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Assessing Climate Change Vulnerability and Risk Coping Strategies among Arable Crop Farming Households in Oyo State, Nigeria

[*1&2]Aminu, R. O., [1]Kilani, F. A., [1]Ibrahim, S. B., [1]Afolayan, S. O., and [1]Ayinde, I. A.

[1]Department of Agricultural Economics and Farm Management,
Federal University of Agriculture Abeokuta, Abeokuta, Nigeria
[2]School of Agriculture, Policy and Development, University of Reading, Reading, United Kingdom
[*]Corresponding Author's email: aminuro@funaab.edu.ng

Abstract
Nigerian farming households have continued to face threats from climate change, especially those undertaking farming under uncontrollable climate conditions. Our study examines climate change vulnerability and risk-coping strategies among arable crop farming households using primary data on socioeconomic characteristics, climate knowledge, and experience. Descriptive statistics, principal component analysis and ordered logistic regression were employed to achieve the study objective. This study indicates that over two-thirds of farming, households are susceptible to climate change. Furthermore, household income, farm size, marriage status, and age of the household head are among the socioeconomic factors that influence household vulnerability to climate change. We also found that farming households adopt strategies such as crop diversification, use of agrochemicals, shifting cultivation and changed planting date as risk-coping strategies. To reduce the vulnerability of arable crop farming households to the adverse effects of climate change, agriculture stakeholders should enhance their non-agriculture enterprises by building capacity and empowering them to enhance their non-agriculture enterprises.

Keywords: Climate change, Vulnerability, Risk coping, Arable crops, Nigeria

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Introduction

Climate change has threatened the livelihood and welfare of farmers, especially those in sub-Saharan Africa whose farming activities are practised under uncontrolled weather conditions. The link between climate change, agriculture and food security seems to be more extreme and intricate, with disastrous effects for developing countries because of its susceptibility to fluctuations in temperature and rainfall (Mangaza, Sonwa, Batsi, Ebuy, and Kahindo, 2021; Omerkhil, Kumar, Mallick, Meru, and Chand, 2020). The outcomes of climate change include rising flood occurrences, droughts, irregular precipitation or rainfall patterns, rising temperatures, and other extreme adverse climate change events that are regularly occurring presently (Oriangi *et al*., 2020; Williams *et al*., 2018). These outcomes have daunting effects on the output of crops; for instance, rising temperatures lower crop yields, heighten pests attack, and irregular rainfall increases the risk of short-term crop failure and long-term yield losses (Oriangi *et al*., 2020). Hence, climate change is a significant challenge for food production, food security and agriculture in almost all developing countries, including Nigeria, and there have been recommendations to raise and strengthen resilience to climate change and the adaptive capacity of food systems, livelihoods and nutrition in response to climate variability and extremes (FAO, IFAD, UNICEF, WFP, WHO, 2019).

Enormous proportions of agricultural households in Nigeria are vulnerable to the unfavourable effects of climate change, and various adaptive measures have been adopted to cope with these effects. The level of vulnerable community livelihoods has mostly been linked to low adaptive capacity and higher sensitivity indicators given the related level of exposure to climatic variability and drought occurrences; a lack of involvement in community-based groups and absence of income diversification have limited people's ability to adapt (Abeje *et al*., 2019). Arable land degradation, intense population pressure on arable land, extreme drought, inadequate water supply, irregular rainfall, and a lack of animal resources are some of the critical sources of vulnerability; because of this, the rich and poor in society had to adopt various coping strategies based on the respective financial status and intensity of vulnerability (Mengistu, Kebede, Feyissa, and Assefa, 2017). Reducing vulnerabilities is crucial to controlling and adjusting to disaster hazards (Cardona *et al*., 2012).

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Several efficient methods for dealing with vulnerability emphasize multilevel governance and creating co-benefits for a variety of groups by establishing connections between local organisations and experts in science through knowledge networks, benefits such as trust and stakeholder engagement as well as knowledge sharing between government and communities are increased (Phadke, Wall, Ding, and Terzija, 2016).

