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Analysis of the Effect of Climate Change Adaptation Measures Used by Cassava Farmers in Central Agricultural Zone of Cross River State, Nigeria

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Abstract:
The study examined an analysis of the effect of climate change adaptation measures used by cassava farmers in a central agricultural zone, Cross River State, Nigeria. A systematic sampling technique was used to select 141 Cassava farmers who participated in the study. Data collected were analyzed using descriptive statistics and a logit model. Adaptation measures and barriers to adaptation were captured using a four (4) point Likert scale, while the data on socio-economic characteristics were analyzed using descriptive statistics such as percentage and frequency, while hypothesis one was tested using a logit regression model and hypothesis two was tested using Chi-square x^2*. The findings show that (*$74.8^0/_0$*) of the respondents were between the ages of 31 years and above. The majority of the respondents were males (*$50.1^0/_0$*), while* $48^0/_0$ *of them were females and were mainly dominated by the married class (*$50.3^0/_0$*). The study reveals that the major cause of climate change in the study area is bush burning, which was ranked first; using agricultural chemicals was ranked second; and deforestation was ranked third, respectively. While the climate change effects were reducing rainfall, was ranked first pest and disease outbreaks and drought were ranked second and third, respectively, as the most adverse effects caused by climate change in the study area. The study also shows that farmers have been able to carry out some adaptation measures to combat the effect of climate change, such as the use of improved cassava varieties, the use of green manure, early planting, change of planting date, change of harvesting date and tillage. It was also revealed that the barriers associated with climate change mitigation include lack of access to weather forecast technology, inadequate finance to cope with the changing climate, and lack of cassava varieties that are adaptable to low rainfall. The result of the Chi-square* x^2 *test on the relationship between the effect of climate change and the adaptive measures used by cassava farmers in the study area shows that* x^2 *values of 287.3 of the effect of climate change on cassava production are greater than the tabulated value of 0.0922. The result, therefore, indicates that there is a significant relationship between the effect of climate change and the adaptive measures used by cassava farmers. The positive sign associated with the variables in the logit regression model improved varieties of cassava stem, green manure, early planting, and mulching would increase cassava yield. It was recommended that policy-makers formulate policies that will strengthen climate adaptation in the study area.*

Keywords: *Climate change adaptation, cassava, food security, farmers*

1. Introduction

Climate change and agriculture have tremendous effects on each other. Agriculture affects climate change through the emission of greenhouse gas (GHG) from different farming practices, while climate change in the form of higher temperature, reduced rainfall and increased rainfall variability reduces crop yield and threatens food security in low-income and agricultural-based economies. Therefore, climate change is expected to have serious impacts on the environment, economy and social life of people, especially the rural farmers whose livelihoods depend largely on

agricultural activities. It was reported by Mahendra (2010) that climate change will result in ecological degradation and further threaten the fragility of soil with serious consequences for crop, livestock production and food security.
Agriculture is the most assured engine of growth and development and a reliable source of industrialization in Nigeria. This sector has been performing below expectations due to many factors, in which climate-related disasters like drought and floods are central (Eboh, 2009).

Climate is seen as the mean state of the atmosphere of an area over a period of time. Climate change, on the other hand, is a significant and lasting change in the statistical distribution of weather patterns with a significant impact on the ecosystem. Climate change, as defined by Fusel (2007), is any change in climate over time due to natural variability or a result of human activities. The change occurs due to variations in parameters such as cloud cover, temperature and increase in greenhouse gas (GHG) emissions through human activities. Climate change is one of the major challenges facing man's survival (Farauta, Egbule, Agwu, Idrisa and Onyekuru, 2021). Climate has attracted a lot of attention in recent years, not only because of low rainfall in recent seasons globally but also because of farmers' low ability to deal with climate change-related risks. Over the past 30 years, the average global temperature has risen steadily at a rapid rate of 0.2^0 degrees (Stern, 2007). This rate of temperature increase is predicted to be sustained over the next two decades with great implications for physical and biological systems, human livelihoods and well-being. The effect of climate change may be physical, ecological, social or economic. One of the evidences of climate change is the rising sea levels and decreased snow cover in the northern hemisphere. (Intergovernmental Panel on Climate Change (IPCC, 2007). The importance of the Agricultural sector in Nigeria cannot be over-emphasized. Agriculture plays a critical role in employment, revenue generation, and provision of raw materials for agro-industries. Nonetheless, the nation's Agricultural potential is far from being realized, which has serious implications for food security and sustainable economic development (Ike & Chukwuji, 2003). The agriculture sector is highly vulnerable to climate-related stress such as temperature, precipitation and increased frequency of drought and floods. Chasi (2008) observed that agricultural crops are extremely vulnerable to climate variability.

