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Factors Affecting Adaptation Strategies to Climate-driven Production Changes by Cassava Farmers in Ondo State, Nigeria

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Abstract:
The study analyzed factors affecting adaptation strategies to climate-driven production changes by cassava farmers from two agro ecological zones in Ondo State. Empirical results from cross-sectional data analysed. The study found that the most important adaptation strategies identified were planting of different crop varieties, increased farm size to minimize crop failure, mixed farming, and mixed cropping. Results from multinomial log it regression revealed that farmers' education, farming experience, family size, and farmers' association membership were major factors affecting choice of climate adaptation measures. Policies and investment strategies must focus on intensifying decision support mechanisms to assist farmers in taking climate adaptation action at community level in the study area.

Keywords: *Adaptation strategies, climate-driven production, climate change and cassava farmers*

1. Introduction

Cassava is a perennial woody shrub with an edible root, which grows in tropical and subtropical areas of the world (International Institute of Tropical Agriculture, IITA, 2009). Cassava has the ability to grow on marginal lands where cereals and other crops do not grow well. It can tolerate drought and can grow in low-nutrient soils. Because cassava roots can be stored in the ground for up to 24 months, and some varieties for up to 36 months, harvest may be delayed until market, processing, or other conditions are favorable. In Africa and Latin America, cassava is mostly used for human consumption, while in Asia and parts of Latin America; it is used commercially for the production of animal feed and starch-based products. In Africa, cassava provides a basic daily source of dietary energy. Roots are processed into a wide variety of granules, pastes, flours, or consumed freshly boiled or raw. In most of the cassava-growing countries in Africa, the leaves are also consumed as a green vegetable, which provides protein and vitamins A and B (International Institute of Tropical Agriculture, IITA, 2009).

Comparing the output of various crops in Nigeria, cassava output ranks first with 34 million metric tons followed by yam production at 27 million metric tons in 2008, sorghum at 7 million metric tons, millet at 6 million metric tons and rice at 5 million metric tons. Nigeria's cassava production is by far the largest in the world, when compared to Brazil, Indonesia and Thailand (Nwaobiala and Nwosu 2014). Cassava is an important food source in the tropics and provides the third-highest carbohydrate yield among the crop plants. Since the plant grows well in poor soils and low rainfall areas, it is a popular crop in the countries of sub-Saharan Africa. Cassava tolerates a wide variety of growth conditions including soils with pH ranging from acidic to alkaline, annual rainfalls from 50 mm to 5 m, elevation between sea-level and 6,600 feet, and even equatorial temperatures. The fact that it is a perennial plant makes it easy to harvest the crop when required and treat it as a food reserve during droughts and famines. Cassava thus serves as both a cash and a subsistence crop. African nations are the most heavily dependent on root and tuber crops like cassava, yams, and sweet potatoes. In some countries of sub-Saharan Africa, cassava is even a staple or a sub-staple. In Ghana, 46% of the GDP of the country is contributed by trade in cassava. Nearly every farming family in the country grow cassava and it accounts for the daily caloric intake of at least 30% of the residents of the country(Obudule. I, 2017). The table 1, below shows the top twenty countries in the world that cultivate cassava most. Nigeria is ranked number one as shown in the table below.

Rank	Area	Production Value Chain
1	Nigeria	47,406,770
2	Thailand	30,227,542
3	Indonesia	23,936,920
4	Brazil	21,484,218
5	Angola	16,411,674
6	Ghana	15,989,940
7	Democratic Republic of the Congo	14,611,911
8	Viet Nam	9,757,681
9	Cambodia	7,572,344
10	India	7,236,600
11	Malawi	4,813,699
12	United Republic of Tanzania	4,755,160
13	Cameroon	4,596,383
14	China, mainland	4,585,000
15	Mozambique	4,303,000
16	Benin	3,910,036
17	Sierra Leone	3,810,418
18	Madagascar	3,114,578
19	Uganda	2,979,000
20	Rwanda	2,948,121

