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Socio-cultural Drivers of Adaptations and Vulnerability to Climate Change: Lessons from Crop Farmers in Ondo State

Ademola Adegoroye[1]; Babatunde Peter Ekundayo[2]; Tolulope Seun Olubunmi-Ajayi[2]*; Oladosu, Olayinka Amos[3]; Oloruntoba, Emmanuel Olalekan[4]

[1]Department of Business Administration, University of Fairfax, Salem. VA. USA
[2]Department of Agricultural and Resource Economics, Federal University of Technology, Akure, Ondo State, Nigeria.
[3]Department of Environmental Planning, Faculty of Environment and Natural Sciences, Brandenburgische Technische Universität, Germany.
[4]Department of Power Engineering, Environment Planning, Faculty of Environment and Natural Sciences, and Mechanical Engineering, Electrical and Energy Systems, Brandenburgische Technische Universität, Germany.
*Corresponding author: tolulopeolubunmiajayi@gmail.com

Abstract

This study investigated the socio-cultural determinants of climate change adaptation and vulnerability among crop farmers in Ondo State, Southwestern Nigeria. The study specifically examined the vulnerability to climate change, determined the factors influencing the level of vulnerability, and determined factors affecting the adaptation to climate change and the vulnerability status of the respondents. Using a multi-stage sampling approach and the Delphi method, 150 respondents were selected from the three Senatorial Zones. Primary data were sourced with the aid of a survey and oral interviews. The collected data were analyzed using the vulnerability index, Ordinal logistic regression, and Heckman probit regression. The findings revealed that the socio-cultural characteristics of respondents contributed to their vulnerability to climate change, as indicated by an average livelihood vulnerability index (LVI) of 0.33. Notably, factors such as water availability and adaptation practices exhibited higher vulnerability indices of 0.49 and 0.42, respectively. The overall LVI and LVI-IPCC averages were 0.35 and 0.02, respectively, highlighting the existence of vulnerability among farming households. The results of ordinal logistic regression revealed that age, marital status, education level, and income from agriculture were statistically significant factors determining the level of vulnerability to climate change in the study area. Consequently, the results of the Heckman two-step regression model revealed that age, marital status, household size, education, religion, belief, family structure, and community teamwork were the significant factors affecting the adaptation and vulnerability to climate change in the area. The policy should be geared towards improving the socio-cultural factors for sustainable livelihoods with an income diversification strategy by the government for crop farmers to cushion the effects of low income realized from farming activities in the area.

Keywords: Adaptive capacity, climate change, exposure, Nigeria, sensitivity, vulnerability

1. Introduction

One of the biggest issues facing the world today is climate change, which continues to have a significant footprint on how poor and developing countries grow. Famine, periodical floods, flash floods, and extreme heat all have detrimental effects on the ecosystem and safety, nutrition availability, and community sustainability (Bulkeley and Michele, 2013; Naqvi et al., 2023). In climate change research, the word "vulnerability" is used to explain different climate change-related factors that have impacted or are expected to influence a particular environment or a particular area (Ranganathan et al., 2009). The phrase "vulnerability" describes "the extent to which a system is susceptible to, or unable to handle, negative repercussions of environmental issues," such as climatic fluctuation and extremes. The vulnerability of a system is determined by its responsiveness, adaptability, and the kind, magnitude, and rate of climatic fluctuations to which it is exposed (IPCC, 2007).

The consequences of climate change affect people in many different categories, ranging from families, enterprises, regions, and nations. This has called for urgent attention in emerging economies. In a study published in 2007, the Intergovernmental Panel on Climate Change (IPCC) highlighted Africa's vulnerability to climate change. Even though they contribute the least to the issue, they are more susceptible to the consequences of climate change because their livelihoods are so dependent on resources that are susceptible to it. Furthermore, they are less equipped and have fewer alternatives to lessen the consequences of climate change (IPCC, 2007).

A careful examination of meteorological data reveals that during the late 1960s and the early 1970s, the climate of Nigeria saw significant regional and temporal variations in variability and change (Nigerian Meteorological Agency (NIMET), 2015). The increased frequency of ocean surges, droughts, and other severe weather and climatic phenomena, among other phenomena, may result in substantial vulnerability even if the impacts of these catastrophic occurrences are delayed. This often led to structural damage, societal upheaval, the destruction of lives and properties, as well as the eviction of local populations from the impacted regions. For example, in recent years, particularly in the Northern portions of the nation, floods have become more frequent and more intense, inflicting huge damage (Abaje and Giwa, 2010; NIMET, 2015; Abaje et al., 2017; Olutumise, 2023a).

Climate change is most likely to affect the agricultural industry, which is also the most susceptible (File and Derbile, 2020; Olutumise, 2023b; Bedeke, 2023). The agricultural industry in Nigeria, like that of other sub-Saharan African (SSA) nations, is particularly sensitive to climate change. About 63.83 percent of all areas in Nigeria are desertified owing to drought (Olagunju, 2015). In recent years, crop producers in Southwestern Nigeria have faced several difficulties as a result of climate change (Olutumise and Oparinde, 2022). The late arrival of rainfall is a clear indicator of this since it depletes the water supply of typically year-round-flowing streams and minor rivers, reducing agricultural yields (Apata et al., 2009). Therefore, the issue of climate change must be brought to the forefront because of the susceptibility of farmers whose crops and farms are being destroyed by extreme weather, thus affecting farmers' livelihoods and the general state of food security (Aldunce et al., 2016). Due to a lack of resources, rural Nigerian farmers were found to be more susceptible to the negative impacts of climate change on agricultural production (Enete and Amusa, 2010). Again, recent research highlights various aspects of climate change adaptation and vulnerability among farmers in different contexts but the information on the nexus determinants of adaptation and vulnerability to climate change, especially the sociocultural factors is not well documented. For instance, the study by Namgyel et al. (2023) emphasizes the role of farmers' perceptions in shaping adaptation strategies, similar to the Nigerian context but not how the socio-cultural factors significantly influence adaptation and vulnerability to climate change. The study of Rithaa et al., (2023) from Kenya focused on the socio-economic determinants influencing adaptation strategies among smallholder farmers. The study places a stronger focus on socio-economic attributes rather than broader socio-cultural characteristics.

A comprehensive review of the literature by Ricart et al. (2023) with that of Gashure and Wana (2023) analyzed how farmers' socio-demographic characteristics affect their perceptions of climate change, their awareness of its impacts, and their adaptation measures but also failed to find out the vulnerability of the farmers and their determinants. Again, previous studies on how farmers in South-western Nigeria see climate change and how they are adapting their practices to this new reality (Ayanlade et al., 2017; Ojo and Bayegunhi, 2020a; Adeagbo et al., 2021; Olutumise and Oparinde, 2022), and crop producers' understanding of climate change causes and impacts (Ibrahim et al., 2015; Olutumise et al., 2024). However, the vulnerability of crop producers, in particular those in the southwestern area of the country, to climate change is, nevertheless, largely unknown. It is against this backdrop that this study gave an in-depth and comprehensive examination of the socio-cultural determinants of climate change adaptation and vulnerability in Southwestern Nigeria. The main aim of this research is to examine the social and cultural determinants of vulnerability to climate change among crop farmers in Ondo State, South-western, Nigeria. The study answered the following research questions: i. what is the respondents' level of vulnerability to climate change in the area? ii. what are the socio-cultural factors affecting the level of vulnerability to climate change in the area? and iii. what are the socio-cultural factors affecting adaptation, and vulnerability to climate change in the area? Therefore, the study's detailed assessment helps in identifying specific areas where farmers are most vulnerable, such as water availability and adaptation practices. The socio-cultural factors are critical for designing targeted interventions that consider the local social fabric. The research underlines the importance of community teamwork and education in increasing adaptive capacity and reducing vulnerability. It advocates for educational programs that increase awareness and understanding of climate change, which are essential for fostering effective adaptation strategies. This research not only adds to the academic understanding of the impacts of socio-cultural factors on climate change adaptation but also provides practical, actionable strategies that local governments and NGOs can implement to support vulnerable communities.

