JOURNAL of SUSTAINABLE AGRICULTURE AND the ENVIRONMENT

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Analysis of Cassava Farmers' Response to Climate Change Adaptation: Implication for Sustainable Food Production in Nigeria

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Abstract

The study examined how smallholder cassava farmers responded to changes in climate by identifying adaptation strategies adopted by the farmers and its determinants. In addition, the study analyzed the trend of production, productivity, and hectarage of cassava in Nigeria from 1980-2017. Multinomial logit model and exponential trend equation were employed to analyze the obtained data. The cassava farmers studied adopted use of irrigation (10%), livestock ownership 53.24%), mixed cropping (79.86%) and use of improved crop variety (92.81%) as major adaptation methods. The adaptive approaches used by cassava farmers were determined by farming experience, level of education and ownership of transport. The empirical trend analysis revealed that the coefficients of cassava output and hectarage were -45.15 and -43.42 respectively and statistically significant at 1% implying a decrease in cassava output and hectarage within the period under study. It was further revealed that the marginal effects for the level of education and ownership of a means of transport were 0.11 and – 0.12 respectively. The implication of this result is that one unit increase in level of education and ownership of means of transport of a cassava farmer is associated with 11% more likely and 12% less likely that the farmer will adopt livestock ownership as adaptation strategy over the use of new crop variety. Therefore, from the established result, it was suggested that educational campaign on climate adaptation strategies should be embarked on so as to hearten the consciousness of cassava farmers on adaption strategies to climate change. More so improved cassava varieties are required for sustainable cassava production and food security in Nigeria.

Keywords: *Adaptation, Cassava, climate change, Production, and Smallholder.*

Introduction

In Nigeria, as in most developing countries, the importance of agriculture to the livelihoods of rural people is evident as it serves as the basis of food security to the populace. It accounts between 60% - 70% of the labour force and produces about eighty percent of calories that we consume either directly as food or indirectly as animal feed (Kalu & Mbanasor, 2016, Ajetomobi, Abiodun & Hassan; 2011). Agricultural output act as resources for many processing industries and as a means of foreign exchange earnings for the country. Nigeria agricultural sector is not immune to impact of climate change due to the dependence of her on rain-fed agricultural production system Christiansen, (2009), FAO, (2009) and an output reducing climate outcome could severely affect the food availability in the country through both reduction in food supply as well as increase in food price. African agriculture cannot deny the effects of changes in weather conditions, although estimate varies among researchers (Thornton, Jones, Ericksen &Challinor, 2011, Challinor & Wheeler 2008a). Evidence of climate change is with us and greater impacts cannot be escaped in years to come. Cassava is one of the root crops that is widely cultivated, consumed and marketed in sub-Sahara Africa as well as Nigeria. The crops' ability to tolerate drought and grow on poor marginal soils makes it a good crop for food security and also these characteristics are highly valuable in the face of climate variability (Awa & Tumanteh, 2001). Moreover the full potential of cassava is yet to be realized as more unpredictable changes are yet to occur (Joel and Anne 1998, legesse, Ayele &Bewket, 2017). The yields of cassava can be affected by low temperatures at high elevations, pests, diseases and waterlog Agricdemy, (2018). The changes in weather with its related increase in temperature will as well increase the prevalence of pest and diseases. The average yields of 10.6 tons per hectare of cassava observed in Nigeria are still far below the achievable of about 25 tons per hectare. Climate variables are among the abiotic factors in yield variations (Hershey *et al*., 2001). The ability of cassava to adapt to climate change have been deliberated on by many scholars (Kamukondiwa (1996), Sangpenchan 2009., Ifeanyi- Obi &Issa 2013). But there is variability in climate parameters,

and they will continue to vary notwithstanding the level of funds provided to reduce that (Joel and Anne, 1998). Therefore, adaptation to climate change is worth considering among faming households in developing countries Hassan and Nhemachena, (2008). In other to counteract the sad consequences of climate change to agriculture, adaptation is essential Kurukulasuriya and Mendelsohn, (2006). Adaptation is said to be the adjustments made in people and natural activities they perform in reaction to real or anticipated changes in weather or their effects, that damages or feats valuable prospects (Intergovernmental Panel on Climate Change IPCC, 2014).To lessen the hostile impacts of extreme weather conditions, smallholder farmers have accustomed themselves to these harsh weather conditions and have already developed a coping strategy over time. The problem of climate change adaptation among rural agricultural household has gained attention from many researchers because smallholder farmers are vital to Nigeria's agricultural success as they currently produce most of our food but their production is characterized by low productivity. Globally, the impacts of climate change are generally understood, and what approaches households use to adapt. On the other hand, little is known about what factors affect the choice of adaptation strategies for farmers. However, few studies have answered the question why farmers combine a variety of strategies for adjusting to the effects of climate and weather variability. It was opined by Aggarwal *et al* (2010) that household adaptation strategy studies, provides better policy options for incorporating adaptation approaches into food security programs. With this in mind, adaptation to the effects of climate change becomes very important if the objective of sustainable food production will be ever achieved. However, the multiple determinants of adaptive responses of cassava farmers are still unknown. This study, therefore, aims to gain a better understanding of how cassava farmers in Abia, Ebonyi and Benue States of Nigeria responds to changes in climate adaptation decision. Specifically this study assessed the trend of cassava production and productivity in Nigeria from 1980- 2018, It also identified the adaptation strategies adopted by cassava farmers to combat extreme weather at the location of study, and also to determine the factors that are

