Climate Change Effects on Household Agric-Economy and Adaptive Responses among Agricultural Households in Nigeria.

By

Akeem Olusola, AJIBOLA
PhD Candidate, Uthman Dan-fodiyo University, Sokoto, Nigeria.
And
Famine Early Warning Systems Network: FEWSNET-NIGERIA,
Abuja, Nigeria.

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ABSTRACT

Climate change is already having significant impacts in Nigeria, and these impacts are expected to increase in the future. Recent estimates suggest that, in the absence of adaptation, climate change could result in a loss of between 2% and 11% of Nigeria's GDP by 2020, further rising to between 6% and 30% by the year 2050. This can significantly stall the attainment of MDG goal on poverty and the Vision 20:2020 of the country by plunging the country economy and worsening the already aggravated poverty level. It is therefore imperative to understand the current real climate change effects on household members, vulnerability level in and across agricultural livelihoods of cropping, livestock production and agro-processing. While an ex-post analysis of adaptive responses of agricultural households will feed into the "National Adaptation Strategy and Plan of Action on Climate Change for Nigeria"- NASPA-CCN which is expected to increase the capacity of the households to adapt to future climate change effects. This work provides answers to these three challenges at household level of analysis.

This study uses Fadama III baseline data. Fadama III is a follow up to the successful Fadama II project sponsored by the World Bank with the aim of improving the livelihood condition of rural farmers through provision of improved inputs, credits and infrastructures. The data covered 9,176 households across the 36 states in Nigeria and the FCT. It was collected by Fadama project monitoring and evaluation section, IFPRI and other consultants.

The household level unit of analysis is policy driven and it conforms to the IPCC and FAO models on vulnerability analysis and Climate Change adaptation research by controlling for **'exposure', 'sensitivity' and 'adaptive capacity/socio-economic'** factors of the households. The model was expanded to include the **'agric-livelihood strategies'** of the households in order to empirically assess their vulnerability and adaptive responses. Frequency distribution and econometric modelling techniques such as Tobit and ordered Logit models were employed in the analysis.

The result shows an ageing farm labour with average age of the households head to be 45 years and the average distances to the nearest town, market and all-weathered road as 13, 8.5 and 7.5km respectively. Climate change affects largely all members of the household, men and children in that order, while the most serious climate change types are: delayed rainfall, early rainfall and less rain. Majority of the households have 'no adaptive response' to the climate change impact while very few have high adaptive response.

Households who are agriculture based: livestock and agro-processing are highly-vulnerable to climate change but those into crop production are less vulnerable than those households who are not?

1.0 Introduction

The agricultural sector is a critical mainstay of livelihoods and GDP in most African countries (Mendelsohn et al., 2000a, b; Devereux and Maxwell, 2001). The contribution of agriculture to GDP varies across countries but assessments observed an average contribution of 21% (ranging from 10 to 70%) of GDP (Mendelsohn et al., 2000b). This sector is particularly sensitive to climate, including periods of climate variability (e.g., ENSO and extended dry spells; see Usman and Reason, 2004). In many parts of Africa, farmers and pastoralists also have to contend with other extreme natural resource challenges and constraints such as poor soil fertility, pests, crop diseases, as well as lack of access to inputs and improved seeds. These problems are usually aggravated by periods of prolonged droughts and/or floods and are often particularly severe during El Nino events (Mendelsohn et al., 2000a, b; Biggs et al., 2004; International Institute of Rural Reconstruction, 2004; Vogel, 2005; Stige et al., 2006).

Agriculture's share of Nigerian GDP average is between 30 to 40 percent but it provides employment for about 70 percent of the population, majority of whom lives in the rural. This situation is similar for many African and other developing countries (Kandlinkar and Risbey 2000). Rain-fed farming dominates agricultural production in sub- Saharan Africa, accounting for 97 per cent of total cropland and exposes agricultural production to high seasonal rainfall variability (Alvaro et al. 2009).

Because agriculture in Nigeria is mostly rain-fed, it follows that any climate change is bound to impact productivity and other socio-economic activities. The impact could, however, be measured in terms of crop growth, availability of soil water, soil erosion, incidence of pest and diseases, sea level rises and decrease in soil fertility (Adejuwon 2004).