2. Materials and Methods

2.1 Study Area

The location of this research is in Ondo State, Nigeria, which is located at latitude 7.25°N and longitude 5.19°E. The States of Ekiti, Kogi, Edo, Delta, Ogun, and Osun border the State on its Northern, North-eastern, Eastern, Southeast, Southwest, and Northwest borders, respectively as indicated in Figure 1. The State has a population of around 3,440,000, with a rural population of approximately 1,700,000, and a land area of approximately 14,606 km2 (NPC, 2006). The tropical State of Ondo has two distinct seasons: a wet period from April to October and a dry period from November to March. A substantial portion of the population relies on the State's favourable environment to support their agricultural endeavors, and as a result, the state's economy relies heavily on the production of staple foods like cocoa, kolanuts, palm, vegetables, maize, and cassava. Annual rainfall varies between 1000 mm and 1500 mm, and daily maximum temperatures average between 30° and 32°C. The bulk of the population of Ondo State is comprised of small-scale farmers who cultivate rice, maize, beans, cocoa, and other food crops. Animal husbandry is secondary employment for the inhabitants of Ondo State, who mostly farm goats, sheep, rabbits, and fish; other vocations include commerce and public service (Amos, 2007).

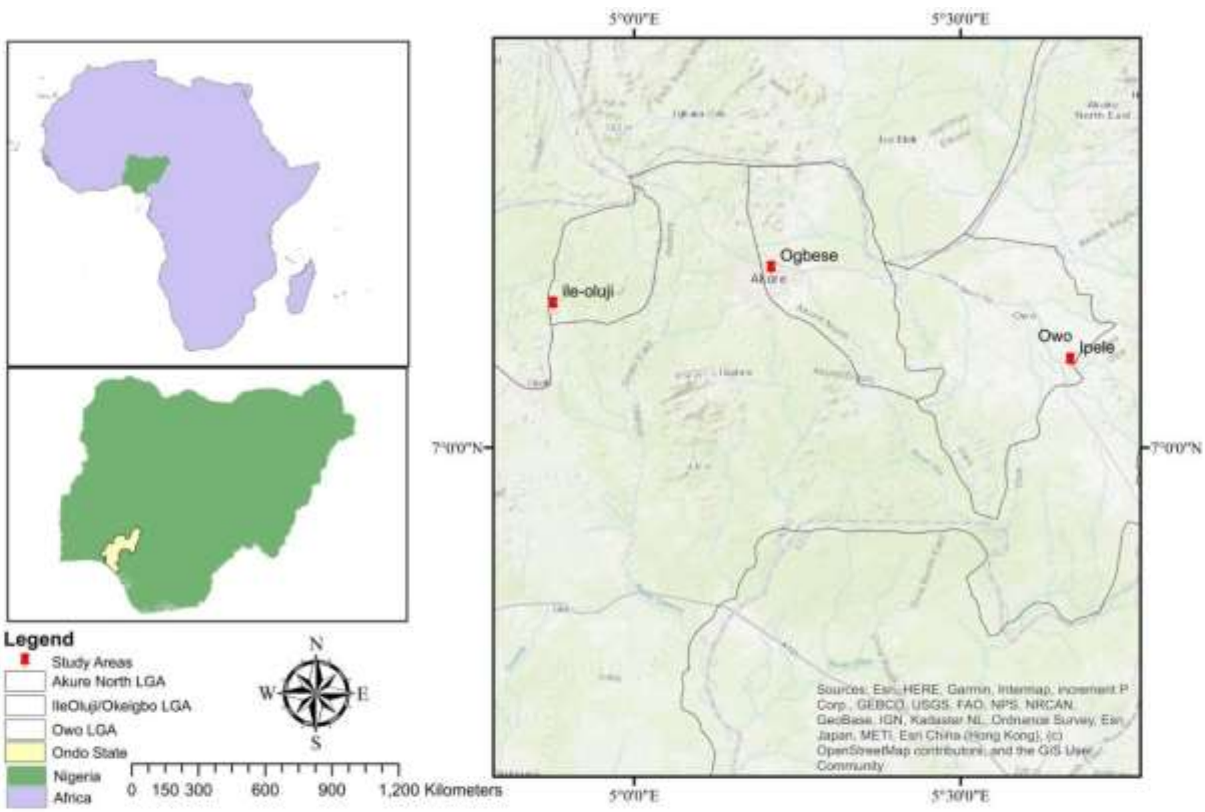

Figure 1. Map of the study area.

2.2 Data Collection

Primary data were used for this study and the data were collected through a direct personal interview and a structured questionnaire to obtain pertinent data on socio-cultural characteristics of the farmers, vulnerability to climate change, factors affecting the level of vulnerability, and factors affecting adaptation to climate change.

2.3 Sampling Techniques and Sample Size

Additionally, the Delphi approach was used to identify the main vulnerability variables used in this study. Ten (10) key informants were identified in each community and these are lead farmers who are knowledgeable about agricultural activities. Questions on vulnerability to climate change were asked from each group. Their responses were aggregated and re-examined to arrive at the variables presented to the respondents. The respondents were chosen using a multistage sampling approach (Zeleke et al., 2022). In the first stage, three (3) Local Government Areas, which represent each of the senatorial zones namely: Owo, Ile-Oluji, and Akure North LGAs, were purposively chosen among the State's eighteen (18) Local Government Areas based on crop farmers' concentration and the incidence of climate change impacts in the area (Olutumise et al., 2021). In the second stage, five (5) communities were chosen at random from each of the designated Local Government Areas, for a total of fifteen (15) communities. In the third stage, ten (10) crop growers were chosen at random from each community. As a result, a total of 150 respondents were used for this study.

2.4 Analytical Techniques and Model Specification

Descriptive statistics such as mean, standard deviation, and percentage were used, as well as the Vulnerability index, Ordinal logistic regression, and Heckman probit regression.

Vulnerability Index: The vulnerability index was utilized to examine the vulnerability to climate change in the area. This index was created using a composite indicator framework technique that was first designed as a community-based risk index (Bollin and Hidajat, 2006). This risk index shares some characteristics with Piers Blaikie's 'Disaster Pressure and Release Model' (Blaikie et al., 1994). A portion of a community-based risk index was used and modified by relevant indicators for the study area. This vulnerability index is divided into three categories: adaptive capacity, sensitivity, and exposure to severe climate conditions. Under each domain, there are several relevant criteria, which are again divided as indicators. These indicators altogether possess certain characteristics of a specific domain about climate variability and extremes (indicating the household's sensitivity to these components). Three domains, under this vulnerability index, comprised 7 indicators. The questionnaire included a full list of domains, criteria, and indicators. Some indicators were adapted from Hahn et al. (2009), using the approach in the study to obtain an index value for each indicator as presented in Equation (1).

Sub-component Index =(Xi-Xmin)/(Xmax-Xmin) …………………….. (1)

where, xi = mean value of the indicator for the household

xmax = the highest value of the indicator for the household

xmin = the lowest value of the indicator for the household/community

The indices, therefore, produce numerical values showing the concerned community's (obtained from the aggregated response of households) relative position and for any one indicator, this value lies between 0 and 1. The maximum and minimum values are usually adjusted to avoid values of more than 1.