In the tropics and particularly in Africa, changes in climate are expected to be detrimental to agriculture. Food and Agricultural Organization (FAO) (2008) argues that many countries worldwide are facing food crises due to conflicts and disasters, while food security is being adversely affected by many factors, including drought and floods linked to climate change. Climate change in the form of higher temperatures and reduced rainfall variability reduces crop yield and threatens food security in low-income economies such as Nigeria. (Apata, Samuel and Adeola, 2009).

Many countries in the tropics and sub-tropics are more vulnerable to global warming because of the additional temperature increases that affect water balance and harm the agricultural sector. The problem is expected to be severe in Africa, where technological change has been slow, and the domestic economy depends heavily on agriculture (Ayinde, 2010). Rain-fed agricultural production is dominant in sub-Saharan Africa, covering about 97 per cent of the total cropland and exposing agricultural production to high sensor oil rainfall variability (Kandlinkar & Rosebay, 2000). Agriculture in developing countries is particularly vulnerable to climate change. It is predicted that in some African countries, the yield from rain-fed agriculture can be reduced by up to 50 percent by the year 2020 (Intergovernmental Panel on Climate Change IPCC, 2000).

Agbola and Ondeye (2007) observed that in the tropics and subtropics, some crops are near the maximum temperature tolerance, and where dry lands and non-irrigated agriculture dominate, yields are likely to decrease with even small increases in atmospheric temperature. From the foregoing, it seems clear that the culmination of high climate variability, poor infrastructure, economic poverty, drought, excess rainfall, reduced crop yields, low productivity and arrangement of other problems associated with climate change constitute important challenges for Africa and Nigeria in particular. It is, therefore, necessary that steps are taken to adapt to the challenges posed by climate change.

Agriculture is the key to industrialization in Nigeria. This sector has been performing below expectations due to many factors in which climate-related disasters like drought and floods are central (Eboh, 2009).

Research has also proved that cassava as a crop is not left out of the menace of climate change. Despite advances in agricultural technology, cassava production remains uncertain and average crop yield is still low (Henry & Westhy, 2001). Climate is claimed to be a factor in yield variation (Hershery
et al., 2001; Office of Agricultural Economics, 2004: 2005: 2006).

The Country need Forty (40) million metric tons of cassava for local consumption and export, but currently, 34 million metric tons are produced, leaving a deficit of 6 million tons, according to the Food and Agricultural Organization (FAO, 2008). To increase cassava productivity, climate change. Adaptation measures must be adopted, using improved cassava varieties, zero tillage or no tillage, agroforestry practices, use of green manure, early planting, mulching tree planting system and timely harvesting. It is evident that the climate is changing and, at the same time, exerting an effect on man and his activities. Studies indicate that Africa's agriculture is negatively affected by climate change (Pearce *et al.,* 1996; Mccarthy *et al*., 2001; Onyeneke, 2010; Grigg, 1995; Allison *et al*., 2005; Ifeanyi Obi *et al.,* 2011). This may be a result of dependence on rain-fed agriculture and poor infrastructure capacity. Unfortunately, the climate change phenomenon may not be stopped due to man's continuous involvement in activities that cause the emission of greenhouse gases. Eboh (2009) stated that even if efforts to reduce greenhouse gas (GHG) emissions are successful, it is no longer possible to avoid some degree of global warming and climate change. Failure to address the issue of climate change may lead to a situation where Nigeria and other West African countries incur agricultural losses of $4^0/_0$ of GDP due to climate change (Mendelsohn *et al.,* 2005). Countries like Nigeria that experienced soil erosion and operated rainfall agriculture could have a decline in agricultural yield of about $50^0/_0$ between 2000 and 2020 due to the increasing impact of climate change (IPCC, 2007).

Considering the above, there is a need to identify the adaptation measures used, with a view to bringing to light the most conversant one, as well as major barriers faced by cassava farmers in adapting to climate change. It is against this background that this study seeks to identify the adaptation measure used by cassava farmers in Cross River Central Agriculture Zone. It is for this purpose that this research has been proposed to provide answers to the following questions:

- What are the socio-economic characteristics of cassava farmers in the study area?
- What are the major causes of climate change in the study area?
- What are the barriers faced by cassava farmers in adaptation to climate change?
- What are the effects of climate change on cassava farmers in the study area?