There is a growing consensus in the scientific literature that in the coming decades the world will witness higher temperatures and changing precipitation levels. The effect of this climate change will lead to low/poor agricultural products. Evidence has shown that climate change has already affecting crop yields in many countries (IPCC, 2007; Deressa *et al*, 2008; BNRCC, 2008), particularly low-income countries (SPORE, 2008; Apata *et a*l, 2009). Many African countries are particularly vulnerable to climate change (Dinar *et al*, 2006). This vulnerability has been demonstrated by recent devastating flooding in the Niger Delta region and various prolonged droughts that are currently witnessed in some parts of Northern region.

The recent assessment of Nigeria Meteorological Agency (NIMET 2008) observed that Nigeria's climate is already changing. Nigerian climate over the period 1941 to 2000 has demonstrated the following changes:

Rainfall: Compared to previous periods, during the period from 1971 to 2000 the combination of late onset and early cessation shortened the length of the rainy season in most parts of the country. Between 1941 and 2000, annual rainfall decreased by 2-8 mm across most of the country, but increased by 2-4 mm in a few places (e.g. Port Harcourt).

Temperature: From 1941 to 2000 there was evidence of long-term temperature increase in most parts of the country. The main exception was in the Jos area, where a slight cooling was recorded. The most significant increases were recorded in the extreme northeast, northwest and southwest, where average temperatures rose by 1.4-1.9^{o}C.

Expected Climate Change: The Federal Ministry of Environment in 2011 predicted future climate change in the country using simulations from the climate change scenarios.

On the temperature, the scenarios suggest a warmer climate in the future, a temperature increase of 0.04°C per year from now until the 2046-2065 period, rising to 0.08°C per year after 2050. However, regional variations are expected, with the highest increase (4.5°C by 2081-2100) projected in the northeast. For rainfall, the projected changes in rainfall vary across the country, with the scenario suggesting a wetter climate in the south, but a drier climate in the northeast. For the 2046-2065 period the projected change ranges from an average increase of 15 cm annually in the south to an average decrease of 7.5 cm annually in the north. Although projected annual rainfall increases in some parts of the country and decreases in others, all areas show increases in rainfall during at least some part of the year.

A summary of the projected trends in the key climate change parameters for Nigeria is presented in the following table, by ecological zone (FME: NASPA-CCN, 2011):

Table 1: Projected changes in Nigeria climate change parameters.

Climate variables	**Mangrove zone**	**Rain-forest zone**	**Savannah**	**Sahel**
Temperature	↑	↑	↑	↑
Rainfall amount	↑	↑	↓	↓
Rainfall variability	↑	↑	↑	↑
Droughts effect	Likely	Likely	↑	↑
Storms and floods effect	↑	↑	Likely	Likely
Sea-level rise	↑	N/A	N/A	N/A

Legend: ↑ Likely increase or increase, ↓ Likely decrease or decrease, N/A Not applicable.

Having established the fact that climate is actually changing in Nigeria and such changes will continue into the future, it is important to understand how climate change will affect Nigerian Agricultural households, their vulnerability and the nature and factors driving their adaptive responses. We note that to a large extent, it is the poorest people (mostly agricultural households) in developing countries that are going to be worst affected as they are heavily dependent on climate sensitive sectors (Nanda 2009).

Several studies have been conducted in Nigeria on climate change (Ayinde et al, 2011; Apata, 2011; Onyenekwe and Madueke, 2010; Falola et al, 2012, Adesina and Odekunle, 2011; Madu, 2012 and others) but most of these studies focus on specific aspects, agricultural productivity, adaptation measures and determination of mitigation approaches. A major shortfall of these studies is their regional nature, their use of few observations at household level, and the adoption of an ex-ante simulation approach with secondary data with unreliable assumptions. More work on effects, vulnerability and adaptations is however needed, particularly at the national scale (UNFCCC, 2006). Rishi, Omprakash and Mudaliar (2010**)** have shown that there is a pressing need to address issues related to climate change adaptation, vulnerability and coping at the national level, in developing nations as these regions has the largest deficiencies in adaptive capacity.

This paper will contribute to the growing literature on this topic by addressing the three important issues: *effects, vulnerability and adaptation* to climate changes in the same study using household level data. It also disaggregates agricultural households into the sub-sectors: crop production, livestock production, fisheries and agro-processing, etc.

The agricultural households were dis-aggregated based on the question that asked about the primary occupation of the household members in the instrument used for the survey. The effects were also measured based on the response to direct question that asked about the specific effect of each climate change factor mentioned and on which member of the household.