responsible for the selection of the different methods of climate change adaptation by cassava farmers in the study area.

1.1 Methodology

1.2 Study Area

The focus of the study was on Nigeria. The country is bounded by Niger Republic, Chad, Benin Republic, Cameroon, and the Atlantic Ocean. Nigeria has inhabitants of over 164 million NPC, (2012) with different agro-ecological zones and livelihood strata. The major occupation of the people is farming; about half of the working population is engaged in agriculture majority of who are smallholder farmers. Cassava, yam, sweet potato, sorghum, maize, millet, and rice are among the major food and cereal crops in Nigeria Fafchamps, Gabre-Madhin, & Minten*;* (2003). The country is faced with ecosystems being destroyed by unfriendly weather conditions. Excessive flooding has been the recent menace the farming communities in the coastal area has to fight with, the Sahel region is experiencing serious desert encroachment. Other environmental issues such as soil depletion, rapid deforestation and water contamination, oil spill affecting air, soil and water, decrease in cultivable lands, the rapid expansion of urban area and so on.

1.3 Sampling Technique

A total of 180 farming households were chosen from the three states of different agro climate namely Abia, Ebonyi and Benue in Nigeria. A two staged sampling approach was used in picking the respondents for the study. There was a purposive selection of one local government area (LGA) from each of the three senatorial zones. The second stage involves two farming communities which were chosen from among the selected LGA. Ten (10) cassava producers were randomly chosen from a list of 30 cassava farmers complied by the extension agent working at the selected areas, which will make up a total of 180 farmers. A well-structured questionnaire was used in collecting data from the respondents. Information on demography and socio-economic parameters were gotten. About 159 cassava producers were used for the analysis; 21 respondents were

dropped because of the uncompleted questionnaire and/or inconsistent data. The time series data on trend in production, productivity and hectarage of cassava in Nigeria from 1980-2017 was collected from Food and Agricultural Organization statistical website (FAOSTAT)

1.4 Analytical Techniques

To analyze objective 1, exponential trend equation was fitted to production, productivity and hectarage of cassava from 1980-2017. The objective (ii), which is designed to ascertain the current adaptation methods that cassava farmers were using in the location under study, was analyzed with descriptive statistic such as frequencies, means and percentages. Objective (iii) was to determine the reasons for adopting different methods of dealing with extreme weather condition amongst cassava farming households within the study location. This was analyzed by use of multinomial logit model. The elicited information were analyzed with STATA 13 software.

1.5 Specifications of Model

To achieve objective one, the exponential trend equation was fitted to output of cassava, yield and hectarage from 1980 -2017 following Onyenweaku and Okoye (2005). This is expressed below as:

$Y_t = e^{\beta 0 + \beta_1 t 1 + ut}$……..1

By taking the natural logarithm mutually, the equation will be written as

$\text{Log } Y_t = \beta_0 + \beta_1 t_1 + U_t$ ……2

t = time trend variable

B_0= intercept of the trend equation

B_1 = trend coefficient

u_t = error term

For objective (iii) which is to determine the reasons why cassava farmers' select different adaptive approach to harsh weather in the location under study was analyzed using model of preference. The model was developed within random utility conceptual structure. A random utility model determines an individual farmer's choice of adaptation strategies and also establishes the connection that exists among the farmer ability to select an adaptive method and the set of explanatory variables. It is presumed that random components of the utilities are independent and

distributed identically, and this assumption results in the MNL model. Following Greene (2003) which notes that the multinomial logit model for adaptation choice stipulates the relation between the ability of farmers to choose option Bi and a group of independent variables Z, it can be expressed in the manner stated below:

Probability (B_i =l) = exp (α_{il} zi)