The broad objective of this study is to identify the adaption measures used by cassava farmers in the central agricultural zone of Cross River State. The specific objectives are to:

- Identify the socio-economic characteristics of cassava farmers in the study area;
- Examine the major causes of climate change;
- Identify the barriers faced by cassava farmers in adaptation to climate change in the study area;
- Examine the effect of climate change adaptation measures used by farmers in response to climate change. In the study area

2. Methodology

The research work was carried out in Central Cross River State. The area lies between Latitude $5^{0}40^{1}$ and $6^{0}10^{1}$ North of the equator, longitude $8^{0}2$ and $6^{0}10$ East of the Greenwich Meridian, and 200 km^2 Northwest of Calabar, the capital of Cross River State. Geographically, the area shares boundaries in the North with the Ogoja Local Government Area, in the South with the Biase Local Government Area, in the East with the Akamkpa Local Government Area, and in the West with Ebonyi State.

Central Cross River has six (6) Local Government Areas, namely: Abi, Boki, Etung, Obubra, Ikom and Yakurr. Agriculture is the economic mainstay of the people of the area, who have evolved a system whereby the land, labour, and other resources are for productivity purposes. Land ownership in the area is a commercial property of family units with families organized in terms of paternal and maternal units.

3. Sampling Technique and Sample Size

The study employs systematic sampling techniques to select respondents for the study. Four (4) local government areas in the study area were purposefully selected out of the six (6) local government areas.

A total of one hundred and forty-one (141) questionnaires were distributed to the selected respondents that were proportionally selected, and a total of one hundred and thirty-one (131) questionnaires were returned. 10% proportionality from one thousand four hundred and ten (1,410) registered Cassava farmers with extension agents in the Change of FADAMA project in the selected local Government Area of the Study was used.

4. Method of Data Collection

Questionnaires were designed to collect data on the analysis of the effect of climate change adaptation measures used by cassava farmers in selected local government areas in the central agricultural zone.

The questionnaires were validated and administered to select respondents as a pilot survey to pretest the instrument and were validated after the pretest before administering the questionnaire to farmers.

Selected Local Government Areas	Sample Frame	Sample Size ($10_{o}/^{o}$)	Questionnaires Returned
Abi	260	26	23
Obubra	440	44	40
Boki	250	25	23
Yakurr	460	46	45
Total	1,410	141	131

Table 1: Distribution of Questionnaires to Cassava Farmers in the Selected Local Government Areas of Cross River Central Should Be Included

Source: Field Survey (2021)

5. Method of Data Analysis

Descriptive statistics such as frequency distribution and percentages were used to analyze the demographic features of the farmers, which include sex, age, gender, marital status, household size, educational level, farming experience and aim of production. The observed frequencies were derived from table 1. Note that very severe (VS) and severe (S) were coded as severe, while less severe (LS) and not severe (NS) were coded as not severe (NS),

Hypothesis one was tested using probit and logit regression model, while hypothesis two was tested using chi-square x^2 and a four-point Likert scale to interpret the objectives of the study as shown below:

Section B	
Response categories	Numerical value
Serious problem	4
Moderate problem	3
Small problem	2
Not a problem	1
Section C	
Response categories	Numerical value
Very severe	4
Severe	3
Less severe	2
Not severe	11
Section D	
Response categories	Numerical value
Strongly agree	4
Agreed	3
Strongly disagreed	2
Disagreed	1

Table 2

5.1.Specification of Models

First stage estimation equation

Production function model for cassava production in the study area

Dependent variable (Y) = yield of cassava per hectare (Kg)

Indepndent variable (X_1-X_{12})

Y = f(X_1, X_2…….X_{12})………………………….equation 1

Where y = yield of cassava (Kg)

X_1 = use of improved cassava varieties

X_2 = Agroforestry practices

X_3 = Green Manure

X_4 = Early Planting

X5 = Zero Tillage Manure

X_6 = Change of planting date

X_7 = Charge of harvesting date

X_8 = Tree Planting

X_9 = Mulching

X_{10} = Land (hectares)

X_{11} = Labour (man-days-per hectare)

X_{12} = Capital Second stage estimation equation

5.2.Probit and Logit Model Specification

The probit and logit model will be used to determine if farmers adopted measures to check climate change in the study area or not.

A form of the logit model adopted in this study (pindyck and Rubifeld, 1981).