Vulnerability was assessed in the form of hazard-loss approach captured through the question that asked about amount of income loss due to climate change by the respondents. We address adaptation through the use of climate change adaptation index (CCAI) by categorizing the households into none, low, average and high adaptation capacity based on the number of actionable steps taken by the household to counter the climate change impacts.

The remainder of this paper is organized as follows. Section 2 reviews the literature on Climate Change and methodologies employed in the analyses that are relevant for this study. Section 3 presents the conceptual framework developed to analyze the effects, vulnerability and adaptive responses of Nigerian agricultural households to climate Change. Section 4 discusses the data. Section 5 presents the results and discussion, and Section 6 concludes the paper.

2.0 Review of literature

Several conceptual approaches and methodologies have been employed to measure vulnerability to climate change. We review some of these studies. On this, we will be relying on the ingenious contributions of Hoddinont and Quisumbing, 2003 and Temesgen et al, 2008 on risks and vulnerability assessment, as a guide.

2.1 Definition of terms.

In order to provide an understanding of the model variables and methodology adopted in this study, we will provide an operational definition of terms for each of the concepts in the study and thereafter discuss the variables that form a vector representative or indicator of each of the concept. Kasperson, et al. (2002) defines as follows:

Exposure: The contact between a system, or system component, and a perturbation or stress. Exposure is a function of both the magnitude and scope of the perturbation, and of the system with which it comes into contact (e.g., its location). **Exposure unit** means any system or part of a system that comes into contact with a perturbation or stress. In practice these units include individuals, groups, economic sectors, places, and various parts of ecosystems. For this study, the exposure units are: crop production, livestock production, fishery production and agro-processing households.

Sensitivity: The extent to which a system or its components are likely to experience changes, harm or stress due to an exposure to perturbations or stress. In the case of this study, it is changes in rainfall and temperature pattern that expose the agricultural households to vulnerability.

Vulnerability: The degree to which an exposure unit is susceptible to harm due to exposure to a perturbation or stress, and the ability (or lack thereof) of the exposure unit to cope, recover, or fundamentally adapt (become a new system or become extinct).

2.2 Conceptual approaches to vulnerability studies

There are three major conceptual approaches to analyzing vulnerability to climate change (Temesgen et al, 2008): the Socioeconomic, the Biophysical (impact assessment), and the Integrated assessment approaches.

Socioeconomic Approach

The socioeconomic vulnerability assessment approach emphasises changes in the socioeconomic status of individuals or groups (Adger 1999; Füssel 2007). Individuals in a community often vary in characteristics. These variations are responsible for the varying vulnerability levels. In this case, vulnerability is considered to be an entry point to climate change crisis that exists within a system before it encounters a hazard event (Kelly and Adger 2000). In general, the socioeconomic approach focuses on identifying the adaptive capacity of individuals or communities based on their internal characteristics. Adger and Kelly (1999) is an example of this approach. The main limitation of the socioeconomic approach is that it focuses only on variations within society (i.e., differences among individuals or social groups). In reality, societies vary not only due to socio-political factors but also to environmental and other factors. Social groups having similar socioeconomic characteristics but different environmental attributes can have different levels of vulnerability and vice versa. In general, this method overlooks—or takes as exogenous—the environment-based intensities, frequencies, and probabilities of environmental shocks, such as drought and flood. It also does not account for the natural resource base to potentially counteract the negative impacts of these environmental shocks—for example, areas with easily accessible underground water can better cope with drought by utilizing this resource.

Biophysical Approach
The biophysical approach assesses the level of damage that a given environmental stress causes on both social and biological systems. For instance, the monetary impact of climate change on agriculture can be measured by modelling the relationships between climatic variables and farm income (Mendelsohn, Nordhaus, and Shaw 1994; Polsky and Esterling, 2001; Sanghi, Mendelsohn, and Dinar 1998). Similarly, the yield impacts of climate change can be analyzed by modelling the relationships between crop yields and climatic variables (Adams 1989; Kaiser et al. 1993; Olsen, Bocher, and Jensen 2000). Other related impact assessment studies include the impact of climate change on human mortality and health terms (Martens et al. 1999), on food and water availability (Du Toit, Prinsloo, and Marthinus 2001; Food and Agriculture Organization [FAO] 2005; Xiao et al. 2002), and on ecosystem damage (Forner 2006; Villers-Ruiz and Trejo-Vázquez 1997). The damage is most often estimated by taking forecasts or estimates from climate prediction models. Füssel (2007) identified this approach as a *risk-hazard approach* and denoted the vulnerability relationship as a hazard-loss relationship in natural hazard research, a dose-response or exposure-effect relationship in epidemiology, and a damage function in macroeconomics. Kelly and Adger (2000) refer to the biophysical approach as an *end-point analysis* responding to research questions such as, "What is the extent of the climate change problem?" and "Do the costs of climate change exceed the costs of greenhouse gas mitigation?"