Ordinal logistic regression: The ordinal logistic regression model was employed in this study to identify the socio-cultural factors influencing the levels of vulnerability to climate change. This model is used when the outcome variable is ordinal in scale, and there are more than two categories, as in this study: (1) less vulnerable, which means the difference between adaptive capacity and potential impact is significantly positive, (2) moderately vulnerable, which means the difference between adaptive capacity and potential impact is nearly zero, and (3) highly vulnerable, which means the difference between adaptive capacity and potential impact is significantly negative. The model analysis aids in identifying elements that contribute to vulnerability or reduce farm families' adaptive capacity/resilience (Greene, 2003).

The reduced form of the Ordered logistic regression model is given by Equation (2).

Y_I^*= 〖βX〗_ij+ u_ij (2)

and

Y_i=j if M_(i-j)< Y_I^* ≤ μ_j

here: Yi is the category of vulnerability and it involves ordered outcome variables that are, Y = 1 (less vulnerable), Y=2 (moderately vulnerable), and Y = 3 (highly vulnerable). The Xij are the explanatory variables, βs are parameters to be estimated, and uij is the disturbance term. Y* is the unobserved variable as expressed in Equation (3).

(Y=1 if Y^* ≤ μ_2@Y=2 if μ_2< Y^* ≤ μ_3@Y=3 if μ_2< Y^*) (3)

μs are the extremely imposed endpoints of the observed categories.

Given the cumulative normal function Φ (β'x), the probabilities can be shown, thus, probability as in Equation (4):

Pr(Y=1 or less vulnerable)= Φ(〖-β〗 ^' X) , (4)

Pr (Y=2 or moderately vulnerable)= Φ(μ2 〖-β〗 ^' X)-Φ(μ3 〖-β〗 ^' X)

Pr (Y=3 or highly vulnerable)=(1 - Φ (μ3 - β'x)

The marginal effect is given by the Equation (5):

(∆pr(y=m/x)/(∆X_k) (_ ^)=Pr (y=m/ X,X_k)-Pr (y=m/ X,X_k= X_s) (5)

where Pr is the probability that changes vulnerability levels, y = m, given X, by assigning a specific value to XK. The change in the probability is interpreted as when XK changes from XS to XE in one unit, the predicted probability of outcome changes by, holding all other variables constant.

Heckman probit regression: Heckman's probit model was used to examine the socio-cultural variables that influence the adaptability and vulnerability to climate change. The first phase in the model estimate is the study of adaptations to climate change (selection model), and the second step is the vulnerability status (outcome model) to climate change, which is dependent on the first stage of adaptation to climate change. Following Ajayi and Olutumise (2018), the probit model for sample selection assumes that there exists an underlying relationship between the selection and outcome models given by the Equations (6) and (7):

Y_1= b'X + U1 …………………….. (6)

Y2 = g'Z + U2 …………………….. (7)

where X is a k-vector of regressors, Z is an m-vector of regressors; the error terms U1 and U2 are jointly normally distributed, independently of X and Z with zero expectations. The independent variable Y1 is only observed if Y2 > 0. Thus, the actual dependent variable is Y = Y1 if Y2 > 0, Y is a missing value if Y2 ≤ 0

The latent variable Y2 itself is not observable, only its sign. Y2 > 0, if Y is observable, and Y2 ≤ 0 if not. If the sample selection problem is ignored and Y regressed on X using the observed Y's only, then the Ordinary Least Squares (OLS) estimator of b will be biased because the estimation in Equation (8) as:

E[Y1|Y2 > 0,X,Z] = b'X + rsf(g'Z)/F(g'Z) ……………………… (8)

where F is the cumulative distribution function of the standard normal distribution, f is the corresponding density, s2 is the variance of U1, and r is the correlation between U1 and U2. When r ≠ 0, standard probit techniques yield biased results. Thus, the Heckman probit model provides consistent, asymptotically efficient estimates for all parameters in such models (Greene, 2003).

For clarity purposes, it is worth noting that adaptation is the selection equation in which farmers who adapt to climate change are rated 1 and farmers who do not are awarded 0. The vulnerability status is determined using the result equation, with vulnerable farmers scoring 1 and non-vulnerable farmers scoring 0.

The explanatory variables for the regressions and their description are presented in Table 1.

Table 1. Regression Variables and their Descriptions

Variable	Measurement Scale	Expected sign
Age	Continuous: Years	
Gender	Dummy: Male =1, and 0, otherwise	-/+
Marital status	Dummy: Married =1, and 0, otherwise	-/+
Household size	Continuous: Numbers	
Education	Continuous: Years spent in school	+
Total income	Continuous: Naira (N)	+
Language	Dummy: Yoruba = 1 and 0, otherwise	-/+
Religion	Dummy: Christian = 1 and 0, otherwise	-/+
Belief	Dummy: Believed that climate change exists = 1, and 0, otherwise	+
Family structure	Dummy: Nuclear = 1, and 0, otherwise	-/+
Care needs	Dummy: Yes = 1, and 0, otherwise	+
Community work	Dummy: Participated = 1, and 0, otherwise	+
Income from Agriculture	Continuous: percentage (%) contribution to total income	+

Source: Field Survey, 2022.

3. Results and Discussion

3.1 Quantifying the Level of Vulnerability (LVI) to Climate Change in the Study Area

The LVI was used to estimate the extent of vulnerability to climate change by the respondents as presented in Table 2 and Appendix *A*. The findings indicated that the respondents' socio-cultural profile contributed to the vulnerability to climate change. The average LVI for the socio-cultural profile component was 0.33. The value was higher than the 0.27 and 0.29 reported by Kalim et al. (2013) for the Trinidad and Tobago regions, respectively. This depicts that farmers in the research area are more vulnerable compared with the farmers in the Trinidad and Tobago regions. It was also observed that livelihood strategy recorded a vulnerability of 0.34 while health and well-being was 0.36. The values are comparable to the outcome of Hahn et al. (2009) who revealed less than 0.41 vulnerability for both livelihood strategy and health. The water component had the highest vulnerability of 0.49 and the probable reason might be due to the issue of water infrastructural problems in the research area. Most farmers drink well and stream water which makes them vulnerable.

Housing and land tenure, as well as adverse effects of natural disasters, had the lowest vulnerability indexes of 0.28 and 0.26, respectively. The low value might be attributed to the type of adaptation strategies employed in dealing with climatic extremes such as floods, drought, and storms. It was observed that many farmers are practicing agroforestry and the government is assisting in building drainages and clearing water banks in some of the sampled locations. The value of the natural disaster component is less than what Hahn et al. (2009) recorded in the Mabote (0.409) and Moma (0.312) areas of Mozambique. The adaptation practices component had a 0.42 vulnerability index which was similar to the findings of Heltberg et al. (2009) who reported 0.490.

Furthermore, the overall average LVI for all the components was 0.35 which showed that the crop farmers are being relatively vulnerable compared with the study of Hahn et al. (2009) who recorded 0.326. On the contrary, it was less vulnerable compared with the findings of Kalim et al. (2013) who recorded an index of 0.41. Also, Dumenu and Tiamgne (2020) showed that farmers in the Chirundu district were more vulnerable to climate change than those in the Masaiti district, with LVIs of 0.47 and 0.41, respectively, signifying that the vulnerability status is location-specific, and may be influenced by a range of factors such as socio-cultural, economic, geographical, and political considerations.