Contrary to adaptation, which is a long-term response to stressors, coping strategies refer to short-term reactions to shocks, such as climate shocks (Alemayehu and Bewket, 2017). It is common for households to select crop varieties adaptively, plant crops at the right time according to rainfall intensity, mix crop species, rotate crop fields every year, and use water harvesting techniques to deal with rainfall variability. A few other strategies to address livelihood challenges due to climate change vulnerability include food lending, food borrowing, livestock sales, non-agricultural enterprises, and remittances. (Sime and Anne, 2019). Risks may have different effects depending on their challenges and the type of livelihoods available to deal with them (Food and Strategy, 2017). In developing countries, adaptation is affected by socioeconomic, geographical, and meteorological conditions; thus, coping with climate change is often challenging (Omerkhil *et al*., 2020). Several significant issues need to be considered and addressed in vulnerability assessments; such problems include inadequate consideration given to indigenous knowledge and experience, the ambiguity surrounding how the vulnerability is operationalized, the lack of standardization in vulnerability measures, and the inadequacy of current assessments in terms of supporting decision-making (Onyeneke *et al*., 2020).

A complete understanding of the level of vulnerability of farming households, the factors contributing to livelihood vulnerability and the coping strategies deployed is essential for planning effective policy interventions. Recent studies in Nigeria focused on vulnerability assessments (Awolala, Ajibefun, Ogunjobi, and Miao, 2022; Onyeneke *et al*., 2020) and coping strategies used by farmers in Nigeria (Chukwuone and Amaechina, 2021). None of these studies, however, has attempted to analyse both vulnerability and coping strategies in Nigerian agricultural households jointly. Hence, this study assesses the agricultural households' climate change vulnerability and risk-coping strategies in Oyo State, Nigeria. This research aims to study the climate vulnerability and risk-coping strategies among arable crop farming households in Oyo State. The specific objectives are to

- Determine the level of vulnerability of arable crop farming households in the study area.
- Determine the factors influencing the vulnerability of these farmers to climate changes in the study area.
- Examine the risk-coping strategies employed by the arable crop farming household in the study area.

The rest of the paper is broken down into sections are follows. The next section discussed the materials and methods, including the study area, data collection and sampling procedure, and the analytical techniques employed. Section 3 presents the result and discussion, while section 4 concludes and presents the recommendations.

Materials and Methods

Study Area

The study was carried out in Oyo state, Nigeria. The State is in the Southwest geo-political zone of Nigeria and is within the longitude $7^0$23'47 "N and $3^0$55'0". The State covers a total landmass of 28,454sqkm and the population as of the 2006 census count was 5,591,589 million (National Population Commission (NPC), 2006). There are 33 Local governments in the State, and the State Capital is Ibadan. The State has an equatorial climate with two distinct seasons: wet and dry. Annual rainfall in the State is estimated to be between 1194mm in the North and 1278mm in the South. It has an average daily temperature of 27^0C (Oladejo and Ladipo, 2012). It has a relatively high humidity, and the economy of the State is largely agrarian. The area favours the cultivation of tree crops such as Cocoa, Kola, Citrus and Oil palm, as well as arable crops such as Cassava, Maize, Yam, Cowpea and Pepper. Oyo State is divided into four (4) agricultural zones by the Oyo State Agricultural Development Project (OYSADEP). The agricultural zones are Ibadan/Ibarapa zone, Ogbomosho zone, Oyo zone, and Saki zone.

Data Collection and Sampling Procedure

Primary data was used for this research. The data was collected through an interview schedule method with the aid of a well-structured questionnaire. A multistage sampling procedure was used to select respondents for the study. The first stage was the simple random sampling of one (Ibadan/Ibarapa) out of the four ADP zones in Oyo state. The second stage was the simple random sampling of two blocks (Ido and Oluyole) under the selected ADP zone. The third stage was the simple random sampling of two cells each out of the selected blocks, making up four cells. The fourth stage is the simple random sampling of three villages in each cell, making up twelve villages. Systematic random sampling was used to select the respondents, and a total number of 301 questionnaires were completed, retrieved, and subjected to analysis.