Table 1: Showing the Top 20 Countries That Cultivate Cassava in the World
Source: Nigeria Circle News, 2017

The climate of West Africa is highly variable and unpredictable and the region is prone to extreme weather conditions, including droughts and floods (Department for International Development, DFID, 2004). Climate change with expected long-term changes in rainfall patterns and shifting temperature zones are expected to have significant negative effects on agriculture, food and water security and economic growth in Africa; and increased frequency and intensity of droughts and floods is expected to negatively affect agricultural production and food security (DFID, 2004).

Adaptation decisions are therefore important to help the faming households to better face extreme weather conditions and associated climatic variations (Adger *et al*., 2003). Adaptation has the potential to significantly contribute to reductions in negative impacts from changes in climatic conditions as well as other changing socioeconomic conditions, such as volatile short-term changes in local and international markets (Kandlinkar and Risbey 2000). Therefore, an analysis of adaptation options and constraints to adaptation is important for the agricultural communities of Nigeria.

A better understanding of farmer perceptions regarding long-term climatic changes, current adaptation measures and their determinants will be important to inform policy for future successful adaptation of the agricultural sector. This study provides insights on farmers' perceptions regarding changes in climate, adaptation options and their determinants as well as barriers to adaptation.

2. Adaptation to Climate Change in Agriculture

The IPCC (2001) defines adaptation as the adjustments in ecological, social or economic systems in response to actual or expected stimuli and their effects or impacts. This term refers to changes in processes, practices and structures to moderate potential damages or to benefit from opportunities associated with climate change. Adaptations were meant to absorb short-term climate variability and extreme events and for reducing vulnerability to long-term climate change. In a developmental context, adaptation policy and measures can be assessed at different levels including the local level. In terms of national outlook, adaptation strategy for a country can mean a general plan of action for addressing the impacts of climate change which may include a mix of policies and measures, selected to meet the overarching objective of reducing the country's vulnerability.

Policy makers also need to focus on the determinants of adaptation capacity that have been suggested by (Nhemachena *et al*, 2007). As the range of available technological options for adaptation; the availability of resources and their distribution across the population; the structure of critical institutions, the derivative allocation of decision-making authority, and the decision criteria that would be employed; the stock of human capital, including education and personal security; the stock of social capital, including the definition of property rights; the system's access to risk-spreading processes, e.g., insurance. Important adaptation options in the agricultural sector include: crop diversification, mixed crop-livestock farming systems, using different crop varieties, changing planting and harvesting dates, and mixing less productive, drought-resistant varieties and high-yield water sensitive crops (Bradshaw *et al*, 2004).

2.1. Problem Statement

The general consensus is that changes in temperature and precipitation will result in changes in land and water regimes that will subsequently affect agricultural productivity. Although estimates suggest that global food production is likely to be robust, experts predict tropical regions will see both a reduction in agricultural yields and a rise in poverty levels as livelihood opportunities for many engaged in the agricultural sector become increasingly susceptible to expected climate pressures (World Bank, 2007). While contemporary policy dialogue has focused on mitigating emissions that induce climate change, there has been relatively limited discussion of policies that can address climate vulnerability, hence adaptation. In Nigeria, few studies have been carried out to address rural vulnerability to climatic changes at a local scale and farm level adaptation to the impacts. This study will enable us to bridge this gap by factors affecting adaptation strategies to climate-driven production changes by cassava farmers in Ondo State, Nigeria.

2.2. Research Questions?
- What are the common adaption strategies among the respondents in the study area?
- What are the major measures affecting the choice of adaption measure choose by the respondents in the study area?

