Futo Journal Series (FUTOJNLS)
e-ISSN : 2476-8456 p-ISSN : 2467-8325
Volume-6, Issue-1, pp- 25 - 39
www.futojnls.org

Research Paper July 2020

Determinants of choice of climate change adaptation options among cassava farmers, in southwest Nigeria

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Abstract

Many agricultural crops and livestock are known to be adversely affected by fluctuations in the weather and climatic conditions which pose threats to agricultural productivity in the sub Saharan Africa. This study examined the perceived effects of climate change and adaptation strategies in cassava production in Ogun State, Nigeria. Primary data were obtained from 120 cassava farmers. Multi-stage random sampling technique was used to select respondents across 6 farming communities in the two agro ecological zones of the State. Data were analyzed using descriptive statistics, Perceived Environmental Impact Index (PEII), and Multinomial Logit model. Results showed that increase in temperature and rainfall intensity were the elements of climate change mainly perceived to be affecting cassava production with PEII of 0.38 and 0.32 respectively. Cassava farmers' adaptation strategies to climate change include crop diversification (41.7%) and off-farm diversification (25.0%). The probability of adopting crop diversification was significantly influenced positively by age ($p<0.01$), negatively by household size ($p<0.05$), extension contact ($p<0.05$) and length of residence in the community ($p<0.01$). Extension contact negatively affected ($p<0.05$) the probability of cassava farmers diversifying into non-farm activities while length of residence and marital status negatively affected ($p<0.05$) the probability of cassava farmers choosing other climate adaptation strategies.

Keywords: Adaptation, Cassava, Climate change, Ogun State, Production,

1. Introduction

In the quest of meeting global food, clothing and shelter, agriculture pose significant problems on the environment, climate on the other hand is the key element of agricultural productivity. Previous researches had revealed that Africa's agriculture is negatively affected by long-term fluctuations in climate (Pereira*,* 2017). Cassava production is largely produced in

Nigeria, but it is concentrated in the hands of numerous small holder farmers and found mostly in the central and southern regions of the country.

From independence to the mid-1980's, cassava production in Nigeria was roughly stagnant. Production of the commodity began to increase between the mid-1980 and the early 1990's and remained almost constant during the 1990's. Nigeria's agricultural image can be judged from cassava production because Nigeria is the largest producer of cassava tuber in the world with production of about 59 million metric tons of the world's production of 291 million metric tons in 2017 (IITA, 2020). According to FAO, (2020), the crop is predominantly grown by smallholders and the total area under cassava cultivation in Nigeria is about 3.7 million hectares. Although the world leader in cassava production, Nigeria is not an active participant in cassava trade in the international market due to the uncompetitive nature of its production and weak processing systems.

According to Sanni, Daniels, Udah, Elechi, Oruwa, and Tijani, (2011); FAO, (2020), cassava is regarded as an essential crop, it is one of the utmost vital crops for farmers in Nigeria; it is the most commonly cultivated crop and provides food and income to more than 30 million farmers and large numbers of processors and marketers. Several studies such as Nweke, Ugwu, Dixon, Asadu and Ajobo, (1997); Taiwo, (2006); Sanni *et al*. (2011) and Ohimain, (2015) have also shown that cassava has the potential to industrialize Nigeria more than any other product if its potential is properly harnessed. Therefore, as a crucial crop to the Nigerian economy it is important to study how farmers perceive the influence of climate change on cassava and adapt to the negative effects that might arise from climatic changes.

Adaptations to climate change are carried out in response or in anticipation to the antagonistic effects of climate change. It involves adopting suitable practise to avert and or minimise the damage they might cause or taking advantage of positive situations that might occur. (European Commission, 2016). According to Adger, Huq, Brown, Conway and Hulme, (2003) in Ogunpaimo and Dipeolu, (2019) climate change will have greater negative impacts on poorer farm households as they have the lowest capacity to adapt to changes in climatic condition. The benefit of adaptation practices can therefore not be overemphasized. It is crucial to help these farming communities better withstand extreme weather conditions and associated climatic fluctuations.

