Does Cassava-Based Farmers' Sociodemographic Characteristics and Perception Predict Adaptation Strategies to Climate Variability in Rain Forest and Derived Savannah Ecosystems of Nigeria?

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Abstract
The study assessed the sociodemographic characteristics of cassava-based (CB) farmers' and their perception of climate variability as predictors of their adaptation strategies. The study covers cassava-based farmers in both the rain forest and derived savannah ecosystems of Nigeria. The study described the farmers' socioeconomic characteristics, their perception of climate variability, adaptation strategies and their socio-demographic factors influencing climate variability adaptation strategies. A cross-sectional survey using a multistage sampling procedure, was used to sample 400 cassava-based farmers in the study area. The data collected were analysed using descriptive statistics and multivariate probit (MVP) regression. Results indicated that 71.68% of the CB farmers were males, married (85.21%), had primary school certificates (30.08%) and received trainings in local adaptation strategy technologies (62.41%) and climate adaptation strategies (65.16%). Majority (68.67%) felt climate variability implied low yield and reduced water supply for farming activities in some years (69.42%). Most (85.21%) CB farmers combatted climate variability through water management practices, 68.17% utilised weather forecast information while 44.86% adapted planting and harvesting time to target peak produce prices. Farmers' perception and their socioeconomic characteristics that predicted their climate variability strategies included access to extension training ($p<0.01$), experience of previous season's low yield ($p<0.01$), membership of professional associations ($p<0.01$), farming experience ($p<0.10$) and credit access ($p<0.10$). Cassava-based farmers' climate variability perception and their sociodemographic characteristics predicted their climate variability adaptation strategies. Enhancement trainings and improved formal credit access are veritable ways to minimise the adverse effects of climate variability on cassava production in the study area.
Keywords: Climate, Perception, Adaptation, Cassava farmers, Ecosystem, Multivariate probit.
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Introduction

Sustainable Development Goal (SDG) 13, emphasised effective adaptation to climate variability/change as a necessity that must be attended to, the world over, especially in developing countries. Hence, climate variability is so important in sub-Saharan Africa (SSA), such that it is closely linked to other important SDGs such as SDGs 1, 2 and 3 for no poverty, zero hunger as well as good health and wellbeing in the region due to their deep connection with SDG 13 (UN 2015a). The UN is resolute to urgently take the bold and transformative steps which are necessary to shift the world onto a sustainable and climate-resilient path (UN 2015b). Essentially, the achievement of these SDGs is critical, especially for SSA where the livelihoods of most households revolve around agriculture; of which climate variability posits major threat (Dube *et al.* 2016). This is more so as the United Nations (UN) has indicated, the year 2019 as a 'critical year' for climate action (UN 2019). Therefore, efforts to systematically tackle the challenges of climate variability and its possible adverse effects on farmers' livelihoods remain notable from the standpoint of policy, research and sustainable development.

The agricultural sector plays a major role in stimulating economic regeneration in Nigeria and to liberate the teaming population from the grip of poverty through improved quality of life. The place of cassava cultivation as a climate variability adaptation strategy cannot be overemphasised given its resilience to harsh soil and environmental conditions apart from its capability to support livelihood strategies against climate variability effects (Agwu *et al.* 2012; Mbanasor *et al.* 2015; Mupakati & Tanyanyiwa 2017; Ayanlade *et al.* 2018). Climate variability and change pose a great risk to the sustainability of rain-fed agriculture (Agwu *et al.* 2012; IPCC 2013; Mbanasor *et al.* 2015), especially in Nigeria whose different vegetative zones are characterised mostly by temperature and rainfall (Odekunle *et al.* 2007). Rainfall is therefore, one of the key climatic variables, giving rise to a marked alternation of wet and dry seasons in most areas, as rain-fed agriculture constitute more than 95% of farmed land in Africa (International Water Management Institute (IWMI 2019). This makes issue of climate variability and associated concerns an important subject of empirical investigation in an agricultural-based economy (Adejuwon 2006).