$\Sigma^{j}_{k=0}$ exp (α^{i}_{k}Zi), l=0,1……l

Where Bi denotes chance or random variable representing the adaptation methods that any cassava farmer uses, with use of improved crop variety as the base category. It was presumed that each cassava farmer has a group of distinct, jointly exclusive adaptive approaches that rely on certain socioeconomic parameters and other factors Z, where αi is a vector of coefficients of each of the independent variables Z. According to Hassan and Nhemachena (2008), equation 1 can be standardized by assuming the α0 =0 and the probability can be estimated as:

Probability (Bi =l/Zi) = exp (α^{i}_{l} Xi)

$1 + \Sigma^{j}_{k=0}$ exp (α^{i}_{k}zi), j=0,1……l α0 =0 ---------- (ii)

Estimating equation (ii) yields the J log odds ratios

Ln (Pil/Pik) = zi (αl – αk) =zi αj if K = 0 ---------- (iii)

The dependent variable is, therefore, the log of one alternative relative to the base alternative.

Marginal effects are resultant to interpreting the effects of independent variables on the probabilities because of problems involved in interpreting the MNL coefficients and associating the lα with the lth outcome which can be misleading. According to Long (1997) and Green (2000 and 2003) marginal effects measures the predicted change in likelihood of a particular option in an explanatory variable concerning a unit change. This can be derived marginal effects as:

Ln (δPi/δPi) = PiΣ (α -l – Σ^{j}_{k}) = 0 $P_k\alpha_k$) = Pi (αj – α) ----------(iv)

The model is specified explicitly as

$Y = f(Z_1, Z_2, Z_3, Z_4, Z_5, Z_6, Z_7, Z_8) + e$
Where,
Y= choice of Adaptation strategies ($0 < LA < or = 1$)

Z_1 = Age of the farmer (years)
Z_2 = Farming experience (years)
Z_3 = Level of Education (Years of formal schooling)
Z_4 = Household size (Number of people feeding from the same pot)
Z_5= Access to credit (Dummy Yes= 1, No=0)
Z_6 = Farm size (hectare)
Z_7 = Contact with Extension agent (Dummy Yes =1, No=0)
Z_8 = ownership of means of transport (Dummy Yes = 1, No = 0)
E =stochastic error term.

1.6 Results and Discussion

Analysis of Trend of Cassava Production, Area harvested and Productivity in Nigeria from 1980- 2017

The trend of cassava production, Area harvested and productivity was done using estimated regression coefficient of the time trend variables presented in table1. The trend for production and area harvested of cassava exhibited a negative trend within the period under study. The trend variables' coefficient for cassava production and the harvested area was -45.15 and -43.42 respectively and significantly different from zero at 1% level. The coefficient being -45.15 and -43.42 implies that there has been a 45 and 43% decrease in cassava production and area cultivated within the period of study.

Table 1: Estimated Functions for Output, Area harvested and Productivity of Cassava in Nigeria from 1980-2017

Variables	Constant (b0)	B1	R2	R2^	F-value
output	356.73 (18.74)***	-45.15 (3.04)***	0.897	0.893	312.55***
Area harvested	299.95 (18.62)***	-43.42 (-17.38)***	0.893	0.89	301.96***
Productivity	-152.24	34.42	0.025	-0.002	0.91

Source: Output data from Stata

Note: Superscript *** denote significant levels at 1% respectively

The output of cassava produced in Nigeria experienced a decline within the period under study. The decline in cassava output over the study period could be attributed to changes in weather among other factors owing to its related increase in temperature which will as well increase the prevalence of pest and diseases. According to Hershey *et al.,* (2001) Climate variables are among the abiotic factors in yield variations in cassava production. The negatively signed coefficient for harvested area under cassava production also confirms a decrease in area harvested over the study period. The gap between the area planted and area harvested could also be due to occurrence of some extreme climate conditions like flood. The Integrated Regional Information Networks (IRIN) reported that increase of drought and floods due to higher temperature has led to greater crop yield losses in Nigeria IRIN, (2013).

1.7 Climate Change Adaptation methods used by Cassava Farmers in the location of study.

Table 2 presents the major adaptive approaches used by cassava cultivators in the study area. The result indicated that almost all households were using at least one of the adaptation methods to combat the variability in weather conditions in other to actualize the sustainability of cassava production in Nigeria. Moreover, most strategies have been into practice over decades ago, but it was observed that the use of these strategies has been on

the increase in the recent years due to incessant rains, prolonged droughts and floods incidents that have been worsened by variability in climate and weather. The major adaptation measure used by root crop farmers includes use of irrigation, mixed cropping, livestock ownership and use of improved crop variety.

Table 2: Distribution of methods Climate Change Adaptation among Cassava Farmers in Nigeria.