In general, the biophysical approach focuses on sensitivity (change in yield, income, health) to climate change and misses much of the adaptive capacity of individuals or social groups, which is more explained by their inherent characteristics.

The Integrated Assessment Approach
The integrated assessment approach combines both socioeconomic and biophysical approaches to determine vulnerability. The hazard-of-place model (Cutter, Mitchell, and Scott 2000) is a good example of this approach, in which both biophysical and socioeconomic factors are systematically combined to determine vulnerability. The vulnerability mapping approach (O'Brien et al. 2004) is the other related example, in which both socioeconomic and biophysical factors are combined to indicate the level of vulnerability through mapping.

Füssel (2007) and Füssel and Klein (2006) argued that the Inter-governmental Panel on Climate Change (IPCC, 2001) definition—which conceptualizes vulnerability to climate as a function of adaptive capacity, sensitivity, and exposure—accommodates the integrated approach to vulnerability analysis. According to Füssel and Klein (2006), the risk-hazard framework (biophysical approach) corresponds most closely to sensitivity in the IPCC terminology. Adaptive capacity (broader social development) is largely consistent with the socioeconomic approach (Füssel 2007). In the IPCC framework, exposure has an external dimension, whereas both sensitivity and adaptive capacity have internal dimension, which is implicitly assumed in the integrated vulnerability assessment framework (Füssel 2007).

Even though the integrated assessment approach corrects the weaknesses of the other approaches, it has its limitations. The main limitation is that there is no standard method for combining the biophysical and socioeconomic indicators. This approach uses different data sets, ranging from socioeconomic data sets (e.g., race and age structures of households) to biophysical factors (e.g., frequencies of earthquakes); these data sets certainly have different and yet unknown weights. Despite its weaknesses, however, this approach has much to offer in terms of policy decisions (Temesgen et al, 2008) than the other two. Thus, we adopt this approach to analyse the vulnerability of Nigerian agricultural households to climate change.

2.3 Measuring Vulnerability to Climate Change

There are several methods for analyzing vulnerability to climate change however we discuss the two methods usually employed in the vulnerability literature—namely, the econometric and indicator methods.

Econometric Method

The econometric method is similar to the poverty and development literature. It uses household-level socioeconomic survey data to analyze the level of vulnerability of different social groups. The method is divided into three categories: Vulnerability as expected poverty (VEP), Vulnerability as low expected utility (VEU), and Vulnerability as uninsured exposure to risk (VER) (Hoddinott and Quisumbing 2003). All three share common characteristics in that they construct a measure of welfare loss attributed to shocks.

Vulnerability as Expected Poverty (VEP)

In the expected poverty framework, vulnerability of a person is conceived as the prospect of that person becoming poor in the future if currently not poor or the prospect of that person continuing to be poor if currently poor (Christiaensen and Subbarao, 2004). Thus, vulnerability is seen as expected poverty, and consumption (income) is used as a proxy for well-being. This method is based on estimating the probability that a given shock, or set of shocks, moves consumption by households below a given minimum level (e.g., consumption poverty line) or forces the consumption level to stay below the given minimum requirement if it is already below that level (Chaudhuri, Jalan, and Suryahadi 2002).

One of the disadvantages of this method is that if estimation is based on a single cross section, one must make a strong assumption that cross-sectional variability captures temporal variability (Hoddinott and Quisumbing, 2003).

Vulnerability as a Low Expected Utility (VEU)

Ligon and Schechter (2002, 2003) defined vulnerability as the difference between the utility derived from some level of certainty-equivalent consumption at and above which the household would not be considered vulnerable and the expected utility of consumption. Ligon and Schechter (2003) applied this method to a panel data set from Bulgaria in 1994 and found that poverty and risk play roughly equal roles in reducing welfare. The disadvantage of this method is that it is difficult to account for an individual’s risk preference, given that individuals are ill informed about their preferences, especially those related to uncertain events (Kanbur 1987).