Analytical Techniques

The data on respondents' socioeconomic characteristics and risk-coping strategies were analysed using descriptive statistics such as mean, frequency counts, percentages, and standard deviation. The climate vulnerability index was computed to determine the vulnerability of respondents to changes in climatic variables. An ordered logistic regression model was used to assess the factors influencing the vulnerability of smallholder arable crop farming households to climate change. All statistical analysis was done using MS Excel

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(Microsoft, 2021) and Stata/SE 17 (StataCorp, 2021).

Calculation of the Climate Vulnerability Index (CVI) – Principal Component Analysis (PCA)

Vulnerability is assessed in this study as the overall impact of a hazard on a system (outcome vulnerability). Data were collected on selected indicators to calculate the climate vulnerability index (CVI) (see Table 1). The study employed an indicator-based approach to assessing vulnerability. The indicators selected for use were selected after a literature review of similar studies (Eze *et al*., 2018; Perez *et al*., 2019; Sharma *et al*., 2018), the available resources at the time of the research and consultation with experts in the field. The indicators selected also encompassed the three properties of a system, i.e., adaptive capacity, exposure, and sensitivity. Principal Component Analysis (PCA) is a multivariate technique for identifying patterns in highly structured data. In addition, it helps reduce the number of dimensions without much information being lost while compressing data. (Sharma *et al*., 2018). It is mainly used primarily as a data reduction technique in determining the common underlying factors and will be used to assign weights to the indicators. The weights generated are used in the calculation of the index. For this research, the index generated was then used to classify the respondents into three classes of vulnerability: less vulnerable, moderately vulnerable, and highly vulnerable.

Assessing the Determinants of Vulnerability– Ordered Logistic Regression Model

Our study examined the relationship between smallholder arable crop farming households' socioeconomic characteristics and their climate vulnerability index using an ordered logistic regression model. When the dependent variable is ordinal or categorical, the Ordered Logit regression model is applicable. We employed this model since our dependent variable has three levels which are ranked. This is similar to the work of Perez *et al*. (2019), who used ordered probit for their analysis.

Econometric Model Specification

Ordered logit regression was used to analyse the socioeconomic factors influencing the vulnerability of respondents to climate change. Following (Perez *et al*., 2019), the model is specified as follows:

$$\gamma_i^* = \alpha + \beta' x_i + e$$
$$\gamma i = 0 \text{ if } \gamma i* \leq 0$$
$$\gamma i = 1 \text{ if } 0 < \gamma i* \leq e + d'xi$$
$$\gamma i = 2 \text{ if } \gamma i* \geq e + d'xi$$

Dependent Variable

The dependent variable is the Climate Vulnerability Index (CVI). The index is a system property representing its predisposition to be affected by changes in the climate. According to IPCC (2007) framework, vulnerability is a function of a system's exposure, sensitivity, and adaptive capacity. This can be implicitly stated as follows: -

Vulnerability = f (Exposure, Sensitivity, Adaptive Capacity) …(1)

Using the equation put forward by Deressa, Hassan and Ringler,

CVI = Adaptive Capacity – (Sensitivity + Exposure) …(2)

Equation (2) can then be operationalised using the formula,

$$CVI = (w_1A_2 + w_2A_2 + \ldots..w_nA_n) - [(w_1S_1 + w_2S_2 + \ldots..w_nS_n) + (w1E1 + w2E2 + \ldots wnEn)] \ldots (3)$$

Where CVI is the climate vulnerability index W_1 - is the weight obtained for factors 1, 2, 3….n from the first principal components, S_1- S_n the sensitivity variables A_1 - A_n the adaptive capacity variables and E_1 - E_n are the exposure variables. The CVI value ranges from 0 – 1.

Independent Variables

The following explanatory variables were included in the model based on a literature review of similar studies, such as the work of Perez *et al*. (2019).