However, to complement the information in Table 1, a spider diagram was created in Figure 2. The scale of the diagram increases by 0.1-unit increment, from 0 (less vulnerable) in the middle of the web to 0.5 (more vulnerable) at the outside border. Water and adaptation practices had a higher vulnerability index score than other components. This means that farmers in the research area are more vulnerable to water and adaptation practices when compared with other indicators such as socio-cultural profile, livelihood strategy, health and well-being, housing and land tenure, and adverse effects of natural disasters. This is expected because several studies on climate change have reported that African countries are vulnerable due to low adaptive capacity.

The Table further presents the LVI-IPCC results. The major components that contribute to the adaptive capacity are socio-cultural profile and livelihood strategy with a vulnerability index of 0.33 and 0.34, respectively. The contributing factor value for the adaptive capacity was 0.09. The major components for sensitivity are health and well-being, water, housing, and land tenure which gave a contributing factor value of 0.1. Likewise, exposure comprises the adverse effects of natural disasters and adaptation practices to climate change. The contributing factor value for the exposure was 0.30. The overall LVI-IPCC value was 0.02 which shows a certain level of vulnerability. Compared with other studies in the literature, the farmers are more vulnerable than farmers at Moma (-0.074) and Mabote (0.005) as reported by Hahn et al. (2009) in Mozambique. It was also more vulnerable than the rural households in Trinidad and Tobago as reported by Kalim et al. (2013). Several empirical findings on the farmers' vulnerability to climate change have reported that rural farmers in Nigeria are vulnerable such as Apata (2011), Eze et al. (2018), and Madu and Nwankwo (2021). In Africa, Hahn et al. (2009) and Dumenu and Tiamgne (2020) in Mozambique and Zambia, respectively attested to the high vulnerability of the rural farming households.

3.2 Determining the Socio-cultural factors affecting the level of Vulnerability to Climate Change in the Study Area

This objective was achieved by using the ordinal logistic regression model. The value (17.21) of the Chi-square was statistically significant at a 1% level, suggesting an overall goodness of fit. Cut1 and cut2 are the threshold values that revealed that the three categories were ordered, while the likelihood ratio (LR) estimate was rightly signed (negative). The value (0.584) of the Pseudo R^2 explained that 58.4% of the regress and was explained by the regressors included in the model, at 1% level, and the log-likelihood ratio value was significant, inferring that the model used for the analysis was fit and appropriate.

Table 2. LVI–IPCC contributing factors calculation (IPCC, 2001)

IPCC contributing factors to vulnerability	Major components	Major component values	Number of sub-components per major component	Contributing factor values	LVI-IPCC value
Adaptive Capacity	Socio-cultural profile	0.33	8	0.09	0.02
	Livelihood strategy	0.34	7		
Sensitivity	Health and well-being	0.36	4	0.10	
	Water	0.49	2		
	Housing and land tenure	0.28	5		
Exposure	Adverse effect of Natural disaster	0.26	2	0.30	
	Adaptation practices to climate change	0.42	3		
Average overall LVI			0.35		

Note: The LVI–IPCC is on a scale from -1 (least vulnerable) to +1 (most vulnerable).
Source: Field Survey, 2022.

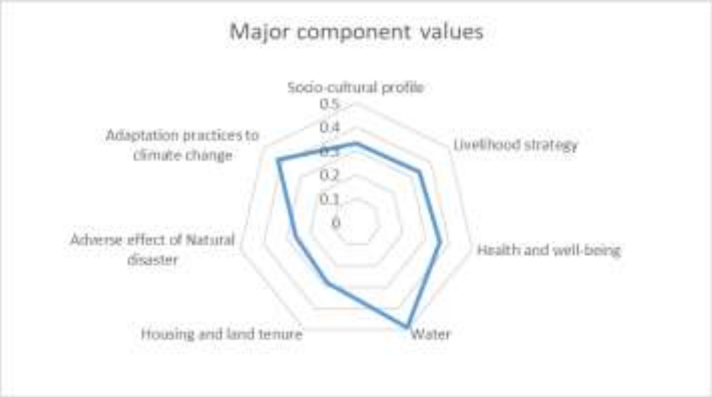

Figure 2. Vulnerability Spider diagram of the major components of the Livelihood Vulnerability Index (LVI).

Table 3 depicts that four variables which are: age, marital status, education level, and farm income were significant at 1% and 5% levels. At the 5% level, the age coefficient was positive and significant. This means that every year that the respondents' age increases, the amount of vulnerability to climate change in the research region increases by 3.5%. This is anticipated because older farmers will not be active and economically productive compared to the young ones in the area. The study supports the findings of Muhammed-Lawal et al. (2012), who posited that younger farmers adapt to climate change better than elderly farmers who are less productive in their farming operations. According to Ojo and Baiyegunhi (2020b), the likelihood of farmers being risk-constrained increases with age. This might imply that elderly farmers are less productive and have a lower proclivity to accept new technology than younger farmers.

The marital status coefficient was 0.618, which was positive and significant at a 5% level. This suggests that being married increases the level of vulnerability by 61.8% more than non-married households. This does not follow *a priori* expectation because two people working together are more effective than one since they are more likely to share ideas, pool resources, and come to wise decisions regarding how to address vulnerability in the area. Again, another probable reason might be due to the number of family members and dependents that are living and feeding from the household heads. The study reported an average of 7 persons per household which is relatively high as it will affect the level of consumption and other expenditures, thus leading to vulnerability to climate change. According to Ojo and Baiyegunhi (2020c), the favorable relationship may be related to their limited access to resources, which causes them to be much less productive than their unmarried colleagues. Tiruneh et al. (2001) confirmed that married families are vulnerable owing to a lack of resources to adjust to the consequences of climate change.

The negative correlation between educational status and vulnerability to climate change indicates that the higher the level of education of the farmers, the more likely to be less vulnerable to climate change in the area. This means that a unit increase in the number of years spent in school will most likely result in a 5.1% reduction in vulnerability to climate change, *ceteris paribus*. It could also be interpreted that the level of vulnerability decreases by 0.051 for each additional year of education. This is so because education enlightens people, thus making them knowledgeable and it encourages the use of technology. The findings go *pari passu* with Olagunju et al. (2019), who posited that education level provided the necessary information to enhance technology adoption for increased output. Thus, the vulnerability to climate change is anticipated to be lessened with an increase in educational levels.

The coefficient of farm income was negative and significant at the 5% level. This implies that a unit increase in the income of the farmers will likely reduce the level of vulnerability by 2.9%. This is expected because farmers with high earnings are expected to be wealthy, and money increases farmers' adaptive capacity. The result is in conjunction with Kuwornu et al. (2013), who reported that farmers with high income from food crop production are less vulnerable to climate change. Similarly, Deressa et al. (2009) indicated that higher-income farmers may be less risk-averse and have greater access to knowledge that might help to lessen the amount of vulnerability to climate change.