Ogun state which is a state in the south west region of Nigeria is one of the leading cassava producing states in the country, Ogun state was selected as a sample of the European Union Cassava Processing Areas (C:AVA areas) which are Ogun, Oyo, Ekiti, Kwara, Ondo, Lagos, Abuja And Nassarawa.

Several researchers had studied the choice of adaptation strategies of farmers to climate change. For instance Soto Arriagada (2005); Nhemachena and Hassan (2008); Ojo and Bayegunhi, (2019) conducted researches on determinants of African farmers' strategies for adapting to climate change while Fosu-Mensah, Vlek and Manschadi (2010) and James *et al.*, (2013) looked at farmers' perception and adaptation to climate change. However, very few researchers studied the factors influencing the choice of climate change adaptation measures adopted by cassava farmers.

Thus this paper sought to assess the perceived effects of cassava farmers to climate change, identify the adaptation strategies adopted by cassava farmers and determine the factors affecting adaptation strategies employed by farmers.

2. Materials and Methods

2.1. Study area

Ogun State is located in the South West Region of Nigeria with its capital at Abeokuta was created in 1976 and comprises former Abeokuta and Ijebu provinces of former Western states. It was carved out of former Western region in 1967. It is located within Latitude 7^{0}N and Longitude 3.58333^{0}E and now covers a total of 16.432 square kilometres of landmass. Its population as at 2006 is 3.75 million. It is bounded partly by Oyo and Osun States in the North, Lagos state in the South, Ondo State to the East and the Republic of Benin to the West (Ogun State Government, 2016).

It is covered predominantly by evergreen forest vegetation in the south and has vast grazing savannah in the north which is suitable for animal husbandry. The state has natural resources that include forest and water bodies as well as large quantities of mineral deposits limestone, chalk, phosphates, granite stone, gypsum, bauxite, bitumen, feldspar, glass sand, kaolin, quartz, tar, gemstones and clay. The people of Ogun State belong to the Yoruba ethnic group, with subgroups are such as Egba, Yewa, Awori, Egun, Ijebu, Remo, Ikale and Ilaje. The language spoken in the state is Yoruba although English is the official language. Agriculture is the economic mainstay of Ogun state with crops such as maize, rice, cassava, yam, plantains, and banana. Cocoa, kolanuts, rubber, palm oil, tobacco, cotton and timber are the main cash crops grown in the state. (The Ogun State Government, 2016)

2.2. Data Description

Data on adaptation strategies were collected directly from cassava farmers in the study area using structured questionnaire. The study was carried out in Ogun State, Nigeria which involved a cross section of 120 cassava farmers. Multi-stage sampling techniques were used to select the cassava farmers. The first stage of sampling involved a random selection of six farming communities each in the two agro-ecological zones of the state. The second stage involved a random selection of 10 cassava farmers from each farming community thereby giving a total number of 120 respondents.

2.3. Analytical Framework

2.3.1. Descriptive Statistics

This involved the use of mean and mode to give a brief summary of the sampled data. Pie chart was used to describe the various adaptation strategies adopted by the cassava farmers in the study area.

2.3.2. Perceived Environmental Impact Index

This was used to determine the awareness level of the respondents to climate change and effects of climate change. This involved a simple 2-step procedure. In the first step, a set of climate change indicators (E_j) was read to the respondents to reveal their opinions on each of these indicators. These were in form of perceptual statements. A value of 1 was assigned to each observed indicator where the farmer recognized the change indicator and 0 otherwise. In the second step, the respondents were asked to reveal the relative importance of each observed indicator on effect of cassava output on a five-scale point (R_m). A score of 1 was assigned for the least important, and 5 for the very high important indicator. These ranks were converted to weighted scores (W_q). A weight of 0.2 was assigned to the lowest rank of 1, and a weight of 1 for the highest rank of 5. Meanwhile, a zero weight was assigned to indicators for which the farmer did not recognize an observed change. This was in line with (Rahman, 2005).

The PEII for each farmer was computed by summing up the mean of the weighted scores of the impact indicators as below:

$$PEII = \sum^{12}\sum^{5}\sum^{1}E_j R_m W_q \quad (1)$$

where:

E_j represents impact indicators of climate change causes and effects.

j ranges between 1 and 12.