P = c(1-e^2 1)

where Pi=Probability that a farmer 1(i=1,2..175) choose to adopt measures to check climate

Change or not, given the information embodied by index Zi and C is a constant choice index Zi = unobserved, was investigated as being predicted by the following relationship, Zl=Bu+B_1

XI+B2X2+-_BnXn…………………………equation Il

Where choice index Zl, on which to classify cassava farmers in climate change adapter and non-climate change adapter in the study area

xi-xn are factors influencing the cassava farmer's decision to adopt climate change measures or not and are also measured as follows:

x_1=: Use of improved cassava varieties (kg/ha)

x_1: Agro-Forestry Practices (Alley cropping) (a dummy variable), which takes the value of unity (1)

if the farmer used Agro Forestry practices and Zero (0) otherwise (did not use Agro Forestry practices)

x_3 = Green Manure (kg!ha)

x_4 = Early Planting (a dummy variable), which takes the value of unity (I) if the farmer planted cassava stems early (Early planting) and zero (0) otherwise (planted

Cassava late (Late planting))

X_5 = Zero tillage Ca dummy variable)

X_6 = Change of planting date (a dummy variable)

X_7 = Change of harvesting date (a dummy variable)

X_8 = Tree planting (a dummy variable)
X_9 = Mulching (What)
X_{10} = Land (hectare)
X_{11} = Labour (man-day per hectare)
X12 = Capital (naira)
Constant is assumed to be unity without loss of generality, and the form in which the logit model was estimated is:
$Ln(P^1/_1\text{-}Pi) = B_1X_1 + B_2X_2 + BnXn$

Determine the adopter Group (low or high). Il used logit analysis to predict low adopter. Prior to technology transfer, the model can be represented explicitly by taking "y" as a probability and making it logarithm to depend linearly on the independent variables:

Log P = a + b: b2 x2. . ……b9x9 + e, this is a situation where "p" approaches 0. Similarly, at the high end of the scale where approaches 1, Log (l -P) depends linearly on the independent variables.

When both ends of the scales are combined with the model, we get Log P-log (l -P) = a+ b_1x_1: ….+ b_2X_2 + baxa e that is Log $(\frac{p}{1-p})$ = a+ b_1x_1 + e is called the odds ratio.

Thus, Log $(\frac{p}{1-p})$ is called the log odds or logit. The classification procedure is as follows:

If Log $(\frac{p}{1-p})$ tend to zero, i classify the individual cassava farmer as belonging to a group "O" (low adopter).

When $(\frac{p}{1-p})$ tend to one, classify the cassava farmer as belonging to the group, the classification boundary was the locus of the points where a b xl + b2xz… bmxa = 0.5. The logit score $(\frac{p}{1-p})$ Log (RTF) was estimated using the Maximum Likelihood Estimate (MLE) procedure. The logit coefficient, "IS's," was estimated by solving simultaneous equations using matrix algebraic form.

6. Result and Discussion

Table 3 revealed that 51.1% of the respondents were moles, while 48.9% of them were females. This implies that the majority of the respondents in the study area were males. These findings were collaborated with earlier results by Jackson (2003), who maintained that the highest percentage of males in the variable indicated a higher labour force and increased productivity of food.

The table also shows that 3.0% of the respondents were within the age range of above 40 years. The implication of the results was that the majority (74.8%) of the respondents were within the economically active age (31 and above 40). The result of the finding collaborates with earlier results by Salay Onuk and Ibrahim (2012) in Nasarawa State, Nigeria, where the respondent had a mean age of 48 years.

The table also shows that 28.2% of the respondents were single, while 50.4% were married, 13.0% were divorced, and 8.4% were widowed. This shows that the majority of the respondents were married.

It was also shown that 62% of the respondents have a family size of 0-5 members, 30.6% of cassava farmers have a family size of 6-10 members, 6.1% of them had that of 11-15 members and 0.7% of the respondents had a family of 16 a d above. It, therefore, implies that the majority of the respondents have families of 0-5 members. The result reveals that their household size is fairly large, and this strongly suggests the practice of the extended family system, which Ekong (2005) noted is common in rural areas. It could imply that family labour was readily available.

The table also shows that 6.9% of the respondents had no formal education, 5.3% had a primary school leaving certificate (FSLC), 19.1% of them had Senior School Certificate Examination (SSCE), 28.2% of them had both OND/NCE and HND/BSC, 10.7% had PGD/M.Sc, while 1.6% of the respondents had a Doctor of Philosophy (Ph.D.). It, therefore, revealed that the majority of the respondents had both OND/NCE and HND/B.S.C. in the study area. The table also revealed that more than 90% of the respondents were literate enough to read and write with at least primary education. Agwu and Anyanwu (1996), in line with the above statement, noted that an increase in the educational status of farmers influences the adoption of improved technologies and practices.

The table further revealed that 9.1% of the respondents had farming experience of 1-5 years, 39.7% of them had 6-10 years of farming experience, 26.8% of the respondents had 11-15 years of farming experience while 24.4% of the respondents have had 16 and above farming experience in the study area. In line with this, Edeh and Mbam (2000) conducted a study on constraint technologies in Abakaliki Local Government Area of Ebonyi State: a factor analysis approach; they found that the mean years of experience in cassava farming in Abakaliki Local Government Area of Ebonyi State was about 29 years with majority (53.3%) of the respondents having cultivated cassava for 30 years.