Results and discussion

Socioeconomic Characteristics of Respondents

The summary of the socioeconomic characteristics of the respondents is shown in Table 3 below. According to the table, the total number of respondents analysed is 301. The mean age of the farmers sampled was 50 years old. This suggests that most farmers are getting old and reaching a period of declining productivity. These findings agree with the work of Enete *et al*. (2015). The average years of experience were 22 years old, implying that most farmers have been in the occupation for a long time. This, therefore, shows that most of the farmers are experienced, and according to (Mbah, Ezeano, and Saror, 2016), an increased year of experience is expected to improve farmers' ability to cope with climate change effects. Table 3 also shows the grouping of respondents according to their farm sizes in hectares. The mean farm size was revealed to be 1.33 hectares, indicating that most farmers are smallholder farmers cultivating small farmland areas. Smallholder farmers have limited access to modern agricultural technology, inadequate access to agricultural credit, limited exposure to extension services, and high input cost. All of this can contribute to farmers' inability to cope with the changing effects of the climate. The farmers' years of complete education showed that most had completed at least primary school education with a mean value of 7 years. The mean household size for the respondents sampled was 6. The results showed that most respondents are average-income earners with a mean income of ₦319,000. Some of these socioeconomic characteristics are expected to affect the vulnerability level of smallholder arable crop farmers, their ability to cope, and the coping strategies adopted.

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Climate Vulnerability Level of Respondents

Table 4 shows the respondents' distribution according to their vulnerability to climatic effects. The table shows that 41.53% of the respondents are highly vulnerable to climate change effects, while 53.16% were moderately vulnerable. This implies that these groups of respondents are susceptible, highly exposed and have low adaptive capabilities to cope with climate change effects. Only a small percentage (5.32%) of the respondents were less vulnerable, and this shows that only a small percentage of the respondents are either less exposed or can cope with the adverse effects of climate change.

Factors Influencing the Vulnerability of Respondents to Climate Change

The estimated coefficients, corresponding standard errors and the marginal effects obtained from the ordered logit regression are presented in Tables 5 and 6, respectively. According to the result shown in Table 5, the age of the household head is positively significant at 5%, implying that an increase in the age of the household head is more likely to increase the vulnerability status of the household. The marginal effect indicates that as the age of the household head increases, the households' propensity of being in moderate and high vulnerability groups increases by 0.4% and 0.1%, respectively, while decreasing the tendency to be in the low vulnerability group by 0.5% (Table 6). A plausible explanation is that aged household heads are almost always set in their ways and are less likely to adopt new measures of coping with climate change, and this will leave them exposed, increasing their vulnerability. This result supports the findings of Opiyo *et al*. (2014) that households headed by older people are more likely to be vulnerable compared with younger persons in Kenya. However, the result contradicts the finding of Notenbaert *et al*. (2013), who found that aged household heads are less likely to be vulnerable to the effects of climate change because of their experience. Respondent's primary and secondary income was also positively significant at 1% and 5%, respectively, implying that an increase in primary income and secondary income could increase the probability of being vulnerability status. The marginal result suggests that as primary income source will increase the probability of a household being in and secondary incomes of household heads increases, the households' likelihood of being in moderate and high vulnerability groups increases, respectively, while decreasing the chances of being in the low vulnerability group. This finding is similar to Umoh *et al*. (2014), who ranked income as an important factor that made households vulnerable to climate hazards. However, Poudel *et al*. (2020) found that poor households were more vulnerable to climate change. The marital status of respondents was negatively significant at 1%, which shows that married respondents are less likely to be vulnerable than their unmarried counterparts. The marginal effect shows that married-headed households are 3.09% more likely to be in the low vulnerability category, 1.91% and 1.18% less likely in the moderate and high vulnerability categories, respectively. This result aligns with the finding of Opiyo *et al*. (2014) who reported that single-headed households are 37.4% more likely to be vulnerable than households headed by couples in Kenya. Farm size was also negatively significant at 1%, implying that respondents with larger farm sizes are less likely to be susceptible to climatic effects than those with smaller farm sizes. The marginal effect revealed that households with larger farm sizes are 3.09% more likely to be in the low vulnerability while less likely to be in the moderate and high vulnerability category by 1.91% and 1.18%, respectively. This is in tandem with the findings of Mutabazi *et al*. (2015), who found that an increase in farm size help reduce the level of vulnerability among smallholder farmer in the Morogoro region of Tanzania.