Climate change/variability is one of the most pressing issues impacting on every facet of human lives, because of its implication on agricultural livelihood in the SSA region. In Nigeria, several research works (Odekunle *et al.* 2007; Adejuwon 2006; Agwu *et al.* 2012; Bose *et al.* 2014; Mbanasor *et al.* 2015; Babatolu & Akinnubi 2016; Falola & Achem 2017; Jellason *et al.* 2019) have been conducted to understand the levels of awareness and perception of smallholder agricultural workers to climate change/variability issues, as well as studies on associated farm-level coping and adaptation strategies employed by farmers. Agricultural adaptation studies to climate variability aims at developing appropriate coping mechanisms to address the negative impacts of climate variability of the livelihoods of farmers and households (Zeirvogel *et al.* 2008). At the farm level in Nigeria, Bose *et al.* (2014) reported that farmers in southwest Nigeria had perceived changes in the climate parameters through the decrease in rainfall pattern, increase in pest infestation in both crops and animals, heavy loss of pasture land and premature ripening of crops (Tambo & Abdoulaye 2013), while in the northern part, through increased temperature, unpredictable, erratic, heavy and increased rainfall, late-onset and early retreat of rains (Babatolu & Akinnubi, 2016; Falola & Achem 2017; Jellason *et al.* 2019).

Similar studies have worked on the effect of climate variability and adaptation strategies on cassava production systems as well as farmers' productivity using different analytical approaches. For example, Agwu *et al.*, (2012) adopted the Cobb-Douglas regression model while Asadu *et al.* (2014) adopted an experimental approach. Furthermore, Boansi (2017) adopted use of co-integration analysis while Dereje and Nega (2019) adopted Chi-square and binary logistic regression analyses. This study therefore, added to the existing body of knowledge by studying cassava-based farmers' perception and the sociodemographic precursors of their adaptation strategies using the multivariate probit analysis. Specifically, the study:

1. Described cassava-based farmers' socioeconomic characteristics.
2. Described cassava-based farmers' perception of climate variability.
3. Identified the various adaption strategies employed by the cassava-based farmers.
4. Determined the socio-demographic factors influencing climate variability adaptation strategies of cassava-based farmers in the study area.

Methodology

Area of study

The study was conducted in mid-2017, targeting cassava-based farmers in the rain forest and derived savannah agro-ecological zones of Nigeria while using Ogun and Kwara States as the study locations.

Abeokuta, the capital city of Ogun State lies between latitude 7º06′ and 7º13′ N and longitudes 3º15′ and 3 º25′ E in the tropical rain forest and South-western part of Nigeria. The climate of the study area is tropical with a distinct wet season (April-October) and a dry season (November-March) with two peak rainfall periods (Aladenola & Adeboye 2010). Figure 1 shows the scaled map of Ogun State.

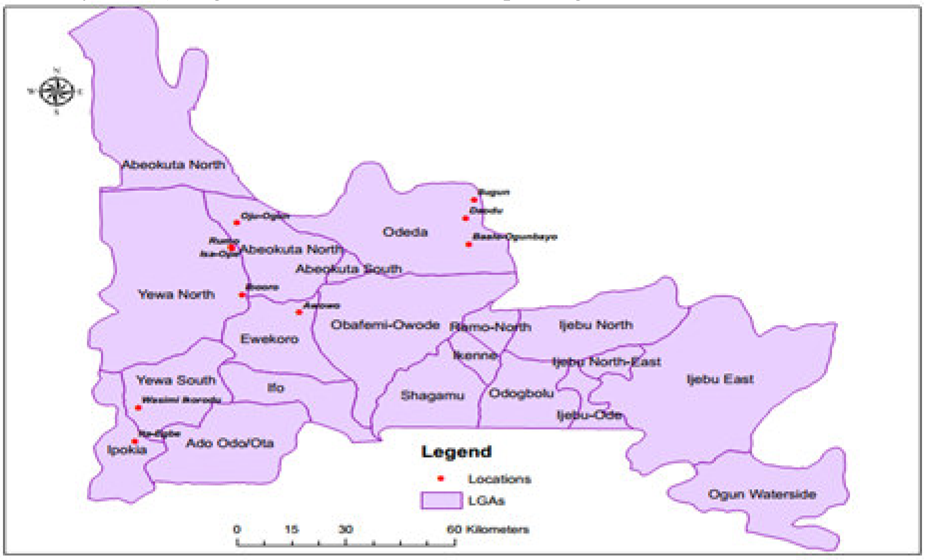

Fig 1: GPRS Location Map of Ogun State, showing the study area

Ilorin, the capital of Kwara State lies between latitude of 8 º28′47.56″ and longitude of 4 º32′30.53″ and it is located in the middle-belt region of Nigeria. Its rainfall distribution peaks between September and early October.