The table also indicates that 9.1% of the respondent's aim of production is for sales, 9.1% of the respondent's aim of production is for consumption, and 81.7% of the cassava farmer's aim of production is for both sales and consumption in the study area.

The table further shows that 93.9% of the respondents were aware of climate change in the study area, while 6.1% said they were not aware of climate change in the study area. It, therefore, implies that the majority (93.9%) of the respondents in the study area were aware of climate change.

The finding of this study agrees with Heogh-Goldberg et al. (2007), who maintained that farmers are aware of climate variation that takes place over months, seasons and years. They further maintained that climate variability occurs over seasons or years instead of day-to-day, like weather.

Furthermore, the table shows that $74{,}0_0/^0$ of the respondents disclosed that climate change reduced cassava production in the study area, which led to the poor yield of cassava production in the area. However, 5.3% of the respondents revealed that there was no climate effect on cassava production in the study area. It, therefore, implies that the majority of the respondents revealed that there is a climate effect on cassava production in the study area. The finding of this study is in line with the earlier findings of Edeh and Mbam (2010). Hoegh-Goldberg *et al.* (2007) maintained that farmers are aware of climate variation that takes place over months, seasons and years. They further maintained that climate variability occurs over seasons or years instead of day-to-day like weather.

Furthermore, the table shows that 74.0$_0$/^{0} of the respondents disclosed that climate change reduced cassava production in the study area, which led to the poor yield of cassava production in the area. However, 5.3$_o$/^{o} of the respondents revealed that there is no climate effect on cassava production in the study area. It, therefore, implies that the majority of the respondents revealed that there is a climate effect on cassava production in the study area. The finding of this study is in line with the earlier findings of Edeh and Mbam (2010), Hoegh-Goldbery *et al. (2007), and Mapuno et al*. (2008), who maintained that climate change affects the yield of cassava production. However, farmers who have sufficient farming experience adapted techniques or adaptive measures to cope with the challenges of climate change.

Characteristics	Variables	Frequency	Percentage %
Gender	Male	67	51.1 o/o
	Female	64	48.9
	Total	131	100
Age (years)	18-20	4	3.0
	21-30	29	22.2
	1-40	56	42.8
	Above 40	42	32.4
	Total	131	100
Marital Status	Single	37	28.2
	Married	66	50.4
	Divorced	17	13.0
	Widowed	11	8.4
	Total	131	100
Household Size	0-5	82	62.6
	6-10	40	30.6
	11-5	40	6.1
	16 and above	1	0.7
	Total	131	100
Educational Level	No Formal Education	9	6.9
	FLSC	7	5.3
	SSCE	25	19.1
	OND/NCE	37	28.2
	BSC/HND	37	28.2
	P. GD/M.SC	14	10.7
	P h.D.	2	1.6
	Total	131	100
Farming experience	1-5	12	9.1
	6-10	52	39.7
	11-15	35	26.8
	16 and above	32	24.4
	Total	131	100
Aim of production	Sales	12	9.1
	Consumption	12	9.1
	Both	107	81.7
	Total	131	100
Climate change awareness	Yes	123	93.9
	No	8	.6.1
	Total	131	100
Climate change effect	Reduce cassava	97	74.0
	Production increase cassava	7	5.3
	None of the above	27	20.7
	Total	131	100

Table 3: Socio-Economic Characteristics of Respondents (Cassava Farmers) in the Study Area
Source Field Survey, 2021

Items	SP (4)	MP (3)	SP (2)	NP (1)	CUM	CUM AV	RANK
Deforestation	18 (72)	72 (216)	3 (3)	3 (3)	367	2.80	3
Land clearing	1 (4)	56 (168)	65 (130)	9 (9)	311	2.38	6
Slash and burn	4 (16)	77 (231)	40 (80)	10 (10)	337	2.58	4
Fertilizer application	2 (8)	70 (210)	48 (96)	11 (11)	325	2.45	5
Tillage	-	26 (78)	87 (174)	18 (18)	270	2.07	7
Use of agricultural chemicals	37 (148)	70 (210)	22 (44)	2 (2)	404	3.09	2
Bush burning	61 (244)	65 (195)	5 (10)	-	449	3.42	1

Table 4: Major Cause of Climate Change in the Study Area
Mean Response (MR) = 2.69
Source: Field survey, 2021

Table 5 shows the major causes of climate change in the study area. Taken together, the ranking saw bush burning as the major cause of climate change in the study area. The use of agricultural chemicals, deforestation, slash and burn, fertilizer application, land clearing and tillage were ranked second, third, fourth, fifth, sixth and seventh, respectively. The result corroborates with earlier findings by Hoegh-Guldberg *et al*. (2017), who reported similar results. This implies that extension agents should guide cassava farmers on adaptive measures like ally cropping, construction of ridges across slopes, mulching of crops, planting of crops and levels of input combination that would ensure efficient production of cassava in the study area.