Risk Coping Strategies Adopted by Smallholder Arable Crop Farmers

According to Table 7, the most adopted risk-coping strategy among smallholder farmers in the study area was the changing of planting date, with a record high 98% of farmers agreeing that they change their planting date to accommodate changes in climate while only a meagre 14.62% choose the use of manure as a coping strategy. Most respondents (88.37%) also adopted crop diversification to mitigate the adverse effects of climate change, while only a tiny percentage (1.99%) of the respondents have their crops insured to cope with climate change effects. This follows the work of Okunlola *et al*. (2019), who reported that (80%) of respondents choose to plant different crops as a risk-coping strategy. This also shows that despite advances in various areas, most farmers in the study area are still not insured against risk. Okunlola *et al*. (2019) reported that although most farmers know insurance as a mitigating strategy against climate change, they do not have the necessary means to use it. This might be because of various reasons, such as the lack of adequate insurance agencies, lack of information among smallholder farmers, insufficient income, and lack of belief in insurance agencies among farmers. The use of agrochemicals was a popular coping strategy among respondents in the study area, with 84.72% agreeing to its usage, while mulching was less prevalent, with only 27.24% adopting it. Most respondents who reported using mulching as a coping strategy were farmers cultivating yams in their farmlands. The table also indicates that most respondents have not adopted the construction of drainage on farmlands as a coping mechanism, with 8.31% of respondents adopting it. At the same time, constructing irrigation systems is also not a popular choice, with just 44.19% of respondents saying they irrigate their farmland in drought. Okunlola *et al*. (2019) reported that the low adoption of irrigation among farmers might be because of the high cost of irrigation facilities which are not in place in most rural areas of the country. The other coping strategy adopted by the respondents is shifting cultivation, with up to 83.06% saying that they regularly move to other areas to plant in case of nutrient depletion, flood, and other reasons. Only 11.3% of respondents adopted cover

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cropping as a coping mechanism, while 22.59% reported using improved varieties of seeds to mitigate climate change effects.

Conclusion

The findings of this study suggest that most of the arable crop farming households in Oyo State are susceptible to climate change's adverse effects. Climate change vulnerability is influenced by several socioeconomic factors, including age, income sources, farm size, and marital status.. Change in planting date, crop diversification, agrochemical use and shifting cultivation were the most adopted coping strategies among these arable crop farming households. It is, therefore, recommended that agricultural stakeholders enhance the capacity of arable crop farmers and empower them to establish their non-agriculture enterprises, thus strengthening their income sources to reduce the vulnerability of agricultural households to climate change adverse effects.

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Table 1: List of indicators used to compute the climate vulnerability index

Indicators	Mean	Std. dev.	Expected sign
Adaptive Capacity			
Years of complete education	7.03	4.64	-
Farming experience (years)	22.28	13.80	-
Member of cooperative society	0.28	0.45	-
Use of crop insurance	0.02	0.14	-
Access to credit	0.48	0.50	-
Recipient of government intervention	0.12	0.33	-
Access to extension services	0.41	0.49	-
Access to irrigation facility	0.17	0.37	-
Use of improved seeds	0.23	0.42	-/+
Percentage of productive land	88.89	18.46	-/+
Sensitivity			
Experience crop failure due to drought	0.99	0.11	+
Experience crop failure due to flood	0.31	0.46	+
Experience crop failure due to pest and diseases infestation	0.99	0.11	+
Experience property loss due to climate risks	0.50	0.50	+
Experience death of family member due to climatic factors	0.01	0.10	+
Experience livestock death due to climate risks	0.56	0.50	+
Exposure			
Farmers experiencing drought	0.95	0.22	+
Farmers experiencing rainfall variation	0.93	0.26	+
Farmers experiencing temperature increase	0.89	0.31	+