The soil in the area is ferruginous and has the tendency of being more productive if not for its water deficiency. Its vegetation is characterised by wooded savannah grassland also known as derived savannah (or derived Guinea savannah) due to the transformation caused by the decline in precipitation and human activities such as shifting cultivation, indiscriminate logging/bush clearing, overgrazing by cattle (Oriola *et al.* 2010). The common trees are shea butter tree (*Vitalera paradosa*) and locust bean tree (*Parkia biglobosa*). While the grains grown in the area include millets, maize, sorghum and rice, common root crops found in this area are yam, cassava, potatoes and cocoyam (Oriola *et al.* 2010).

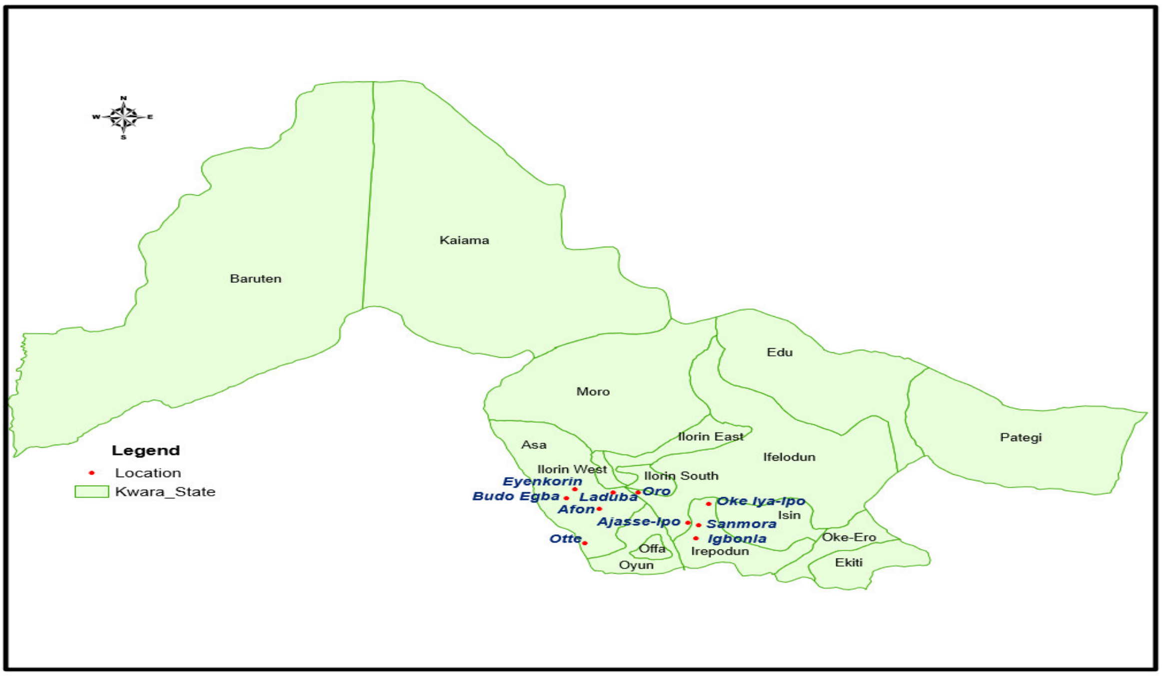

Fig 2: GPRS Location Map of Kwara State, showing the study area

Data:
Farmers quantitative data were obtained with the use of interview guide. The data collected included respondents' socio-economic data, perception on climate variability adaptation strategies and livelihood coping strategies, among others. The survey guide used for quantitative data collection was adapted from Ogunbameru *et al.* (2013) and Ibrahim *et al.* (2015).

Data Sampling and Analysis
Sampling used in the study followed the zoning system of the Agricultural Development Programmes (ADPs) in both States. A multi-stage sampling technique was adopted to select respondents for this study. In stage one, Ogun and the Kwara States were selected in the rain forest vegetation and derived savannah vegetation respectively, using a simple random sampling technique. In the second stage, two zones apiece (constituting 50% each) were selected through a simple random sampling technique from the existing ADP zones in both states. In the third stage, one sub-location (block) was selected per zone (making two blocks for each state), making four blocks altogether. In the fourth stage, five villages were selected from each block to give ten villages per state and 20 villages in all. In the fifth stage, twenty households were selected per village through a systematic random sampling technique to give a total sample size of 400 respondents.