Vulnerability as Uninsured Exposure to Risk (VER)
The VER method is based on ex post facto assessment of the extent to which a negative shock causes welfare loss (Hoddinott and Quisumbing 2003). In this method, the impact of shocks is assessed by using panel data to quantify the change in induced consumption. Skoufias (2003) employed this approach to analyze the impact of shocks on Russia. In the absence of risk-management tools, shocks impose a welfare loss that is materialized through reduction in consumption. The amount of loss incurred due to shocks equals the amount paid as insurance to keep a household as well off as before any shock occurs. The disadvantage of this method is that in the absence of panel data sets, estimates of impacts—especially from cross-sectional data—are often biased and thus inconclusive.

Indicator Method
The indicator method of quantifying vulnerability is based on selecting some indicators from the whole set of potential indicators and then systematically combining the selected indicators to indicate the levels of vulnerability.

Two options are available for calculating the level of vulnerability using this method at any scale. The first is assuming that all indicators of vulnerability have equal importance and thus giving them equal weights (Cutter, Mitchell, and Scott 2000). The second method is assigning different weights to avoid the uncertainty of equal weighting given the diversity of indicators used. Some of the approaches often used in assigning weights include expert judgment (Kaly and Pratt 2000; Kaly et al. 1999), principal component analysis (Easter 1999; Cutter, Boruff, and Shirley 2003), correlation with past disaster events (Brooks, Adger, and Kelly 2005), and use of fuzzy logic (Eakin and Tapia 2008). Even though this method attempts to give weights, their appropriateness is still dubious; because there is no standard weighting method against which each method is tested for precision.

2.4 Overview of climate change studies in Nigeria.

There has been several research works on climate change in Nigeria which capture several concepts using plausible methodologies.

Several scholars have confirmed the incidence of climate change in Nigeria. Adesina and Odekunle (2011) ascribed the climate change impact to the variability in rainfall and temperature regimes. They further identified a weak resilience to climate change in the Sudan-Sahel zone of the country declaring the North-East and the North-West zones as the most vulnerable zone, while South-West and South-East zones are the least vulnerable. It was concluded that climate change is real and happening in Nigeria from their findings.

Agricultural impact of climate change in Nigeria is uncertain (Apata, 2012). The paper is however very quick to observe a positive impact in the south but negative impact in the north. At aggregate level, he found a reduction of 178.37 percent in food production in the country with the North-West as the highest danger zone, while the south experiences marginal positive contribution except South-East that experienced a reduction of about 9.09 percent in food production. This is similar to Madu (2012) findings that northern states are more vulnerable because of greater exposure to climate induced environmental hazards and low adaptive capacity (inadequate health-care, educational status, poor infrastructure and local economies). Using Principal Component Analysis, he identified states with low vulnerability (Lagos, Imo, Anambra, Abia and FCT) and those states that are most vulnerable (Jigawa, Bauchi, Adamawa, Sokoto and Gombe). He summed up that infrastructure, technology adoption and diversification of economic activities are key to reducing climate change vulnerability.

Ayinde et al, 2011 used a Co-integration model approach on time-series data from 1980 to 2000 to estimate the effect of climate change on agricultural productivity in Nigeria. The study shows the negative climate change trends and also have negative effects on Nigerian agriculture. It revealed that heavy rainfall of the previous year could lead to erosion and leaching, while rainfall variability affects agric production, temperature variability seems not to have important effects on agricultural productivity in Nigeria economy.