Table 2: Description of explanatory variables used in the Ordered Logistic Regression Model

Variables	Definition	Units
Gender	Dummy for the gender of household head (male = 1)	Dummy
Age	Age of household head (years)	Years
Household Size	Number of household members	Counts
Primary Income	Income from primary occupation (Naira)	Naira (₦)
Secondary Income	Income from secondary occupation (Naira)	Naira (₦)
Farm Size	Area of land cultivated (Ha)	Hectares
Dependency Ratio	Number of dependents aged 0 to 14 and over the age of 65	Ratio
Marital Status	Marital status of household head (1 if married, 0 otherwise)	Dummy

Table 3: Socioeconomic characteristics of respondents

Variables	Mean	Std. dev.	Min	Max
Sex	0.68	0.47	0	1
Age	49.50	12.05	25	72
Household size	6.16	1.85	1	13
Primary income (‘000)	318.54	203.67	4	120
Secondary income (‘000)	32.10	43.52	0	36
Farm size	1.33	0.99	0.1	6.8
Dependency ratio	1.21	0.91	0	5
Years of complete education	7.03	4.64	0	16
Farming experience (years)	22.28	13.80	1	65
Marital status	0.83	0.37		

Source: Field Survey, 2021

Table 4: Classification of Respondents According to their Level of Vulnerability

CVI Class	Frequency	Percentage (%)	Cumulative (%)
Highly Vulnerable	125	41.53	41.53
Moderately Vulnerable	160	53.16	94.68
Less Vulnerable	16	5.32	100
Total	301	100	

Source: Field Survey, 2021

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Table 5: Ordered Probit Regression Result

Variables	Coefficient	Standard error	z	P>z
Sex	-0.178	0.171	-1.04	0.297
Age	0.014**	0.007	1.97	0.048
Household size	0.019	0.044	0.43	0.666
Primary income	0.041***	0.008	5.12	0.000
Secondary income	0.041**	0.017	2.44	0.015
Farm size	-0.444***	0.151	-2.94	0.003
Dependency ratio	-0.059	0.079	-0.75	0.452
Marital status	-0.928***	0.203	-4.56	0.000
cut1	0.420	0.356		
cut2	2.523	0.385		
Number of Observation	301			
LRchi2(8)	56.45			
Prob>chi2	0			
Pseudo R2	0.1094			
Log likelihood	-229.687			

Source: Field Survey, 2021. *** p<0.01, ** p<0.05, * p<0.1

Table 6: Results of the marginal effects

Variable	Y = 1 (Low)		Y = 2 (Moderate)		Y = 3 (High)	
	Dy/Dx	Std. Err.	Dy/Dx	Dy/Dx	Std. Err.	Dy/Dx
Sex	0.068	0.065	-0.055	0.051	-0.014	0.014
Age	-0.005**	0.003	0.004**	0.002	0.001*	0.001
Household size	-0.007	0.017	0.006	0.014	0.002	0.003
Primary income	-0.158***	0.003	0.013***	0.000	0.003***	0.001
Secondary income	-0.016**	0.006	0.013**	0.005	0.003**	0.001
Farm size	0.171***	0.058	-0.140***	0.049	-0.032***	0.013
Dependency ratio	0.023	0.030	-0.019	0.025	-0.004	0.006
Marital status	0.309***	0.054	-0.191***	0.033	-0.118***	0.042

****** p<0.01, ** p<0.05, * p<0.1***

Table 7: Distribution of Risk Coping Strategies Adopted by respondents.

Coping Strategies	Yes (%)	No (%)
Irrigation	44.19	55.81
Mulching	27.24	72.76
Crop Diversification	88.37	11.63
Use of Agrochemicals	84.72	15.28
Improved Seeds	22.59	77.41
Used Manure	14.62	85.38
Cover Cropping	11.30	88.70
Drainage Construction	8.31	91.69
Shifting Cultivation	83.06	16.94
Crop Insurance	1.99	98.01
Changed Planting Date	97.67	2.33

Source: Field Survey, 2021

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