Effect	Vs (4)	S(3)	Ls(2)	Ns(1)	Cum	Cum av	Rank
Flood	5(20)	16(48)	70(140)	40(40)	248	1.98	6
Drought	2(8)	45(135)	70(140)	14(14)	297	2.27	3
Pest and disease outbreak	2(8)	43(129)	80(160)	6(6)	303	2.31	2
Erosion	1(4)	19(57)	110(220)	1(1)	282	2.16	4
Reduces rainfall	40(160)	76(228	14(28)	1(1)	417	3.19	1
Increased rainfall	2(8)	12(36)	34(68)	83(83)	195	1.49	7
Worsening soil condition	-	14(42)	112(224)	5(5)	271	2.07	5

Table 5: Effect of Climate Change in the Study Area
Mean Response = 2.20
Source: Field Survey (2021)

The table above indicates that Cross River Central suffers mostly from reduced rainfall (1st), pest and disease outbreaks (2nd), Drought (3rd), Erosion (4th), worsening of soil condition (5th), flood (6th), increased rainfall (7th) which is the least experience in the area. In line with this, Zhou, Minakawa, Gifheko and Yan (2004) maintained that climate variability has had far-reaching effects on human health, reduces rainfall, and includes, but is not limited to the following heat stress, air pollution, asthma, vector-borne diseases such as malaria and dengue. He further revealed that climate change is expected to exacerbate the occurrence and intensity of future disease outbreaks and perhaps increase the spread of diseases in some areas.

Barriers	SA (4)	A(3)	SD(2)	D(1)	Cum	Cum AV	Rank
Lack of cassava varieties that are adaptable to low rainfall	52(208)	73(219)	4(8)	2(2)	437	3.33	3
Lack of access to weather forecast technology	74(296)	57(171)	-	-	467	3.57	1
Inadequate finance to cope with the changing climate	66(264)	53(159)	3(6)	9(9)	438	3.34	2
Inadequate knowledge of how to cope or build resilience to climate change	51(204)	64(192)	4(8)	12(12)	416	3.18	4
Illiteracy of farmers and lack of knowledge of adaptation	36(144)	68(204)	11(22)	16(16)	386	2.94	6
Poor agricultural extension service delivery	44(176)	52(156)	14(28)	21(21)	381	2.90	7
Lack of cassava varieties that are resistant to drought	37(148)	82(246)	3(6)	9(9)	409	3.12	5
Mean response (MR) = 3.20							

Table 6: Barriers Faced by Cassava Farmers in Adaptation to Climate Change
Source: Field Survey (2021)

The table above shows the barriers faced by cassava farmers in adaptation to climate change in the zone. It, therefore, indicates that lack of access to weather forecast technology is ranked (1st) because the government does not make this available to the farmers when necessary. This is followed by inadequate finance to cope with the changing climate (2nd), lack of cassava varieties that are adaptable to low rainfall (3rd), inadequate knowledge to cope with the changing climate (4th), and lack of cassava varieties that are resistant to drought (5th).

The result in table 5 agrees with that of Mark Maridy, Gary, Lan, Saleemul and Rowena (2008), who argued that lack of adaptive capacity due to constraints on resources like access to weather forecasts or better seed varieties may result in further food insecurity. The result of a study conducted by Center for Environmental Economics and Policy in Africa (CEEPA, 2006) across African countries shows that lack of adequate information about climate change is one of the major barriers encountered by farmers in adapting to the effects of climate change.

The findings also collaborate with the earlier results of Desersa et al. (2008), who analyzed the barriers to adaptation to climate change in the Nile basin of Ethiopia, indicating that there are five (5) major constraints to adaptation farmers. These, as reported by the author, are lack of information, lack of access to weather forecast technology, lack of money, shortage of labor, shortage of land and lack of varieties that are adaptable to low rainfall or poor potential for irrigation.

6.1. Test of hypotheses

The hypothesis formulated by the study states that:

- H01: There is no significant relationship between the socio-economic characteristics of cassava farmers and their adaptation to climate change in the study area.
- H02: There is no significant relationship between the effects of climate change and the adaptive measures used by cassava in the study area.

The chi-square X^2 statistical analysis was analyzed as follows.