Descriptive statistics and inferential statistics were used for this study. Descriptive statistics (frequency and percentages tables) were used to describe the socio-economic characteristics of respondents and their perception of the effects of climate variability on farming activities and adaptation strategies adopted.

The multivariate probit regression model was applied to determine the socio-demographic factors influencing adoption of farmers' climate variability strategies in the study areas. Adoption of multivariate probit regression was motivated given that the choice of adaptation strategies is not mutually exclusive such that a farmer can adopt more than one set of strategies at a time. This contemporaneous peculiarity is accommodated in the multivariate framework. The multivariate probit regression model is stated in Equation 1:

$$C^*_{ij} = X_{ij}\beta_j + e_{ij}$$

$$C_{ij} = \begin{cases} 1\, if\ C^*_{ij} > 0 \\ 0\, if\ C^*_{ij} \leq 0 \end{cases} \tag{1}$$

$e_{ij}, j = 1,... J$ are multivariate normal distributed error terms distributed, each with a zero mean and variance-covariance matrix Q. Each of the elements of the principal diagonal of Q has a value of 1, and correlations ρjm = ρmj as off-diagonal elements. There are four mutually inclusive strategies from which farmers can select in this study. Hence, J =4. For the J -equation systems, E(**ee'**)=∑ $\otimes$ $\mathbf{I}_N$, where ∑=(σ_{ij}) is four by four positive-definite matrix and $\otimes$ is the Kronecker products of the two matrices (Cameron & Trivedi 2010).

Where:

C_{ij} = 1 if farmer i adopts adaptation strategy j, 0 otherwise
X_1 = State (1 if Ogun State, 0 otherwise)
X_2 = Age of the farmer (years)
X_3= Marital status of the farmer (1 if married, 0 otherwise)
X_4 = Sex of the farmer (1 for male, 0 for female)
X_5 = Farm experience (years)
X_6 = Farmer's association (1 if the farmer is a member of an association, 0 otherwise)
X_7 = Household size of the farmer (number of people)
X_8 = Credit facility (1 if the farmer has access to a credit facility, 0 otherwise)
X_9= Access to extension services (1 if farmer have access to extension services, 0 otherwise)
X_{10} = Education (years spent in acquiring formal education)
X_{11}= Previous experience of late rainfall (1 if farmer has experienced periods of late rainfall before, 0 otherwise)
X_{12}= Previous experience on low crop yield due to climate variability (1 if the farmer had previously experienced low crop yield due to unstable climate variability, 0 otherwise)

Results and Discussion

Socio-demographic Characteristics of Respondents:

The mean age of the farmers was approximately 47 years, and most of them (64.41%) were within 31 and 60 years age bracket (Table 1). This suggests that the farmers were in the active age groups and were expected to be able to maximise farm labour productivity, *ceteris paribus*. Most (85.21%) respondents were married with a mean household size of eight (8) persons, suggesting availability of family labour for farming activities, as a complement to hired labour. Majority (77.97%) of the cassava-based farmers belonged to farmers' professional groups, which gives farmers the advantage of access to some benefits (such as access to improved seeds, fertilisers, credit and new production information) and attendant enhancement of their farm production. Furthermore, 54.39% of the respondents had less than secondary school education. This may affect the ability to efficiently combine resources to manage farm production when confronted with the negative effects of climate variability (Dereje & Nega 2019). Over 70% of the farmers were males, suggesting that cassava-based farming enterprise was male dominated in the study area. Similarly, 86.72% of the farmers reported that they had access to credit. This was mainly the local, non-institutional sources of credit, some of which included loan from friends and family members, credit purchase of input (for later payment) and contributory credit. Also, most (65.16%) of the farmers have received agricultural extension training on adaptation strategies to climate variability. Extension access is a common feature among many smallholder farmers especially in Southwest and Northern Nigeria contrary to (Ziervogel *et al*. 2008) who opined that little is known empirically about the role of agricultural extension training in enhancing adaptation strategy adoption in Nigeria.