Table 3. Result of Ordinal Logistic Regression

Variables	Coefficient	Standard Error	P>/Z/
Age	0.035**	0.018	0.057
Gender	-0.064	0.433	0.883
Marital Status	0.618**	0.301	0.040
Household Size	0.027	0.074	0.718
Education Level	-0.051***	0.005	0.000
Income	0.325	0.248	0.191
Language	7.90e-07	1.58e-06	0.617
Religion	0.072	0.093	0.438
Belief	0.228	0.497	0.647
Family Structure	-0.125	0.240	0.603
Care Need	0.065	0.236	0.782
Community Work	0.220	0.268	0.412
Income from Agriculture	-2.890**	1.420	0.044
Cut 1	3.627	1.750671	
Cut 2	5.312	1.786	
No of Observations	150		
LR chi2(13)	17.21		
Prob > chi2	0.0052		
Log-likelihood	-138.8067		
Pseudo R^2	0.584		

*** indicates the level of significance at 1%
** indicate the level of significance at 5%
Source: Field Survey, 2022.

3.3 Heckman Two-step Regression Model of Socio-cultural Factors Affecting the Adaptation, and the Vulnerability to Climate Change

The Heckman two-step regression was used to determine factors affecting the adaptation and the vulnerability to climate change in the area. The model was run and evaluated for its suitability above the normal probit model. The model estimate of Wald Chi^2 (14) of 48.81, which is statistically significant at 1%, indicates that the explanatory factors included are relevant in predicting changes in the dependent variables, according to Table 4. As a result, Heckman's sample selection method is suitable. Furthermore, 0.373 is the adjusted standard error for the regression, and rho (p = -0.032) is the correlation coefficient between the error component that determines selection in adaptation to climate change, and the outcome of the extent of vulnerability. The statistic labeled *'lambda'* which is the estimated non-selection hazard or inverse mills' ratio is negative and statistically significant. Also, the likelihood ratio test of independence of the selection and outcome equations reveals that the null hypothesis may be rejected since it has no relationship between adaptation and vulnerability to climate change.

Therefore, the selection model's results indicated that the respondents' age, marital status, household size, education, religion, belief, family structure, care need and community work were the significant determinants of adaptation to climate change. Likewise, the significant determinants of vulnerability status to climate change were gender, marital status, education, language, income, and community work. In terms of the age of the respondents, the study discovered that as farmers become older, their likelihood of adaptation decreases by 7%, but not significant in addressing the vulnerability status of the farmers. The most likely explanation is that aging farmers have lost productive strength, which has affected their adaptive capacity vis-à-vis making them vulnerable in the area. This can also be interpreted that a household's ability to adjust to climate change in the study area declines with aging every year. The results of Milkias and Abdulahi (2018), Asfaw et al. (2016), and Oparinde (2021) provide credence to this claim. Deressa et al. (2009) and Olutumise (2023b) showed a negative connection between age and the adoption of enhanced soil conservation methods which also attests that it could cause the farmers to be vulnerable.

The coefficient of gender was not significant in affecting adaptation but statistically significant with a positive correlation with vulnerability. This means that female farmers are expected to be 6.6% more vulnerable than their male counterparts. This supports the previous studies which labeled females as the most vulnerable (Deressa et al., 2009; Eze et al., 2018; Fahad and Wang, 2018; Olagunju et al., 2019; Olutumise, 2023c). The probable reason might also be because most male households in the area have other means of income aside the farm earnings to combat the effect of climate change vulnerability. The coefficient of marital status was significant in addressing adaptation and vulnerability to climate change at 5% and 10%, respectively. This implies that married households are more likely to adapt to climate change by 6.7% than unmarried households, while the vulnerability of unmarried households increases by 34.9%. The reason might be that married households are responsible and mature in handling climate change to have improved productivity. Sometimes, the family members assist in farming activities which will help them to adopt several adaptations that could make them not vulnerable. This, however, conflicts with the conclusion reached by Massresha et al. (2021) and Giziew and Mebrate (2019) that married households are more vulnerable due to the unavailability of resources and increased consumption expenditure which could impoverish the household vis-à-vis making them vulnerable.

Household size had a substantial favorable impact on farmer adaptation at a 5% level. This suggests that an increase in the number of households increases the probability of adapting to climate change. This is expected as family members assist in farming activities which allows them to adopt multiple strategies. Deressa et al. (2009), Olutumise (2023c) and Huka et al. (2023) also reported that the availability of large household sizes would boost the capacity to adopt agricultural technologies and adapt to climate changes.

The respondents' educational level was positively and significantly linked with adaptations at a 1% level but negatively associated with vulnerability at a 1% level. This means that educated farmers have a 2.2% better chance of adopting adaptations, and a 3.2% better chance of reducing vulnerability, *ceteris paribus*. The reason is that high educational attainment is likely to expose farmers to more knowledge on new technologies and markets, which might help farmers develop strong adaptive capacity that will not leave them vulnerable to climate change. This study supports the findings of Ajayi and Olutumise (2018) and Kadilikansimba et al. (2023), who affirmed that education improves farmers' capacity to absorb, analyze, and grasp information crucial to making creative agricultural decisions. Education is one of the most important attributes that farmers must have to mitigate the effects of climate change, whether via adaptation or mitigation measures. The result also supports the findings of Deressa et al. (2009), Tesfaye and Seifu (2016), Oparinde (2021), and Olutumise et al. (2024 whom all indicated in their respective studies that education improves adaptation adoption as well as lessens vulnerability to climate change.

The language variable was negative but significant at a 1% level in affecting the vulnerability to climate change. It implies that Yoruba spoken language will likely reduce vulnerability by 22.8% compared with other languages. This suggests that the local or native language spoken in the area matters when it comes to reducing vulnerability to climate change. This is understandable given that the majority of instructions and training are delivered in the local language, which is their mother tongue. It was observed that farmers adopt technologies more when they could easily be translated into Yoruba language than other languages, being the popular spoken language in the area. The respondent's language proficiency would lead to a better grasp of the extent of climate change vulnerability. Thus, the language barrier that could affect their commitment to passing weather reports information from governmental organizations and service providers to the farmers would be overcome (Hansen et al., 2013).

Income has a negative and strong correlation with vulnerability status at the 1% level. According to this result, farmers' vulnerability to climatic effects decreases with an increase in the income of the farmers. Crop farmers with higher incomes can invest in the technology required to protect themselves from vulnerability in the study area due to the ability to adopt adaptation measures. This supports the findings of Belay and Mengiste (2021), and Olutumise et al. (2022) who found out significant relationship between income and technology adoption. According to the findings of Deressa et al. (2009) and Fatuase and Ajibefun (2014), participation in non-farm income-generation activities increases the likelihood of adopting adaptation strategies that could reduce vulnerability.

The religion coefficient was statistically significant at a 1% level and positively related to adaptation adoption. This means that being a member of a Christian religious organization will likely raise the adoption of climate change by 10% when compared to other religions. This is expected because the region is dominated by Christians (Ilesanmi et al., 2023) and most of them have agricultural packages for their members which are normally delivered by the NGOs and government agents in a bit to enlighten them on climate change and other agronomical practices. Also, the climate change belief coefficient was positive and significant with adaptation adoption at a 1% level. This means that believing in the existence of climate change increases the likelihood of adopting adaptations by 8.7% when compared to those who do not believe. This outcome is predicted because farmers would respond to climate change problems and strive to avoid being vulnerable since they believe it exists. For adaptation and vulnerability to climate change, community work has a positive and significant coefficient of 1% level each. This means that those who are committed to community teamwork will likely adopt adaptations by 5.1% and as well reduce vulnerability to climate change by 15.7%. This suggests that to adapt and lessen the degree of vulnerability to climate change in the study area, "all hands are needed to be on deck." These go on to claim that community organizations, particularly farmers' associations will profit from the training provided by partners, facilitating access to knowledge and technical skills.

Table 4. Results of Heckman selection correlation model of Socio-Cultural factors affecting adaptation and Vulnerability to Climate.