$X^2 = \sum$ [(observed value – expected value)^2]

Expected value

Let's observe value = O

Expected value = E

$X^2 = \sum[(O-e)]^2$

e

The expected frequencies were calculated using the formula below:

E = column total x Row total

Grand total

To test the hypothesis, data collected on the effect of climate change on cassava in the study area (see Table 7) was analyzed using the Chi-square (X^2) test at 0.05 level of significance, as shown in the table below.

Effect of Climate Change on Cassava Produced	Frequencies of Adaptation Measure to Climate Change		Row Total
	Severe	Not Severe	131
Flood	21(39.6)	110(91.4)	131
Drought	47(39.6)	84(91.4)	131
Pests and disease outbreak	45(39.6)	86(91.4)	131
Erosion	20(39.6)	111(91.4)	131
Reduce rainfall	116(39.6)	15(91.4)	131
Increased rainfall	14(39.6)	117(91.4)	131
Worsening soil condition	14(39.6)	117(91.4)	131
Column total	277	640	917

Table 7: Summary of Observed Frequencies (0) and the Calculated Expected Frequencies (E) on the Effect of Climate Change on Cassava Production in the Study Area
Source: Field Survey, 2021

Footnote

$X^2 = \sum[(O2-e2)]^2$

E2

Where 0! = observed frequency

E = expected Frequency

E-1= Degree OF freedom

X^2 = 0.0922 (tabulated value)

287.3 (calculated value)

E = column total x Row total

Grand total

e.g for cell 1E = $\frac{277 \times 131}{917}$ = 39.6

7. Result for Tested Hypotheses

Cell	O	E	O-E	(O-E)²	(O-E)²/E
1	21	39.6	-18.6	346.0	8.7
2	110	91.4	18.6	346.0	33.7
3	47	39.6	7.4	54.8	1.3
4	84	91.4	-7.4	54.8	0.5
5	45	39.6	5.4	29.1	0.7
6	86	91.4	-5.4	29.1	0.3
7	20	39.6	-19.6	384.1	9.6
8	111	91.4	19.6	384.1	4.2
9	116	39.6	76.4	5,837.0	147.3
10	15	91.4	-76.4	5,837.0	63.8
11	14	39.6	-25.6	655.3	16.5
12	117	91.4	25.6	655.3	7.1
13	14	39.6	-25.6	655.3	16.5
14	177	91.4	25.6	655.3	7.1

Table 8: Chi-square (x^2) Analysis of Effect of Climate Change on Cassava Production

X^2 =287.3

$X2 = \frac{n\ (O^2 - E^2)^2}{\sum n-1= E2} = \frac{(O^1 - E^1)^2}{E} - \frac{(O - E^2)}{E2} + \frac{(O_n - E_n)^2}{E_n}$

Where:

O = Observed frequency

E= Expected frequency

E-1 = Degree of freedom

Degree of freedom = (R-1) (C-1)

If the calculated X^2 value of 287.3 of the effect of climate on cassava production is greater than the tabulated value of 0.0922. Therefore, we reject the null hypotheses and accept the alternative hypotheses that state:

- There is a significant relationship between the socio-economic characteristics of cassava farmers and their adaptation to climate change in the study area.
- There is a significant relationship between the effects of climate change and the adaptive measures used by cassava farmers in the study area.

Parables	Coefficients	Standard Error	Z	P>/Z/	Marginal Effects
Use of improved varieties X_1	2.2282	0.0138	3.77**	0.000	-0.0522
Agroforestry X_2	-1.5737	0.0913	-3.06**	0.002	-0.2792
Green manure X_3	2.473	0.7784	3.34**	0.001	0.437
Early panting X_4	2.2052	0.0141	3.32**	0.001	0.469
Zero Tillage X_5	1.0175	0.0018	2.19*	0.029	0.0040
Charge of planting date X_6	1.1429	0.1062	-0.31*	0.760	-0.0234
Charge of harvesting date X_7	1.0751	0.0078	2.20*	0.028	0.01522
Tree planting X_8	-1.585	0.0676	3-40*	0.028	0.01522
Mulching X_9	1.698	0.0953	0.41	0.684	0.0387
Constant	5.7869	2.3582	3.4**		
Log-likelihood	-73.7362				
Chi-Square	56.90				
Pseudo R^2	0.2451				
Number of observations	= 131				

Table 9: The Result of the Probit and Logit Regression Analysis
Source: Field Survey (2021)