Adaptation Strategy	Frequency	Percentage
livestock ownership	74	53.24
Use of Irrigation	14	10
Mixed Cropping	111	79.81
Use of improved crop variety	129	92.81

Computed from field survey 2018

1.8 Climate Change Adaptation methods commonly applied by Cassava Farming Households.

Cassava farming households in the study area have applied some climate change adaptation measures in other to overcome these harsh weather conditions. The result from table 2 shows that about seventy-nine percent of farmers in the location of study practiced mixed cropping as a means of crop diversification while approximately 10% uses irrigation. Most of the farmers diversified their crops in order to spread the risks and challenges presented by changes in weather condition. The use of irrigation was the least adaptation strategy practiced by the cassava crop farmer surveyed because cassava is a drought-resistant crop and also Nigeria agricultural sector depends mainly on rain-fed subsistence agriculture (Christiansen, 2009). Ninety-two percent of the farming households grow improved crop varieties. It was reported that such improved varieties had advantages over local varieties because some of them have the ability to produce a high yield in spite of drought and floods. More than half of the household surveyed owns livestock as an alternative source of income. The ownership of livestock as a means of income generation activity acts as a source

of income to argument their earning from crop production.

1.9 Determinants of Climate Change Adaptation methods used by Cassava Farming households in Nigeria.

Table 3 presents the marginal effect from multinomial logit for the factors that influence farmers' adaptive capacity towards weather variability. This was achieved using the four adaptation methods that were commonly adopted by the cassava farming households. The three categories equated with the base outcome which is the use of improved crop variety and the three are the use of irrigation, mixed cropping, and ownership of livestock.

Table 3: Estimates of the Marginal effects from Multinomial Logit (MNL) Model for Cassava Farmers Adaptation methods to Climate Change.

Variables	Use Irrigation/use of new crop variety	Mixed cropping/ use of new crop variety	Livestock ownership/ use of new crop variety
Age	-.0008499	-.0001219	-.0052591
Farmingexp	.006783*	-.0036924	.0001446
Level of education	-.0018696	.0048912	.0111242*
Household size	-.01075	-.0025716	.0136207
Access to credit	.0357568	-.0004598	-.0029227
Farm size	.0085318	.0018297	.0078667
Contact with EA	-.0433914	.0059996	.0711699
Owns a means of transport	-.0639788	-.0330708	-.1206655*

Output result from Stata. Note * 10% significance level.

The result in table 3 indicated that marginal effect of an explanatory variable factor of farming experience was 0.007. The determinants of adaptive responses of cassava farmers studied shows the decision to adopted were influence by farming experience, level of education and ownership of transport. The result infers that for a rise in the level of acquired skill of a cassava farmer by a unit is associated with a probability of 7% being possible of using irrigation strategy relative to the use of new crop variety, given the other variables constant. Therefore, if a farmer were to have added experience increased by a point, the multinomial log-odds for

choosing irrigation as an adaptive strategy to use of improved crop variety would be anticipated to increase by 0.007 unit while all other variables are held constant. Thus, alludes to the fact that farming experience significantly influenced farmer's ability to use irrigation strategy over the use of new crop variety as an adaptive strategy. The result is in line with apriori expectation which propound farming experience as a positive and continuous variable. It was further revealed that the marginal effects for the level of education and ownership of a means of transport were 0.11 and –0.12 respectively. This result means that one unit increase in level of education and ownership of means of transport of a cassava farmer is associated with 11% more likely and 12% less likely that the farmer will adopt livestock ownership as adaptation strategy over the use of new crop variety. Additionally, if the level of education of a farmer is to increase by one unit the multinomial log – odds for preferring owing livestock to the use of improved variety would be expected to increase by about 0.11, similarly a one unit increase in ownership of transport will decrease the log-odds for preferring owing livestock to the use of improved variety by 0.12 unit. This finding is in line with Ifeanyi-Obi and Issa (2013) who noted that lack of access to improved crop variety and illiteracy can act as a barrier to climate change adaptation.

23.4 Conclusion and Recommendations

This study concludes that the trend of cassava production and area harvested of cassava exhibited a negative trend within the period under study. It also identified that the use of irrigation, mixed cropping, livestock ownership and use of improved crop variety are among the main adaptive approaches used by the cassava farming households in the location of study. The analysis further shows that the factors that influenced cassava farmers' choice of adaptation strategy to variability in climate included farming experience, level of education and ownership of transport. There is need for more educational campaign on climate adaptation strategies which will help to hearten the consciousness of cassava farmers on adaption to climate change. More so improved cassava varieties are required for sustainable cassava production and food security in Nigeria.

Commented [USER 11]: You did not effects of educational campaign on climate change! Conclude base on farmers response to climate change adaptation strategies and the implications……

Commented [J2]: Yes level of education was among the significant variables the determines adaptive strategy the farmer adopts

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