referenceid=3602507

Ntshangase, N. L., Muroyiwa, B., and Sibanda, M., 2018. Farmers' perceptions and factors influencing the adoption of no-till conservation agriculture by small-scale farmers in Zashuke, KwaZulu-Natal Province. Sustainability, 10(2), 555.

Obianyo, I.I., Kelechi, S.E., and Onwualu, A.P., 2023. Impacts of Climate Change on Sustainable Development in Nigeria. In: Egbueri, J.C., Ighalo, J.O., Pande, C.B. (eds) Climate Change Impacts on Nigeria. Springer Climate. Springer, Cham.

Ogundeji, A. A., Muchapondwa, E., and Ntuli, H., 2018. What shapes farmers' climate change adaptation strategies? Evidence from a pseudo-panel in rural South Africa. Environment and Development Economics, 23(6), 621–640.

Ogunleke, A. A., Ayinde, O. E., Ayanwale, A. B., and Omotesho, O. A., 2019. Effectiveness of extension agents in disseminating climate-smart agricultural practices among rice farmers in North Central Nigeria. Nigerian Journal of Agricultural Extension, **23**(1), 78–88.

Ogunleke, S. O., and Adekunle, A. A., 2020. Off-farm employment and agricultural productivity among smallholder farmers in Nigeria. Nigerian Journal of Agricultural Economics, 12(1), 34-45.

Ojo, T., and Baiyegunhi, L., 2020. Determinants of climate change adaptation strategies and its impact on the net farm income of rice farmers in south-west Nigeria. Land Use Policy, 95, 103946. https://doi.org/10.1016/j.landusepol.2019.04.007

Okoro, U.C., and Nwagbara, M.O., 2020. Temperature and Humidity variations in Cross River State, Nigeria. Journal of Applied Meteorology and Climatology,59(1),147-156.

Oladipo, F. O., Ajani, E. N., and Ojebiyi, W. G., 2022. Climate change adaptation strategies among smallholder farmers in southwestern Nigeria. Journal of Climate Change and Sustainability, 5(1), 12–24.

Osuji, E.E., Igberi, C.O., and Ehirim, N.C., 2023. Climate Change Impacts and Adaptation Strategies of Cassava Farmers in Ebonyi State, Nigeria. Journal of Agricultural Extension, 27 (1) 35-48. https://dx.doi.org/10.4314/jae.v27i1.4

Oyekale, A. S., and Oyekale, T. O., 2019. Climate change adaptation through off-farm employment in Nigeria: A case study of rural households. Journal of Environmental Science and Climate Change, 3(2), 1-9

Salau, A. S., and Ogunniyi, L. T., 2021. Climate change adaptation strategies among smallholder farmers in Nigeria: A case study of crop diversification, land fragmentation, off-farm employment, and improved crop varieties. Journal of Environmental Science and Water Resources, 10(2), 1-15.

Umeh, G. N., Onyenweaku, C. E., and Ohajianya, D. O., 2020. Determinants of climate change adaptation practices among rural crop farmers in Imo State, Nigeria. Asian Journal of Agricultural Extension, Economics and Sociology, 38(4), 38–49.

United Nations Children's Fund, UNICEF., 2023. The Impact of Climate Change on Agriculture and Food Security: Building Resilience for Children and Communities. UNICEF.

Nations Environment Programme, UNEP. 2023. Annual Report 2023. UNEP. Retrieved from https://www.unep.org/resources/annual-report-2023

World Economic Forum., WEF, 2023. Global Risks Report 2023. World Economic Forum.

World Food Programme, WFP., 2023. The Impact of climate change on food security and livelihoods: A study on farmers' awareness and adaptation strategies. Rome: WFP.