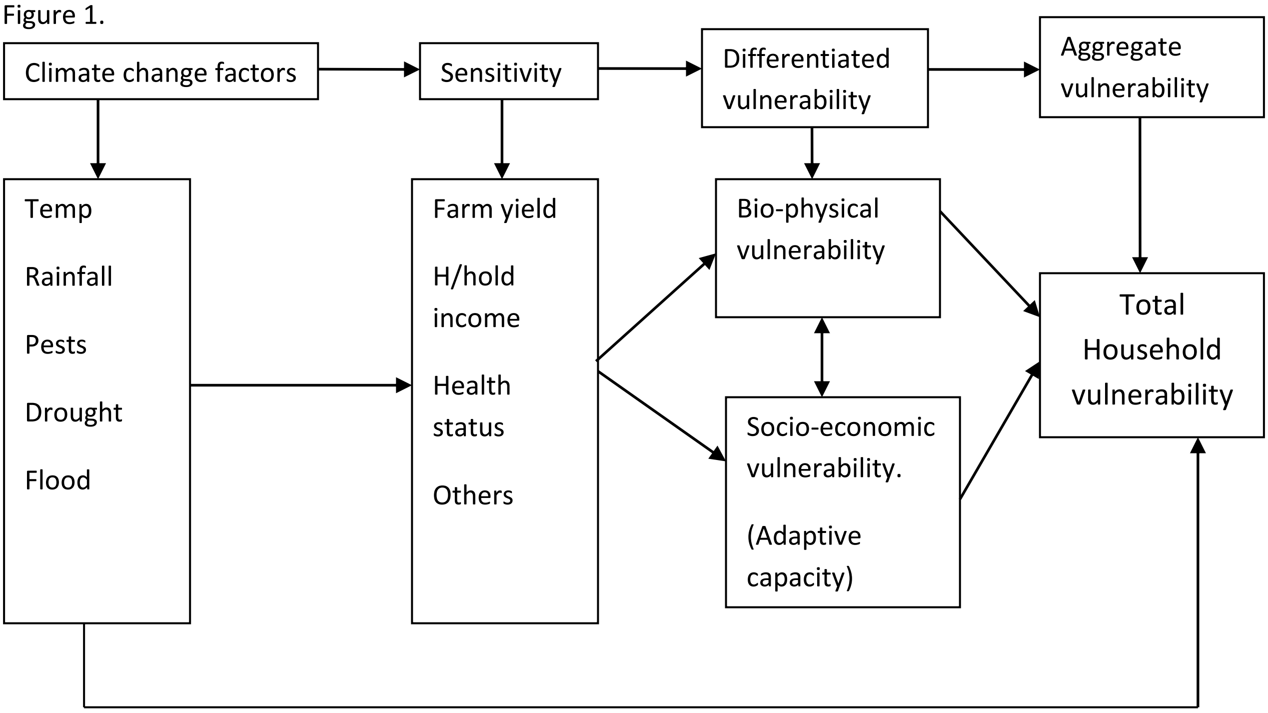
Using annual data for 34 countries from 1961 to 2009, Odusola and Abidoye (2012) found a negative impact of climate change on economic growth in Africa. Their results show that a 1 degree Celsius increase in temperature reduces GDP growth by 0.27 percentage point for the region. A higher impact of 0.41 percentage point was however observed when the sample period was reduced to 1961 to 2000 indicating a reduction in the influence possibly given increase in efforts towards adapting to climate change. The two largest economies in the Sub-Saharan Africa (South Africa and Nigeria) played some significant role in ameliorating the negative economic impact of climate change in the region.

Falola et al. (2012) observed that Nigeria loses about $750 million annually to the depletion of its 350,000 hectares of land by direct human activities and climate change. While identifying appreciable efforts by the households to mitigate the effect, it also unravelled the factors that positively influence households into taking mitigation steps as: household size, educational status and farming experience of the household heads.

3.0 Conceptual framework

The degree of vulnerability or adaptation of a system is a function of character, magnitude and variations to which the system is exposed, the sensitivity and its adaptive capacity (IPCC, 2001). This reflects an integrated approach to vulnerability and will form the basis of the conceptual framework for this study; this prioritizes the bio-physical and socio-economic characteristics of the household in the assessment of their vulnerability. The figure below presents the conceptual framework for this study which is a modification of frameworks adopted by Adger, 1999, Kelly and Adger, 2000 and IPCC, 2007.

Figure 1.



The figure above provides a clear perception of the vulnerabilities of ecological, economic and social systems within a country. The IPCC Third Assessment Report (TAR) defined vulnerability as the degree, to which a system is susceptible to, or unable to cope with adverse effects of climate change, including climate variability and extremes.

Three main elements which form the basis of any vulnerability assessment are mutually exclusive. They include the *exposure* of a system to climate variations, its s*ensitivity* and *adaptive capacity* (IPCC, 2007).

Exposure is the degree of climate stress to which a particular unit or system is exposed. The stress could be changes in climate conditions or variability in climatic behaviour including the magnitude and frequency of extreme events. In the case of agriculture, the less dependent an agriculture system is on climate the less exposed it is. Thus a well irrigated faming system will be less exposed to drought than a rain-fed system since its immediate source of water is not necessarily rainfall. It should be noted that the efficiency of the irrigation method in use will influence the vulnerability of the irrigation system itself. A system where the surface method of irrigation is dominant is more exposed than one with the drip method because drip is more efficient than the surface type.

Sensitivity is the degree to which a system is affected, adversely or otherwise, by climate-related stimuli. It is the degree to which a system is influenced or affected by an internal or external disturbance or set of disturbances. This measure is influenced by both socioeconomic and ecological (bio-physical) conditions and determines the degree to which a system will be affected by environmental stress.