2.3. Objectives of the Study
- Identify the adaptation strategies among rural households in the study area; and
- Assess the determinants of choice of climate adaptations measures

3. Materials and Methods

3.1. Study Area

This study was carried out in Ondo State in the Southwest part of Nigeria The State is located between latitudes 06º 42¹ and 07º 14¹ North of the equator and longitudes 05º 00¹ and 05º 32¹ East of the Greenwich Meridian. There are two distinct geographical seasons occasion by the rainy and the dry seasons. The mean annual temperature varies between 22 ºC and 32 ºC. The annual rainfall is between 800mm and 1500mm and the soil is relatively acidic but fertile with high clay content and good drainage (Ondo State Government, 2012). Ondo State has a population of 3,440,000 according to 2006 census with the land surface area of 15,500 km² (6,000 sq mi) (Ondo State Government, 2014).

3.2. Sampling Techniques

Multi-stage sampling technique was used to select respondents for this study. The first stage involved purposive sampling of tropical forest and the mangrove swamp Agro-Ecological Zones (AEZs) where cassava production is very prominent. In the second stage, Irele local government area (LGA) was randomly selected in the tropical forest while Okitipupa was randomly selected in the mangrove forest AEZ. The third stage involved random selection of four communities in each LGA which totaling eight (8) selected communities while in the fourth stage sixteen respondents were randomly selected. A total of one hundred and twenty-eight (128) respondents were sampled for the study.

3.3. Method of Data Collection

Primary data were collected on farmers' perceptions on impacts, socioeconomic profiles and adaptation strategies) were collected using a well-structured questionnaire administered to rural households. Interviews and Focus Group Discussions (FGDs) were also used to collect cross-section on perceptions and adaptations to climate changes among respondents.

3.4. Econometric Estimation: Multinomial Logit Model

The determinants of farmers' decisions on choice of adaptation options were estimated with multinomial logit (MNL) model. To describe the MNL model, let y denote a random variable taking on the values (1, 2, …*j*) for J, a positive integer and let *x* denote a set of conditioning variables. In this case, y denotes adaptation options or categories and *x* contains household characteristics such as age, education, income level, etc. The question is how *ceteris paribus* in the elements of x affect the response probabilities $P(y = J / x)$, $j = 1, 2, \ldots J$. Since the probabilities must sum to unity, $P(y = J / x)$ is determined once we know the probabilities for $j = 2, \ldots J$.

Let *x* be a 1 x *K* vector with first element unity. The MNL model has response probabilities:

$$P(y = j \mid x) = \frac{\exp(x\beta_j)}{\left[1 + \sum_{h=1}^{J} \exp(x\beta_h), \quad j = 1, \ldots . J\right]} \qquad \ldots\ldots\ldots 1$$

where β_j *is* K x1, $J = 1 \ldots\ldots J$

where β is a vector of parameters that satisfy $\log(P_{ij}/P_{ik}) = X'(\beta_j - \beta_k)$ (Greene, 2003)

Therefore, the probability that household *i* with characteristics X chooses adaptation option *j* is specify as:

$$P_{ij} = prob\ (Y=1) = \frac{e^{x'\beta}}{1+\sum_{j=1}^{j} e^{x'\beta}}, \quad j = 1, \ldots . j, \qquad \ldots\ldots\ldots 2$$

where β is a vector of parameters that satisfy $\log(P_{ij}/P_{ik}) = X'(\beta_j - \beta_k)$

To interpret the effects of independent variables on the probabilities, marginal effects are usually derived by differentiating equation 6 with respect to a unit change in an independent variable from the mean.

$$\delta_j = \frac{\partial P_j}{\partial x_i} = P_j\left[\beta_j - \sum_{k=0}^{J} P_k \beta_k\right] = P_j\left(\beta_j - \beta\right) \qquad \ldots\ldots\ldots 3$$

The marginal effects measure the expected change in probability of a particular choice being made with respect to a unit change in an independent variable. The signs of the marginal effects and respective coefficients may be different, as the former depend on the sign and magnitude of all other coefficients.