Variables	Selection: Adaptation		Estimated Outcome: Vulnerability Extent	
	Coefficient	P-Value	Coefficient	P-Value
Age	-0.007**	0.045	0.020	0.101
Gender	-0.190	0.155	0.066***	0.001
Marital Status	0.067**	0.010	0.349*	0.081
Household Size	0.057**	0.013	-0.021	0.666
Educational Level	0.022***	0.003	-0.032***	0.004
Language	0.077	0.463	-0.228***	0.000
Income	6.59e-06	0.250	-6.59e-06 ***	0.000
Religion	0.010***	0.005	0.077	0.217
Belief	0.087***	0.004	0.056	0.864
Family Structure	-0.196***	0.002	-0.196	0.227
Care Need	0.181**	0.015	0.091	0.574
Community Work	0.051***	0.000	-0.157***	0.000
Income from Agriculture	-0.040	0.596	-0.182	0.212
/athrho	-0.031			
/lnsigma	-0.987			
Rho	-0.032			
Sigma	0.373			
Lambda	-0.012			
No of Observation	150			
Wald chi2(13)	48.81			
Prob > chi^2	0.0000			
Log-likelihood	-125.391			

*** indicates the level of significance at 1%
** indicate the level of significance at 5%
* indicate the level of significance at 10%
Source: Field Survey, 2022.

4. Conclusion and Recommendation

The study was carried out to examine the effects of socio-cultural factors on adaptations and vulnerability to climate change, using Ondo State as the case study. It has been concluded that crop farmers experience some levels of vulnerability in the area. The adaptive capacity of the farmers is made up of socio-cultural profiles and livelihoods with vulnerability indices of 0.33 and 0.34, respectively. This showed that socio-cultural factors play a significant role in the vulnerability of the farmers in the area. The adaptive capacity is low because the farmers are mainly coping through their socio-cultural profiles and livelihoods. The farmers are being affected mainly through sensitivity and exposure because most of the indicators are out of reach of the farmers. The results of LVI and LVI-IPCC further conclude that there is a presence of vulnerability among the farmers. The implication is that socio-cultural factors significantly explain vulnerability to climate change among crop farmers. Also, the age of the farmers, marital status, educational level, and farm income are the main socio-cultural factors that influence the level of vulnerability in the area. The implication is that young, married, and educated farmers who accrue tangible income might be less vulnerable to climate change in the area. In determining the factors affecting adaptation and vulnerability to climate change, it has been established that marital status, education, and participation in community teamwork play significant roles. The implication is that for a crop farmer to adapt to climate change and not be vulnerable, he will likely be married, educated, and ready to participate in community work that could abate climate extremes such as flood, drought, erosion, and storm. The study further identifies specific variables that could determine either adaptation or vulnerability separately. In the case of adaptations, the age of the farmers, their religion, belief in the existence of climate change, and family structure all play significant roles. Religious young farmers who believe that climate change is real and have a good family structure will adopt more adaptation strategies to combat the effects of climate change in their area than their counterparts who do otherwise. In determining vulnerability status, gender, language, and income play significant roles. In the study area, Yoruba happens to be the most acceptable and preferred indigenous language used by the farmers in communicating and disseminating information among themselves, as this has helped overcome the language barrier problem. There is also an indication of potential labour availability for farm work, which reduces labour constraints and the cost of labour among the respondents. Furthermore, higher educational attainment is likely to expose farmers to more knowledge about new technologies and markets, which might help farmers develop adaptive capacities that will not make them vulnerable to climate change. Farmers' vulnerability to climatic effects was observed to decrease with increases in their income, irrespective of the determinants or indicators of vulnerability. The adoption of an adaptation strategy is necessary and needed to curb vulnerability among crop farmers in the study area. On this note, we have been able to prove how socio-cultural variables such as gender, marital status, religion, belief, family structure, and community work participation contributed to climate change adaptations and vulnerability using Ondo State as a case study. The following recommendations are made in light of the aforementioned findings: 1.The government should provide an enabling environment for culture to triumph among the farmers, especially those that bring peace, love, and harmony to the rural settlements. This is because when family structure is not broken with freedom of religion and participation in community development, it will assist in the adaptations and reduce vulnerability to climate change. 2.Through focused initiatives and properly crafted visual aid materials, governments should employ more extension services for farmers so that they can become familiar with early warning indicators and interpretations of climatic data to mitigate the harmful effects of climate change. The language in which information is disseminated is very germane; hence, relating in the mother tongue will go a long way to improving adaptation and reducing vulnerability to climate change. 3.Youths in the area should be encouraged to practice agriculture for them to be able to respond properly to climate change vulnerability since they are still able-bodied and the elderly class is aging with limited resilience. The government can achieve this by providing incentives and farm settlements that will accommodate young people who can farm. 4.Alternative sustainable livelihoods with income diversification strategies should be introduced by the government for crop farmers to cushion the effects of low income realized from farming activities in the area, like in other parts of the developing world. 5.Government and non-governmental organizations (NGOs) can provide the basic social amenities, such as pipe-borne water, a good road network, and the building of community health centers for crop farmers, to reduce the vulnerability of climate change to the barest minimum, particularly among the rural food crop producers.

References:

1. Abaje, I.B. & Giwa, P.N. (2010). Flood risk assessment and vulnerability in Kafanchan town, Jema'a local government area of Kaduna State, Nigeria. International Journal of Sustainable Development, 3(1), 94-100.

2. Abaje, I. B., Onu, V., Abashiya, M., Oyatayo, K. T., Ibrahim, A. A., Ati, O. F., & Sawa, B. A. (2017). Climate change vulnerability assessment in the northern part of Katsina State, Nigeria: A quantitative approach. Dutse Journal of Pure and Applied Sciences, 3, 1-14.

3. Adeagbo, O. A., Ojo, T. O., & Adetoro, A. A. (2021). Understanding the determinants of climate change adaptation strategies among smallholder maize farmers in South-west, Nigeria. Heliyon, 7(2), e06231.

4. Ajayi, C.O. & Olutumise, A.I. (2018). Determinants of Food Security and Technical Efficiency of Cassava Farmers in Ondo State, Nigeria. International Food and Agribusiness Management Review, 21(7), 915 – 928.

5. Aldunce, P., Handmer, J., Beilin, R., & Howden, M. (2016). Is climate change framed as 'business as usual or as a challenging issue? The practitioners' dilemma. Environment and Planning Government and Policy, 34(5), 999-1019.

6. Amos,T.T (2007). An Analysis of Productivity and Technical Efficiency of Smallholder Cocoa Farmers in Nigeria. Journal of Social Sciences, 5(2),127-133.

7. Apata, T.G. (2011). Factors influencing the perception and choice of adaptation measures to climate change among farmers in Nigeria. Evidence from farming households in Southwest Nigeria.

8. Apata, T.G., Samuel, K.D. & Adeola, A.O. (2009). Analysis of Climate Change Perception and Adaptation among Arable Food Crop Farmers in South Western Nigeria. Contributed Paper prepared for presentation at the International Association of Agricultural Economists' 2009 Conference, Beijing, China. August 16, 2009.

9. Asfaw, S., Di Battista, F., & Lipper, L. (2016). Agricultural technology adoption under climate change in the Sahel: Micro-evidence from Niger. Journal of African Economies, 25(5), 637-669.

10. Ayanlade, A., Radeny, M. & Morton, J. F. (2017). Comparing smallholder farmers' perception of climate change with meteorological data: A case study from south-western Nigeria. Weather and Climate Extremes, 15, 24-33.

11. Bedeke, S. B. (2023). Climate change vulnerability and adaptation of crop producers in sub-Saharan Africa: a review on concepts, approaches and methods. Environment, Development and Sustainability, 25(2), 1017-1051.

12. Belay, M., & Mengiste, M. (2021). The ex-post impact of agricultural technology adoption on poverty: Evidence from north Shewa zone of Amhara region, Ethiopia. International Journal of Finance & Economics, 25, 1-11. https://doi.org/10.1002/ijfe.2479.

13. Blaikie, P., Cannon, T., Davis, I. & Wisner, B. (1994). At Risk: Natural hazards, People's vulnerability, and disasters. London, Routledge, pp.496.