R_m represents the relative level of awareness of the indicators each for climate change causes and effects on a five scale point of 1 to 5.

m ranges between 0 and 5.

W_q represents the mean of the weighted score of each R_m. A weight of 0.2 is assigned for lowest rank of 1 and a weight of 1 is assigned for the highest rank of 5. A zero weight is assigned for indicators for which the farmer does not recognize an impact. q ranges between 0.2 and 1.

2.3.3. Multinomial Logit Model

This was used to estimate the factors affecting most adopted adaptation strategies employed by respondents in the study area.

To describe the MNL model, let y denote a random variable taking on the values (1, 2 …..J) for a positive integer J and X denote a set of conditioning variables. In this case y denotes adaptation options or categories and x contains different household, institutional and environmental attributes, how do changes in the elements of x affect the response probabilities.

P(y=j/x), j=1,2,……J. Because probability must sum to unity, P(y=j/x) is determined once we know the probabilities for j=2,…..J (Deresa, Ringler and Hassan 2010)

The MNL model has a response probability of

$$P(y = j\backslash x) = \exp(x\beta j)/[1 - \sum_{h=1}^{J}\exp(x\beta h).\ j = 1 \ldots..J] \quad (2)$$

The dependent variable is therefore the log of one alternative relative to the base alternative. The MNL coefficients are difficult to interpret, and associating the β*j* with the *jth* outcome is tempting and misleading. To interpret the effects of explanatory variables on the probabilities, marginal effects are usually derived as (Greene, 2003):

$$\delta j = \frac{\partial P_j}{\partial x_i} = \left[\beta j - \sum_{k=0}^{J} P_k \beta_k\right)] P_k\left(\beta j - \bar{\beta}\right) \quad (3)$$

In this analysis, the four adaptation categories considered are given below:

- Did nothing (reference category)
- Diversify more into other crops
- Diversify into non-farm activities
- Other adaptation strategies

To estimate this model there is need to normalize on one category, which is referred to as the "reference state." In this analysis, the first category (did nothing) is the "reference state."

where

ε* = is a random disturbance term,

β* = is a vector of unknown parameters that can be interpreted as the net influence of the vector of explanatory variables influencing adaptation,

Y = the probability of choosing an adaptation category

X = the explanatory variables as shown in Table 1.

Table 1: The Description Measurement and A Priori Expectation of the Variables

Variable	Description	Measurement	A priori expectation
X_1	Farming experience	Years	+
X_2	Educational level	Years	+
X_3	Age	Years	±
X_4	Household size	Number	+
X_5	Years of residence in a community	Years	+
X_6	Secondary occupation income	Naira	+
X_7	Frequency of extension contact	Number	+
X_8	Gender	Dummy: 1 for male; 0 otherwise	±
X_9	Marital status	Dummy: 1 for married; 0 otherwise	±
X_{10}	Access to credit	Naira	+

3. Results and Discussions

The summary of respondent's personal characteristics are shown in Table 2, as indicated most cassava farmers are main, married (91.7%) with an average household size of 7 persons.

Table 2: Summary of Characteristics of Cassava Farmers in the Study Area

Dependent variable	Mean	Percentages
Age	52.5 years	
Household Size	7 members	
Educational Level	9 years	
Length of Residence in the community	28.8 years	
Years of farming experience	20.73 years	
Gender		Male=68.3% Female =31.7%
Extension Contact		No= 71.7% Yes =28.3%
Marital Status		Married=91.7% Single =8.4%
Secondary Income	N13117.00/month	

Source: Field Survey

3.1. Perceived Effects of Climate Change on Cassava Production

The mean values of the perceived effects of climate change on cassava production showed in Table 3 indicates that respondents ranked increase in temperature highest (0.375), closely followed by increase in rainfall intensity (0.32). The lowest ranking observed change was flood occurrence (0.02). The overall index of perceived effect of climate change on cassava production is 0.18; this implies that only about 18% of the whole population believes that climate change influences cassava production.