Table 1: Distribution of respondents by socio-demographic characteristics

Variables	Frequency	Percentage
Age		
Less than 31	74	18.55
31-45	147	36.84
46-60	110	27.57
61-1000	68	17.04
Household size		
1 to 5	112	28.07
6 to 10	191	47.87
10 to 15	73	18.3
above 15	23	5.77
Education		
No formal education	97	24.31
Primary	120	30.08
Secondary	96	24.06
Tertiary	86	21.55
Received training on local strategy technology		
No	150	37.59
Yes	249	62.41
Access to credit facilities		
No	53	13.28
Yes	346	86.72
Farmers association membership		
No	88	22.06
Yes	311	77.94
Received adaptation strategies training by extension agents		
Yes	260	65.16
No	139	34.84
Sex of household head		
Male	286	71.68
Female	113	28.32
Marital status		
Single	36	9.02
Married	340	85.21
Widowed	19	4.76
others	4	1
Total	**399**	**100**

Perceived Effects of Climate Variability on Farm Production by Cassava-based Farmers:
The perception of cassava-based farmers on the effects of climate variability on their farm production are presented in Table 2. Approximately 69.0% of the farmers reported that climate variability resulted in water shortage and yield reduction over the years. This finding agrees with empirical studies reported in different parts of Nigeria (Bose *et al.* 2014; Falola & Achem 2017; Jellason *et al.* 2019). Approximately 25% of the farmers reported damage to cassava crops due to variability in climate while 6.77 reported pest infestation. These challenges pose enormous implications for research, extension, and communication on climate-related information to enable farmers to minimise loss of farm production and income.

Table 2: Farmers perception of the effects of climate variability on farm production

Variables	Frequency*	Percentage
Change in rainfall pattern affects (have reduced) water availability for farming in some years	277	69.42
I have been experiencing low yield from my cassava-based farms in some years	274	68.67
Climate variability has resulted in pest infestation	27	6.77
Crop Damage (Cassava)	100	25.06

*Multiple responses

Adaptation Strategies Employed by Farmers to Perceived Adverse Effects of Climate Variability

The distribution of respondents according to farm-level adaptation strategies employed to perceived adverse effects of climate variability is shown in Table 3. Most (85.21%) of the farmers adopted water harvesting scheme (such as ridging across the slope, use of tie-ridges, etc.) while 68.17% adopted weather forecast information strategy. Fewer (44.86%) farmers targeted planting of crops and harvesting time to periods that command higher output prices. Also, 41.10% of the farmers adopted soil amendment strategy (such as crop rotation) to reduce adverse effects of climate variability. The local strategies adopted by the cassava-based farmers in the study area abound in literature (Ziervogel *et al.* 2008; Ogunbameru *et al.* 2013; Mupakati & Tanyanyiwa 2017; Mahouna *et al.* 2018).

Table 3: Farm-level adaptation strategies used by farmers to combat perceived effects of climate variability

Adaptation measures	*Frequency	Percentage
Use of soil amendment practices (Crop rotation)	164	41.10
Use of water management practices	340	85.21
Use of weather forecast information	272	68.17
Adapt planting and harvesting time to period that commands higher output prices	179	44.86

* Multiple Responses

Famers Perception and Socio-demographic Factors Predicting Climate Variability Adaptation Strategies of Cassava-based Farmers

The estimated multivariate probit regression model (Table 4) shows an estimated value of the log-likelihood function (-862.837) and the Wald Chi square statistics (135.16) which was significant ($p<0.01$), implying overall significance of the model that the model's explanatory variables (soil amendment, water harvesting scheme, use of weather forecast information and targeting planting and harvesting activities at periods expected to commands higher prices) jointly explained the likelihood of selecting the adaptation strategies employed by farmers in the study area.

The coefficient of location of the cassava-based farmer has a significant and positive relationship with the likelihood of employing soil amendment ($p<0.10$), water management practices (($p<0.01$) and weather forecast information ($p<0.01$) as strategies to mitigate potentially adverse effects of climate on their farms. This means that cassava-based farmers in Ogun State have higher chances of employing all these strategies than farmers in Kwara State. This may be as a result of higher rainfall pattern occasioning the nature of the soil in these areas (as a result of ecological variation). Loranty *et al.* (2016) opined that processes that resulted in vegetation change (such as ecosystem responses to climatic elements) have potential effects on crop productivity.

Household size negatively affects farmers' choice of targeting production and harvesting activities at the period that command higher prices ($p<0.10$). Increased household size imposes urgency of farmers to produce at the earliest available time in order to have food on their table (Okonkwo *et al.* 2015).