The standard form of logit model was given by;

$$Log\ [P/(1-P)] = \alpha_0 + \sum \alpha_i X_i + \varepsilon \qquad \ldots\ldots\ldots 4$$

where P = probability that the dependent variable Y = 1; (1-P) = probability that Y = 0

α's = parameters to be estimates for the independent variable

ε = the unexplained random component
X = vector of explanatory variables of farm household.

The independent variables were sex, family size, farming experience, membership of farmer's association, extension services, credit, land ownership, farmer's income, level of education, farm size and awareness of climate information while the dependent variables were increase farm size, reduced farm size, mixed farming, planting different varieties and early harvesting.

4. Results and Discussions

4.1. Socio-economic Characteristics of the Respondents

The distribution on Table 1 indicates that 60.8% of the respondents are male while 39.2% are female. This shows the dominance of male farmers in cassava farming activities than female in the study area. The production enterprise is male dominated, climate change adaptation decisions might likely be favoured and supported for action.

The distribution further shows that 42.5% of the respondents fall between 51 and 60 years and 27.5% are between 41 and 50 age brackets indicating that majority of the sampled cassava farmers are still in their productive working age with a mean of 54.65 years (although 0.8% of the respondents are less than 30 years of age and 6.7% are in 31- and 40-years brackets). Further distribution shows that 21.7% of the respondents fall between ages of 61 and 70 years. The oldest respondent is 80 years old while the youngest respondent is 25 years old. An average cassava farmer is still in his middle age and could positively influence decisions associated with climate adaptation risks. It was also showing that 54.2% of the sampled respondents have farm size less than three hectares, 39.2% of the sampled cassava farmers have farm size between four and six hectares while about 7% of the respondents have farm size above six hectares. The average farm size in the study area is 3.7 hectares. This implies that most of the respondents are smallholders, which is typical of most farmers in developing countries. This result agrees with Ajayi and Solomon (2010) that small farming holdings constitute more than 70.0% of all farming activities in Nigeria.

Experience plays a prominent role in agribusiness or farm enterprise. Table 2 further presents 39.2% have spent between 10 and 20 years in cassava production, about 40% have spent close to 30 years while 10.8% of the sampled cassava farmers have farming experience over 30 years while 3.4% have spent over 40 years in cassava production as mean of livelihood. A sampled farmer has been in farming for about 22 years on the average. It is expected that this distribution will position farmers with required experiences to accept innovations and knowledge of climate related production technologies and adaptation strategies that will enable them adjust as coping mechanisms. This is expected to enhance farmers' adaptation capacity in the study area.

Sex	**Frequency**	**Percentage**
Male Female	73 47	60.8 39.2
Total	120	100.0
Age of the Respondents (Years)	Frequency	Percentage
Less than 30 31-40 41-50 51-60 61-70 Above 70	1 8 33 51 26 1	0.8 6.7 27.5 42.5 21.7 0.8
Total	120	100.0
Mean age=54.65 years. Std dev=9.13		
Farm Size (ha)	Frequency	Percentage
Less than 1 1-3 4-6 Above 6	1 63 47 8	1.7 52.5 39.2 6.6
Total	120	100.0
Mean Farm size =3.7 hectares Std dev=2.39		
Farming Experience (years)	Frequency	Percentage
Less than 10 10-20 21-30 31-40 Above 40	9 47 47 13 4	7.4 39.2 39.2 10.8 3.4
Total	120	100.0
Mean Farming Experience =22.86 years. Std dev=10.27		

Table 2: Distribution of Respondents by Selected Socio-Economic Characteristics
Source: Field Data, 2014