Table 3: Perceived Effects of Climate Change on Cassava Production

Indicators of Observed change	Mean	Std. Deviation	Rank
Increase in temperature	0.375	0.391	1
Increased Rainfall intensity	0.32	0.407	2
Increased Rainfall duration	0.26	0.397	3
High sunlight intensity	0.22	0.314	4
Changed timing of Rains	0.19	0.290	5
Increased moisture content in produce	0.18	0.348	6
Decrease temperature	0.18	0.311	7
Reduced Rainfall intensity	0.17	0.326	8
Have you experienced erosion	0.14	0.322	9
Reduced Rainfall duration	0.11	0.263	10
Drought occurrence	0.06	0.227	11
Increase in wind intensity	0.05	0.164	12
Flood occurrence	0.02	0.116	13

Overall Index of perceived effect of climate change on cassava production	0.175	-

3.2. Distribution of Adaptation strategies adopted by Respondents

Adaptation strategies employed by farmers included crop diversification, off-farm diversification and other adaptation strategies which include monitoring weather change by indigenous knowledge, implementing soil conservation techniques, changing cassava variety, changing planting and harvesting time and storing of produce. Figure 1 showed that majority (41.67%) of cassava farmers diversified more into other crops, 25% diversified into non-farm activities, 22.5% chose other adaptation strategies while only 10% of respondents were found to do nothing in adapting to climate change.

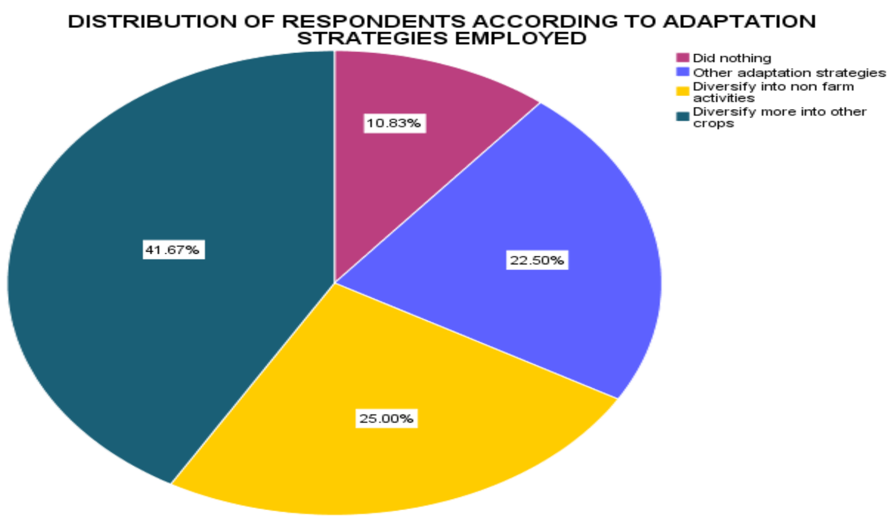

Fig. 1: Adaptation Strategies Employed by Cassava Farmers

3.3. Determinants of Adaptation Strategies Employed by Respondents

This choice set now has four strategies.

1. Did nothing (reference category)
2. Diversify more into other crops
3. Diversify into non-farm activities
4. Other adaptation strategies/ management practices.

In this analysis, the first category (did nothing) is the “reference state”, therefore inference from the estimated coefficients for each choice category was made with reference to did nothing. The result of the multinomial logit model shows the value of the log likelihood function to be -108.03774 which implies the explanatory variables in the model significantly explain the factors affecting adaptation strategies employed by farmers in the study area. The Chi-square value of

91.91 associated with the log likelihood ratio was significant at 1% ($p<0.01$) suggesting strong explanatory power of the model (Table 4)

Among the explanatory variables considered in the model age, household size, length of residence in the community, extension contact, and marital status are the factors that influence adaptation strategies employed by respondents across the different adaptation strategies in the study area with reference to doing nothing.