Farmers' association membership has a significant negative relationship with the choice of soil amendment applied ($p<0.01$). Also, access to credit increased the chances of farmers' adaptation strategy. This implies that membership of farmers' organisation allows farmers ease of access to technical information and group finance for use of soil amendments (Wood *et al.* 2014).

Access to extension training by farmers significantly and positively influence all the choices of adaptation strategies modelled in the equation. This shows the ramifying implication of the need for a viable and virile extension service delivery in the mitigation of climate variability by farmers (Asrat & Simane 2018).

Furthermore, late rainfall experience has a significant positive relationship ($p<0.10$) with usage of weather forecast information. This means that the more the farmers experience late rainfall, the more their chances of employing this strategy in order to prevent avoidable crop failure. In the same vein, age of farmers ($p<0.01$) and prior experience of low yield ($p<0.01$) have a significant positive relationship with targeting production and harvesting activities at the period that command higher prices. Age and experience impose more wisdom on farmers over the years to adopt techniques that prompt higher farm productivity (Okonkwo *et al*. 2015).

Table 4: Farmers perception and socio-demographic determinants of the choice of livelihood adaptation strategies

Explanatory Variable	**Soil Amendment**	**Water Management practices**	**Weather forecast Information**	**Adjusting the Planting and Harvesting Period**
State (Ogun dummy)	*0.268	***0.590	***0.816	0.175
	(0.148)	(0.188)	(0.159)	(0.148)
Age	-0.005	0.011	-0.001	***0.023
	(0.007)	(0.009)	(0.007)	(0.007)
Marital Status (Married dummy)	-0.171	-0.108	-0.140	-0.154
	(0.189)	(0.257)	(0.204)	(0.192)
Sex (male dummy)	0.129	0.094	0.151	0.173
	(0.136)	(0.191)	(0.153)	(0.142)
Farming Experience	0.004	0.006	0.000	-0.013
	(0.006)	(0.008)	(0.007)	(0.307)
Membership of Association	***-0.624	-0.325	-0.040	0.115
	(0.157)	(0.214)	(0.167)	(0.160)
Household Size	$3.0e^{-4}$	-0.026	-0.032	*-0.031
	(0.018)	(0.021)	(0.018)	(0.018)
Access to Credit	*0.366	0.257	-0.188	0.329
	(0.210)	(0.232)	(0.217)	(0.204)
Extension Training (dummy)	**0.361	***0.663	***0.485	*0.250
	(0.142)	(0.172)	(0.146)	(0.141)
Education (Years of Schooling)	-0.009	0.005	0.000	-0.013
	(0.009)	(0.011)	(0.009)	(0.009)
Experienced late onset of rainfall previously (dummy)	0.090	0.266	*0.288	-0.173
	(0.148)	(0.185)	(0.159)	(0.149)
Experienced low yield previously (dummy)	0.229	-0.188	0.144	***0.812
	(0.195)	(0.250)	(0.223)	(0.209)
Constant	-0.201	-0.139	0.103	-1.088
	(0.429)	(0.545)	(0.458)	(0.437)
Log likelihood	-862.837			
Wald Chi square	135.16			
Prob > chi2	0.0000			

Standard errors in the parenthesis, *** - *Coefficients significant at 1%,* ** - *Coefficients significant at 5%,* * - *Coefficients significant at 10%*

Conclusion

The issues of climate variability and its effects on the livelihoods of farmers have continued to be a prime focus globally. In this study, the perception of 400 cassava-based farmers concerning climate variability, adaptation measures employed to combat the adverse effects of climate variability as well as their perception and sociodemographic characteristics determining choice of adaptation strategies were examined. The study concluded locational variation in adaptation strategies employed by farmers while farmers' sociodemographic characteristics (such as age, membership of farmers' associations, access to credit and extension training) and the way they perceived climate variability were prime determinants of adaptation techniques employed by them to mitigate effects of climate variability.

Both the States and Federal Governments of Nigeria have roles to play in enhancing state-of-the-art extension delivery system that continues to provide out-of-school training to farmers for farm productivity enhancement. Ogun and Kwara States Ministries of Community Development and Cooperatives should provide enabling environment to farmers' cooperatives for enhanced access to credit, in order to stimulate choice adaptation strategies that minimises the adverse effects of climate variability on farm production while enhancing farmers' food security and livelihoods.

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