Adaptability is the degree to which adjustments or modifications are possible in practices, processes, or structures of systems to anticipated or actual changes of climate. It is a measure of the resilience or resistance to negative climatic stimuli as well as the coping capacity of a community or nation. Coping capacity is usually considered as a sub-system under adaptation. It refers to the degree to which systems or practices can be adjusted or modified to respond to changing conditions.

Adaptation is influenced by the quality of the *resistance* and *resilience* of a system. It is also affected by the *readiness* of a given system to act on the potential opportunities for adaptation. Systems that are resilient are able to return to a steady state after a period of perturbation.

Our conceptual framework in figure 1 indicates that when an agricultural household (crop production, livestock production, fisheries and agro processing) is *exposed* to climate change factors or stimuli, it then becomes *sensitive* to such crises as decrease farm yield, low income, low health status, etc. The level of degeneration in the *sensitivity* will be determined by factors such as the environment and the socio-economic characteristics of the household: the environment (*bio-physical*) either aggravate its sensitivity thereby increasing the vulnerability or otherwise reduce the negative impact, while the *socio-economic* condition of the household will determine how well and effective it can resist the vulnerable condition (*adaptive capacity*). It is the sum total of the two factors (*bio-physical and socio-economic*) that determines the aggregate or total household vulnerability of the agricultural household. In short, the climate factors or stimuli as a result of their immediate and future changes continue to make the agricultural households vulnerable.

4.0 Data sources, Model specifications, Variables and Data analysis.

4.1 Data sources

This study uses Fadama III baseline data. Fadama III is a follow up to the successful Fadama II project sponsored by the World Bank with the aim of improving the livelihood condition of rural farmers through provision of improved inputs, credits and infrastructures. The data covered 9,176 households across the 36 states in Nigeria and the Federal Capital Territory (FCT). It was collected by Fadama project monitoring and evaluation section, IFPRI and other consultants.

4.2 Model specifications

The model for this study (vulnerability) is captured through integrated approach to vulnerability using econometric method of 'vulnerability as exposure to uninsured risk'. The model is a variant of vulnerability to shocks (as stated by Hoddinot and Quisumbing, 2003 and Tesliuc and Lindert, 2002) as shown in the equation below:

$$lnC_{hv} = \alpha + \Sigma_i \lambda_i S(i)_v + \Sigma_i \beta_i S(i)_{hv} + \delta X_{hv} + \varepsilon_{hv} \dots\dots\dots\dots\dots\dots (1)$$

Where lnC_{hv} is the log of consumption loss per household (household *h* residing in state *v*) which was captured in this work by log of income loss due to climate change. Taking the natural log of this income loss controls for potential differences in inflation rate across different states since the data is countrywide.

$S(i)_v$ and $S(i)_{hv}$ represent the covariant shocks of the community and the idiosyncratic shocks of the agricultural households respectively as expressed by the households. The covariant shocks is expressed in terms of sensitivity to climate change scenarios in the form of observed change in rainfall and temperature patterns, while the idiosyncratic shocks capture the exposure of households to shocks in different agric sub-sectors like cropping, livestock production, fisheries, agro-processing, etc.

δX_{hv} in equation 1 captures the fixed household characteristics as depicted in the socio-economic information of the respondents.

It should be noted that if there are no shocks to the household as depicted in equation 1, the income loss equation will be of the form:

$$lnC_{hv} = \alpha + \delta X_{hv} + \varepsilon_{hv} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.. (2)$$

The impact of the shocks (covariant and idiosyncratic) will be the difference between equation 1 and 2. Put another way, if the shocks were to be fully insured against, then λ and β would equal zero.

Due to the cross-sectional nature of the data, it is assumed that the standard deviation of the income loss due to climate change as obtained in the data implies that cross sectional variability proxies inter-temporal variation.

The model estimated to capture the adaptation level of households response to climate change challenges is as follow:

$$R_{hv} = \Sigma_v \delta_v (D_v) + \Sigma_i \beta_i S(i)_{hv} + \gamma X_{hv} + \varepsilon_{hv} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.. (3)$$

In the equation above, R_{hv} represents the adaptive response level of the household which is ordered in the sense that those who took the maximum 3 steps allowed in the instrument in combating the climate change challenge have “high adaptive response”, those who took 2 steps were classified as “average adaptive response”, those who only took 1 step are categorised as “low adaptive response” and those with score zero as “No adaptive response” households. D_v represents the idiosyncratic shocks vector of changes in rainfall and temperature while $S(i)_{hv}$ and γX_{hv} means the same things as detailed in equation 2.