Age of Respondents: The study found out that age is significant ($p<0.01$) and positive, implying that an increase in age will increase the probability of respondents' to adopt crop diversification such as planting of cassava and maize as an adaptation option and off-farm diversification as against those that did nothing. This result is in support of

Table 4: Parameter Estimates of Multinomial Logit Model of Respondents' Adaptation Strategies

Explanatory Variable	Diversify more into other crops	Diversify into other non-farm activities	Other adaptation strategies
Age	0.20***	0.14*	0.05
	(2.69)	(1.93)	(0.63)
Household Size	-0.42**	-0.29	-0.13
	(-2.02)	(-1.35)	(-0.57)
Educational Level	-0.012	0.10	-0.03
	(-0.13)	(0.83)	(-0.24)
Length of Residence in The Community	-0.09***	-0.03	-0.12***
	(-2.80)	(-1.01)	(-3.02)
Farming Experience in Cassava	-0.08**	-0.07**	0.01
	(-2.04)	(-2.09)	(0.11)
Secondary Occupation Income	0.04	0.10	0.42
	(1.14)	(1.14)	(1.13)
Gender	-1.45	-1.41	0.43
	(-0.93)	(-0.88)	(0.25)
Marital Status	-1.50	-16.02	3.07**
	(-1.05)	(-0.01)	(2.09)
Extension Contact	-2.32**	-2.40**	-1.80
	(-2.02)	(-2.09)	(-1.23)
Access to Credit	-1.66	-17.61	-17.36
	(-0.00)	(-0.01)	(-0.01)
Constant	0.89	16.45	18.60
	(0.00)	(0.01)	(0.01)
Observations	120	*** *Coefficients significant at 1%*	
Log Likelihood	-108.04***	** *Coefficients significant at 5%*	
Lr Chi2(33)	91.91***	* *Coefficients significant at 10%*	
P-Value	0.000	**t-values ---** values in parenthesis	

Obayelu *et al*., (2015); Ogunpaimo and Dipeolu, 2019 but contrary to the findings of Nhemachena, Hassan, and Chakwizira, (2014) which found that age of the farmer did not seem to influence diversification of crop cultivation by farmers. It is also contrary to the findings of Ojo and Baiyegunhi,2019 who found a negative relationship between age and decision of farmers to adopt mixed cropping. He argued that the negative relationship suggests that younger farmers are more likely to choose adaptation strategies than older farmers, however we supposed that older farmer are more patient and sometimes more open to climate change adaptation strategies.

Household Size: As indicated in Table 4, household size is a significant ($p<0.05$) but negative for the crop diversification option in contrast to not adopting any adaptation strategy, it can be inferred that an increase in household size will decrease the probability of respondents' diversifying into other crops as against doing nothing. This finding is in line with Apata *et al*. (2009); Aemro, Jemma and Mengistu, (2012); and Dang *et al*. (2014), who found that increase in household size reduces the probability of a farmer adapting to climate change. This finding is against Derresa *et al*. (2009); Alli and Ereinstein, (2015); Ojo and Baiyegunhi, (2019) and Ogunpaimo and Dipeolu, (2019).

The justification for this result is that cassava is a turgid crop that can withstand varying weather conditions and as such can mostly meet household consumption needs at varying period of the year. Thus, households will be encouraged to continuously cultivate cassava with increase in household size.

Length of years of residence in a community: This indicator has significant ($p<0.01$) and negative effects on both crop diversification and management practices strategies, suggesting that an increase in this variable will lead to decrease in the probability that the respondents will choose each of these adaptation options as against those that did nothing. With increase in years of residence in the community comes increased knowledge and expertise in the environmental condition that will favour the cultivation of cassava. Cassava farmers in the study area are aware that most cassava crops will thrive even in the case of mild and sometimes serious environmental challenges, as such a decreased yearning to diversify into other crops that more influenced by fluctuations in climatic conditions. This finding is against the result of Ogunpaimo and Dipeolu, (2019) largely because cassava processing is more negatively influenced by climate change than cassava production.