14. Bollin, C., & Hidajat, R. (2006). Community-based disaster risk index: pilot implementation in Indonesia. In: Birkmann, J. (Ed.), Measuring Vulnerability to Natural Hazards-Towards Disaster Resilient Societies. UNU-Press, Tokyo, New York, Paris.

15. Bulkeley, H., & Michele, B. M. (2013). Revisiting the urban politics of climate change. Environmental politics, 22(1), 136-154. DOI: 10.1080/09644016.2013.755797.

16. Deressa, T. T., Hassan, R. M., Ringler, C., Alemu, T., & Yesuf, M. (2009). Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. Global environmental change, 19(2), 248-255.

17. Dumenu, W. & Tiamgne, X. (2020). Social vulnerability of smallholder farmers to climate change in Zambia: the applicability of social vulnerability index. SN Applied Sciences, 2(3), 1-16.

18. Enete, A. & Amusa, T. (2010). Challenges of agricultural adaptation to climate change in Nigeria: a synthesis from the literature. The Journal of Field Actions, 4. http://journals.openedition.org/factsreports/678.

19. Eze, J. N., Aliyu, U., Alhaji-Baba, A., & Alfa, M. (2018). Analysis of farmers' vulnerability to climate change in Niger state, Nigeria. International Letters of Social and Humanistic Sciences, 82.

20. Fahad, S. & Wang, J. (2018). Farmers' risk perception, vulnerability, and adaptation to climate change in rural Pakistan. Land use policy, 79, 301-309.

21. Fatuase, A., & Ajibefun, I. (2014). Perception and adaptation to climate change among farmers in selected communities of Ekiti State, Nigeria. Gaziosmanpaşa Üniversitesi Ziraat Fakültesi Dergisi, 31(3), 100-113.

22. File, D. J., & Derbile, E. K. (2020). Sunshine, temperature and wind: Community risk assessment of climate change, indigenous knowledge and climate change adaptation planning in Ghana. International Journal of Climate Change Strategies and Management, 12(1), 22-38. https://doi.org/10.1108/IJCCSM-04-2019-0023.

23. Gashure, S., & Wana, D. (2023). Smallholder farmers' perceptions, coping and adaptation strategies to climate variability in the UNESCO designated cultural landscapes of Konso, Ethiopia. Local Environment, 28(10), 1243-1262.

24. Giziew, A. and Mebrate, B. (2019). Determinants of the role of gender on adoption of row planting of tef (Eragrostis tef (Zucc.) Trotter] in central Ethiopia. Ethiopian Journal of Science and Technology 12(1):19. DOI: 10.4314/ejst.v12i1.2.

25. Greene, W.H. (2003). Econometric Analysis. 6th Edn., Prentice Hall, New York, ISBN-13: 9780135132456, Pages: 1178.

26. Hahn, M.B, Anne, M., & Stanley, O. (2009). The Livelihood Vulnerability Index: A pragmatic approach to assessing risks from climate variability and change - A case study in Mozambique. Global Environmental Change, 19(1), 74-88.

27. Hansen, J., Kharecha, P., & Sato, M. (2013). Climate forcing growth rates: doubling down on our Faustian bargain. Environmental Research Letters, 8(1), 011006.

28. Heltberg, R., Siegel, P. B., & Jorgensen, S. L. (2009). Addressing human vulnerability to climate change: toward a 'no-regrets' approach. Global environmental change, 19(1), 89-99.

29. Huka, H. A., Kilima, F. T., & Mchopa, A. D. (2023). Socio-Economic Factors Influencing the Participation of Smallholder Vegetable Farmers in High-Value Markets (A Case Study of Arumeru District, Tanzania). International Journal of Agricultural Science, Research & Technology (IJASRT), 13(3). https://dorl.net/dor/20.1001.1.22517588.2023.13.3.5.5

30. Ibrahim, S. B., Ayinde, I. A., & Arowolo, A. O. (2015). Analysis of arable crop farmers' awareness to causes and effects of climate change in south western Nigeria. International Journal of Social Economics, 42(7), 614-628. https://doi.org/10.1108/IJSE-09-2013-0201.

31. Ilesanmi, J. O., Akeredolu, K. E., Akinbola, A. E., Oladoyin, P. O., & Ijigbade, J. O. (2023). Resource-Use Efficiency of Pepper Farmers in Ado-Local Government Area of Ekiti State. International Journal of Agricultural Science, Research and Technology in Extension and Education Systems (IJASRT in EESs), 13(2), 103-111.

32. IPCC (2007). Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Parry, M.L., Canziani, O.F., Palutikof, J.P., van der Linden, P.J., Hanson, C.E. (Eds.), Cambridge University Press: Cambridge, UK, 976pp.

33. Kadilikansimba, P. B., Machimu, G. M., & Sife, A. S. (2023). Effects of Socio-demographic Characteristics on Adoption of Improved Sorghum Farming Practices in Dodoma region, Tanzania. International Journal of Agricultural Science, Research and Technology in Extension and Education Systems (IJASRT in EESs), 13(3). https://dorl.net/dor/20.1001.1.22517588.2023.13.3.2.2

34. Kalim, U., Hari, B., Craig, J. & April, B. (2013). Understanding livelihood vulnerability to climate change: Applying the livelihood vulnerability index in Trinidad and Tobago. Geoforum, 46, 125-137.

35. Kuwornu, J.K., Amoah, E. & Seini, W. (2013). Technical efficiency analysis of maize farmers in the eastern region of Ghana. Journal of Social and Development Science, 4(2), 84.

36. Madu, I. A., & Nwankwo, C. F. (2021). Spatial pattern of climate change and farmer–herder conflict vulnerabilities in Nigeria. GeoJournal, 86(6), 2691-2707.

37. Massresha, S. E., Lema, T. Z., Neway, M. M., & Degu, W. A. (2021). Perception and determinants of agricultural technology adoption in North Shoa zone, Amhara regional state, Ethiopia. Cogent Economics & Finance, 9(1), 1956774.

38. Menike, L. & Arachchi, K.K. (2016). Adaptation to Climate Change by Smallholder Farmers in Rural Communities: Evidence from Sri Lanka. Procedia Food Science, 6, 288-292.

39. Milkias, D., & Abdulahi, A. (2018). Determinants of agricultural technology adoption: The case of improved highland maize varieties in Toke Kutaye District, Oromia Regional State, Ethiopia. Journal of Investment and Management, 7(4), 125–132. https:// doi.org/10.11648/j.jim.20180704.13.

40. Muhammad-Lawal, A., Salau, S. A., & Saka, A. Y. (2012). Assessment of Vulnerability of Farming Households to Climate Change in Ekiti State, Nigeria. Ethiopian Journal of Environmental Studies and Management, 5(2), 173-181.

41. Namgyel, U., Dorji, S., Lee, W. K., & Wang, S. W. (2023). Farmers' Perceptions of Climate Change and Its Socio-Ecological Consequences in Bhutan's Biological Corridor Network. Sustainability, 15(19), 14517.

42. Naqvi, S. A. H., Rehman, A. U., Chohan, S., Umar, U. U. D., Mehmood, Y., Mustafa, G., ... & Hasnain, A. (2023). Sustainable Development in Agriculture Beyond the Notion of Minimizing Environmental Impacts. In Disaster Risk Reduction in Agriculture (pp. 147-168). Singapore: Springer Nature Singapore.

43. National Population Commission (NPC) (2006). Nigeria Report on the Survey of Demographic and Health Survey. Retrieved from http:www.nigeria/npc/

44. Nigerian Meteorological Agency (NIMET). (2015). Nigeria Climate Review Bulletin (63 pp). Nigerian Meteorological Agency (NIMET), Abuja.