4.2. Farmers' Adaptation Strategies

Table 3 presents various examples of adaptation strategies in practice in the study area. It was shown that 29.2% of the sampled cassava farmers practice shading/mulching to combat impact of extreme weather and climate events, 34.2% rely on increased farm size to minimize crop failure, 21.7% reduced their farm size while 32.5% practiced mixed farming as adaptation strategy. Further responses show that 49.2% of the respondents planted different crop varieties to adjust, 53.3% practiced mixed cropping while 77.5% of the respondents used early harvesting as their strategy to manage infestation of pest and/or disease or other forms of unfavourable weather for food crops. Some 36.7% of the respondents have being using soil amendments such as application of organic fertilizer to supplement for lost soil fertility and improve cassava yield while 25.0% of sampled cassava farmers change row orientation with respect to slope to control erosion and leaching to avoid loss of soil nutrients for the cassava tubers formation and hence lead to reduction in yield.

Adaptation Strategy	Response %
Shading /mulching	35(29.2%)
Increase farm size	41(34.2%)
Reduce farm size	26(21.7%)
Mixed farming	39(32.5%)
Planting of different varieties	59(49.2%)
Mixed cropping	64(53.3%)
Early harvesting	93(77.5%)
Apply soil amendments	44(36.7%)
Change row orientation with respect to slope	30(25.0%)

Table 3: Distribution of Respondents by Adaptation Strategies
Source: Field Data, 2014
**Multiple Responses*

4.3. Determinants of Farmers' Adaptation Decisions

The multinomial logit regression presents estimated parameters which provide only direction of the effect of the independent variables on the dependent variables as estimates do not represent actual magnitude of change or probabilities. The chi-square of 62.30 associated with the log likelihood ratio of 146.92 was significant ($p<0.05$) which suggests model with strong explanatory power.

Level of education would increase the likelihood of adapting to climate change. Household head education was positive and significantly ($p<0.05$) mixed farming option shown in Table 3. A unit increase in the number of years of education acquired would increase the probability of choosing mixed farming to adapt. It is obvious that with higher level education, farmers are more likely to access better information on production technologies and extreme climate conditions. The coefficient of farming experience was positive and significant ($p<0.05$) in choosing increase farm size as adaptation option. It then implies that increase in years spent in cassava production will increase the probability that sampled farmers will increase farm size as adaptation strategy. Long farming experience is expected to result in a higher likelihood that an individual will be better resourceful in management practices, access to productive assets and social capital that would enhance their capacity to quickly adjust to impacts of climate change.

Family size has a positive coefficient and significant ($p<0.05$). This will increase the likelihood of using mixed farming as an adaptation measure. This result is in line with Deressa *et al.* (2011) who also noticed that the probable reason for this relationship is due to the large family size which is normally associated with a higher labour endowment and this would enable a household to accomplish various agricultural tasks especially at the peak seasons.

Farmer's association significantly ($p<0.05$) increased the probability of choosing reduction in farm size as an adaptation strategy. It had positive coefficient with reduce farm size adaptation option adopted by the respondents. This implied that members of the association may have access to sharing information such as epidemic, hazard, disasters, etc. through association to reduce their farm size under cultivation to enable them minimize the damages and economic losses from climate impacts.

5. Conclusions and Policy Issues

The study showed that farmers' have been adapting to climate-driven production changes in cassava production by increasing farm size, practicing mixed farming, planting different varieties, early harvesting, soil amendment and change row orientation. However, major constraints to wider adoption include lack of information on climate methods, access to extension service and level of education. The policy drivers influencing farmers' decision-making capacity on adaptation to climate change were farming experience, farmer's association, family size and education of household heads, statistically significant in determining the adaptation strategies to climate change in the study area.

The study shows that decisions and actions to support climate adaptation strategies to reduce impact to climate changes and enhance farmers' resilience are therefore required. Government should encourage cassava farmers to engage in climate smart agriculture and cultivate crops in their agro-ecological zones that best support their production system in cassava production. These outcomes will assist decision makers, donors and government agencies in making decisions on interventions with regard to institutional supports for climate-smart developments, thereby reduce the over-arching effect of climate-driven production changes in cassava production in Ondo State, Nigeria.

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