Significant 5% level
Significant at 1% level
Production function model for cassava production in the study area
Dependent variable (Y) = yield of cassava per hectare (Kg)
Dependent variable (X_1-X^{12})
= f (X_1, X2…………….X_{12}) –equation 1
Where:
Y= yield of cassava (Kg)
X_1= Use of improved cassava varieties
X_2 = Agroforestry practices
X_3 = Green manure
X_4 = Early planting
X_5 = Zero Tillage Manure
X_6 = Charge of plating date
X_7 =change of harvesting data
X_8 Tree planting
X_9 = Mulching
X_{10} = Land (hectares)
X_{11}= Labour (man-days-per hectare)
X_{12}=Capital (naira)

Table 8 indicates that the coefficient of use of improved varieties of cassava stems (x1), early planting (x4) and mulching (X9) were positively related to the odd to climate change adaptation measure and significant at 1% level. While the coefficient of zero tillage (X5), change of planting date (X6) and change of harvesting date (x7) were statistically significant at a 5% level and positive, this conforms with the prior expected positive sign. The positive sign associated with the variables in the model implies that the adoption of climate change adaptation measures like the use of improved varieties of cassava stem, green manure, early planting and mulching would increase cassava yield. The result of the analysis showed that agro-forestry practices (X2) were significant at a 1% level and negatively related to climate change adaptation measures used.

This implies that an increase in agro-forestry practices by one hectare reduces the odd to cassava yields by 2.7%. Whereas tree planting was significant at a 5% level and negative to climate change adaptation measure used/cassava yield. This implies that an increase in planting of trees on one hectare of land reduces cassava yield by 2.5%.

Green manure (X2) was significant at a 1% level and positively related to the output of cassava. This implies that an increase in one kingdom of green manure applied to soil would increase cassava yield by 4.3%. This finding is in line with the work of Adinya (2001), who maintained that an increase in one kilogram of green manure applied to soil would increase cassava yield by 5%.

8. Conclusion and Recommendations

The study was primarily designed to assess the effect of climate change adaptation measures used by cassava farmers in Central Agricultural Zone of Cross River State, Nigeria. Data were collected from 131 respondents, who were systematically selected from four (4) local government areas: Abi, Boki, Obubra and Yakurr. Findings from this study reveal that climate change and cassava farmers were also making decisive efforts to mitigate its impact to avert both foreseen and unforeseen dangers it might bring. The majority of the respondents were male (51.1%), while 48.9% of them were females and were mainly dominated by married farmers (50.3%). The majority had both OND/NCE and B.Sc/HND (56.4%), with an average of 10 years of farming experience. Furthermore, the study also reveals that the majority of respondents were within the age range of 31 and above 40 (74.8%). Farmers with a household size of 0-5 members constitute 82(62.6%), which is the highest. It was revealed that the majority of the farmer's aim for cassava production is for both consumption and sales (81.7%) in the study area.

Frequency distribution by number and percentage cumulative average were used for ranking in some cases. The Chi-square (X^2) statistical analysis was used to test the hypothesis.

Bush burning: Use of agricultural chemicals and deforestation were ranked first, second, and third, respectively, as the major causes of climate change in the area, while reduced rainfall, pest and disease outbreaks and drought were seen as the most adverse effects of climate change.

The use of improved varieties, green manure and early planting were considered to be the most effective ways of adapting to climate change in the area.

The relationship between the effect of climate change and the adaptive measures used by cassava farmers in the area was hypothetically tested using the chi-square (X^2) statistical analysis. The X^2 chi-square result shows that the X^2 value of 287.3 of the effect of climate change on cassava production is greater than the tabulated value of 0.0922. The result indicates that there is a significant relationship between the effect of climate change and adaptive measures used by cassava farmers in the study area.

Climate change is one of the most serious environmental threats to the fight against hunger, malnutrition, diseases and poverty, essentially because of its impact on agricultural productivity.

This study has revealed that agricultural activities like bush burning, use of agricultural chemicals, deforestation, etc., carried out in the study area were detrimental to the environment. Most of the activities lead to global warming, leaving the environment worse than it was. It is recognized that the effect of climate change is mostly felt by cassava farmers in the area and the farmer's vulnerability to climate change.

Based on the result of the study, it is concluded that the major adaptation measures used by cassava farmers in the study area include the use of improved cassava varieties, green manure and early planting, and the major changes are a lack of access to weather forecast technology, inadaptability to climate change extension source of communication consisted creditable in Cross River Central that could be used to strengthen climate change adaptation measures.

Based on the findings of the study, the following recommendations were made:

- Policy-makers should formulate policies that will strengthen climate adaptation measures in the study area.'
- Cross River Agricultural Development Programme (CRADP) should make room for extension agents to visit farmers, create awareness and disseminate proven measures to boost the adaptive resilience capacities of the farmers in the study area.
- Government through the extension service of Agricultural Development Programme should help farmers have access to land, labour, affordable credit as well as subsidized agricultural inputs in order to effectively adapt to climate change.

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