45. Ojo, T. O., & Baiyegunhi, L. J. S. (2020a). 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.

46. Ojo, T. O., & Baiyegunhi, L. J. S. (2020b). Impact of climate change adaptation strategies on rice productivity in South-west, Nigeria: An endogeneity corrected stochastic frontier model. Science of The Total Environment, 745, 141151. doi:10.1016/j.scitotenv.2020.141151.

47. Ojo, T. O., & Baiyegunhi, L. J. S. (2020c). Determinants of credit constraints and its impact on the adoption of climate change adaptation strategies among rice farmers in South-West Nigeria. Journal of Economic Structures, 9(1). doi:10.1186/s40008-020-00204-6.

48. Olagunju, K. O., Ogunniyi, A. I., Awotide, B. A., Adenuga, A. H., & Ashagidigbi, W. M. (2019). Evaluating the distributional impacts of drought-tolerant maize varieties on productivity and welfare outcomes: an instrumental variable quantile treatment effects approach. Climate and Development, 1–11. doi:10.1080/17565529.2019.1701401.

49. Olagunju, I.E. (2015). Drought, Desertification and the Nigerian Environment: A Review. Journal of Ecology and Natural Environment, 7, 196-209. http://www.academicjournals.org/JENE.

50. Olutumise, A. I., Ijigbade, J. O. and Aturamu, O. A. (2022). Marketers' Conduct and Profitability as a Response to Sustainable Livelihood: The Example of Bush Mango Kernels (Irvingia spp.) in Ondo State, Nigeria. Small-scale Forestry, 1-18.

51. Olutumise, A.I., Ajibefun, I.A. & Omonijo, A.G. (2021). Effect of Climate Variability on Healthcare Expenditure of Food Crop Farmers in Southwest, Nigeria. International Journal of Biometeorology, doi:10.1007/s00484-021-02079-z. Epub ahead of print. PMID: 33474613.

52. Olutumise, A. I., & Oparinde, L. O. (2022). Climate Information and Health Variables as Determinants of Technical Efficiency: Insight from Food Crop Farmers. International Journal of Agricultural Science, Research and Technology in Extension and Education Systems (IJASRT in EESs), 12(3), 127-137.

53. Olutumise, A.I. (2023a). Intensity of adaptations to heat stress in poultry farms: A behavioural analysis of farmers in Ondo state, Nigeria. Journal of Thermal Biology, 103614. https://doi.org/10.1016/j.jtherbio.2023.103614

54. Olutumise, A.I. (2023b). Impact of relaxing flood policy interventions on fish production: lessons from earthen pond-based farmers in Southwest Nigeria. Aquaculture International, 1-24. https://doi.org/10.1007/s10499-023-01062-2

55. Olutumise, A.I. (2023c). Impact of credit on the climate adaptation utilization among food crop farmers in Southwest, Nigeria: application of endogenous treatment Poisson regression model. Agricultural and Food Economics, 11(1), 7. https://doi.org/10.1186/s40100-023-00251-0

56. Olutumise, A. I., Ekundayo, B. P., Omonijo, A. G., Akinrinola, O. O., Aturamu, O. A., Ehinmowo, O. O., & Oguntuase, D. T. (2024). Unlocking sustainable agriculture: climate adaptation, opportunity costs, and net revenue for Nigeria cassava farmers. Discover Sustainability, 5(1), 67. https://doi.org/10.1007/s43621-024-00249-8

57. Oparinde, L.O. (2021). Fish Farmers' Welfare and Climate Change Adaptation Strategies in Southwest, Nigeria: Application of Multinomial Endogenous Switching Regression Model. Aquaculture Economics & Management, 25(4): 450-471. DOI: 10.1080/13657305.2021.1893863.

58. Ranganathan, C. Singh, N. Bantilan, M. Padmaja R. & Rupsha, B. (2009). Quantitative Assessment of Vulnerability to Climate Change: Computation of Vulnerability Indices. ICRISAT/ADB, India. Retrieved from http://www.icrisat.org/what-we- do/impi/trainingcc/october-2-3-2009/vulnerability-analysis-manual.pdf.

59. Ricart, S., Gandolfi, C., & Castelletti, A. (2023). Climate change awareness, perceived impacts, and adaptation from farmers' experience and behavior: a triple-loop review. Regional Environmental Change, 23(3), 82.

60. Rithaa, J. N., Mwendandu, I. W., & Wambongo, C. S. R. (2023). Socio-Economic Determinants for Adoption of Adaptation Strategies to Climate Change and Variability among Smallholder Farmers in Igambang'ombe, Sub-County, Kenya. American Journal of Environment and Climate, 2(3), 51-60.

61. Tesfaye, W., & Seifu, L. (2016). Climate change perception and choice of adaptation strategies: Empirical evidence from smallholder farmers in east Ethiopia. International Journal of Climate Change Strategies and Management, 8(2), 253-270. https://doi.org/10.1108/IJCCSM-01-2014-0017

62. Tiruneh, A., Tesfaye, T. Mwangi, W. Verkuijl H. (2001). Gender Differentials in Agricultural Production and Decision-Making Among Smallholders in Ada, Lume, and Gimbichu Woredas of the Central Highlands of Ethiopia. https://repository.cimmyt.org/handle/10883/1018.

63. Zeleke, G., Teshome, M., & Ayele, L. (2022). Farmers' livelihood vulnerability to climate-related risks in the North Wello Zone, northern Ethiopia. Environmental and Sustainability Indicators, 17, 100220. https://doi.org/10.1016/j.indic.2022.100220.

Appendix A: Indexed Sub-Components, major components, and overall Livelihood Vulnerability Index (LVI)

Major Component	Sub-component	Index	Average Value
Socio-cultural profile	Age of the Respondents	0.53	0.33
	Gender	0.19	
	Family Size	0.29	
	Highest Level of Education	0.06	
	Monthly Income	0.12	
	Language spoken	0.33	
	Religion	0.77	
	Average size of the cultivated Land	0.33	
Livelihood Strategy	How many people in your household go to a different community to work	0.20	0.34
	Does Agriculture activities account for your main income	0.55	
	If no, what is the income recorded from agricultural activities	0.19	
	What is the income recorded from non- agricultural activities	0.01	
	Do you or any of your household work in an activity not related to growing of crops	0.86	
	Did you borrow any money from relatives or friends in the past months	0.51	
	In the past 12 months, have you or any of your household gone to your local government office/official for help	0.08	
Health and Well-being	Do any members of your household require daily care because of age, physical or mental condition, illness or disability	0.17	0.36
	If yes, how many members of your household require daily care	0.16	
	What is the distance to health care facilities	0.86	
	Do you get your food primarily from your personal farms	0.25	
Water	Do you have access to water	0.50	0.49
	If yes, what is your source of water	0.48	
Housing and Land Tenure	Ownership of house	0.67	0.28
	Have you ever experience flooding	0.23	
	If yes? How many times has your area been flooded between 2020 – 2022	0.17	
	Have you recorded any damages due to flood	0.21	
	If yes, estimate the amount of damages recorded	0.15	
Adverse effect of Natural Disaster	Has anyone in your household been injured as a result of adverse effect of weather	0.06	0.26
	If yes, number of people affected	0.45	
Adaptation Practices	Do you engage in any adaptation practices	0.93	0.42
	Have you attended climatechange adaptation trainings	0.04	
	If yes, how many trainings have you attended	0.28	
Average overall LVI			0.35

Source: Computed by the Author, 2022