Years of farming experience: An increase in farming experience will decrease the probability respondents choose crop diversification or off-farm diversification with reference to did nothing as indicated in Table 4. These findings are contrary to that Aemro, Jemma and Mengistu (2012) and Evengelista, (2013); who found out that the more experienced farmers are the more likely they are to adapt than the less experienced

The result in unique in that that experienced cassava farmers recognizes cassava as a climate resilient crop to some degree thus decreases their level of adopting climate change adaptation. The experienced farmers identify cassava as a savior crop which might meet farmers needs even when other crops fail.

This outcome is in support of Acquah (2011); Quayum and Ali (2012) and Ojo and Baiyegunhi, (2019). They opined that experienced farmers might be more interested in maintaining familiar traditional methods of farming, instead of adopting new techniques. The coefficient of access to extension services had

Marital Status: Table 4 showed that marital status is a significant ($p<0.05$) and positive for management practices strategies option, it entails that an increase in number of married farmers in relation to single farmers will increase the probability of respondents' to employ other management strategies in relation to doing nothing.

Extension Contact: Furthermore, extension contact was found to be significant ($p<0.05$) and negative, for strategies of crop and off-farm diversification. It implies that an increase in extension contact would decrease the likelihood of the respondents diversifying into other crops and diversifying into non-farm activities. This implies that farmers who had access to extension services are more likely to continue the cultivation of cassava due to awareness brought by the extension contacts about the importance and turgidity of cassava crop. This result contrast with previous findings such as Aemro, Jemma and Mengistu (2012), Nhemachena, Hassan, and Chakwizira, (2014); who stated that better access to extension services seems to have a strong positive influence on the probability of choosing adaptation measures.

3.3.1. Marginal Effects of Respondents' Adaptation Strategies

The marginal effects of a probabilistic outcome give an indication of by how much the dependent variable is explained by the explanatory variables.

In this study, a year increase in age of respondents will increase the probability of respondents to adopt crop diversification with respect to doing nothing by 0.27 and will increase the probability of respondents to implement off-farm activities in relation to not choosing any adaptation strategies by 0.01 (Table 5). An increase in number of household size of will decrease the probability of respondents diversifying more into other crops in relation to doing nothing by 0.56 .Table 5 also indicated that a year increase in length of residence in the community will decrease the probability of respondents to choose crop diversification and management practices adaptation in relation to doing nothing by 0.01

An increase in farming experience in cassava will decrease the probability of respondents to implement crop and off-farm diversification in relation to doing nothing by 0.01 and 0.001 respectively while increase in extension contact will decrease the probability of respondents diversifying more into other crops in relation to doing nothing by 0.11.

4. Conclusion

The adaptation strategies adopted by cassava farmers are classified into four categories in this study which are mainly crop diversification and off-farm diversification and other management practices.

The result of perceived effect of climate variability on cassava production showed that the overall index of perceived effect of climate variability on cassava production was found to be 0.175. The respondents identified increased temperature, increased rainfall intensity and increased rainfall duration as the major climatic indicators that they felt affect cassava production.

Table 5: Marginal effect of Multinomial Logit Model of Respondents' Adaptation Strategies

Explanatory Variable	Crop diversification	Off-farm diversification	Other adaptation strategies
Age	0.27	0.01	-0.02
Household Size	-0.56	0.04	-0.13
Educational Level	-0.05	0.01	-0.01
Length of Residence In The Community	-0.01	0.01	-0.01
Farming Experience In Cassava	-0.01	-0.001	0.02
Secondary Occupation Income	0.02	0.02	0.03
Gender	-0.25	-0.03	0.27
Marital Status	-0.46	-0.39	0.85
Extension Contact	-0.11	-0.02	0.087
Access to Credit	0.75	-0.28	-0.48

The Multinomial logit model showed that the choice of adaptation options to climate change by cassava farmers is reduced with increase in household size, length of residence in the community, farming experience in cassava, and extension contact.

Therefore, the study recommends that improved access to extension contacts by farmers should be encouraged to enhance dissemination of information and advisory services on the importance of cassava cultivation and the need to adopt or not to adopt to climate change adaptation strategies.

Acknowledgements

The authors will like to acknowledge the Cassava Adding Value for Africa (C:AVA) and the Cassava market for the grant provision in conducting this study.

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