4.3 Variables and Data analysis.

The variables in the analysis are as presented in Appendix 1. Each of the variables serving as indicator has been classified into respective conceptual class to enhance policy direction.

We tested for the endogeneity in the model (equation 1) and both “Robust score chi2” and “Robust regression F” value of 49.3339 and 49.8223 were significant with p-values of 0.0000 each. This necessitated the use of “researchpart” i.e. participation in research and extension activities by the farmers as instrument for education. Since it is highly probable that those who are educated will take part in extension activities.

To ensure appropriateness of instrument, we also tested for the strength of the instrument used through the first stage regression statistics and the F-value of 44.63 which far exceeds the minimum value of 10 required shows that our instrument “researchpart” is strong enough and adequate.

For the vulnerability analysis, due to the “endogeneity problem noted above, we employ the use of Instrumental Variable Regression (IVR) analysis chosen the option of 2 Stage Least Square (2SLS) methods in order to take care of endogeneity problems and measurement error in equation 1.

In the case of adaptation level response, Ordered Logit of the ordinal response regression model was performed as in equation 2.

4.3.1 Climate change effects

The result of the climate change as it affects the household members (Table 2) shows that all members of the household were being affected in more than 80 percent of the population, followed by 7 percent of the household where the children of less than 15 years were affected, men, elderly and women followed in that order. The table 2 below gives a matrix of the climate change types and the household members that each of these factors affected. The alphabets in superscripts represent the ranking of the climate change types and its impact on the household members in decreasing order. We note that the most potent climate change type that affects the household is delayed rainfall, followed by less rain, drought, etc.

In Table 3, we present a detail outlook of the negative consequences of each of the factors and the dispersion of its impacts among the household members. It is evident from both Tables 2 and 3 that climate change poses great danger to all household members.

Table2: Climate change effects on household members.

Household members affected						
Clim-change type	Children (<15)	Women	Men	Elderly	All members of HH	**TOTAL**
Frequent drought	9.6	1.91	4.21	3.36	80.92	**16.09[c]**
Delayed rainfall	6.11	1.41	5.01	4.76	82.72	**29.29[a]**
Early rainfall	4.44	1.87	5.87	6.04	81.78	**3.36[g]**
Erratic rainfall	5.05	2.13	4.33	6.02	82.46	**9.51[f]**
Hailstorm	7.29	2.43	3.64	6.48	80.16	**0.74[h]**
Too much rainfall	10.22	4.42	14.30	5.72	65.34	**12.14[d]**
Less rainfall	5.83	1.57	4.97	3.39	84.24	**18.02[b]**
High temperature	7.39	1.38	4.54	3.53	83.15	**10.57[e]**
Others	5.32	3.19	6.38	1.06	84.04	**0.28[i]**
TOTAL	**7.11[b]**	**1.98[e]**	**5.91[c]**	**4.44[d]**	**80.57[a]**	**100**

Source: Calculated by the author from FADAMA III data (Values are percentages & a – e are ranking)

4.3.2 Climate change factors and effects on household members

From table 2, it is evident that the major stimuli of climate change affecting agricultural households in Nigeria is heavily skewed towards rainfall and temperature since most of the identified changes are mainly drought or flood related. Also the fact that virtually all the members of the households were been affected most often (consistently higher than 80 percent) is an indicator that climate change poses a great threat to the poor households. Its impact on the children and men in that order is another factor that may undermine the availability of essential household unpaid labour, which usually characterise the labour input of farming household in Africa.

For table 3, under the Climate change result: 1 is decline in crop yield, 2 is decline in livestock productivity, 3 is death of livestock, 4 is food shortage and insecurity and 5 is food price increase.

Children under 15 years

The table reveals that for the children (under 15 years of age), the three most serious climate change problems are: hailstorm that resulted in death of livestock (28.57%), hailstorm that causes death of livestock (21.43%) and frequent drought that result in death of livestock (22.03%). This is plausible as the children at this stage need a lot of protein.

Women

For women, hailstorm that causes decline in livestock productivity is the most serious issue (21.43%) followed by frequent drought resulting in death of livestock (12.71%) and then early rainfall which led to decline in livestock productivity (6.67%). This is another pointer to the problem of nutritional security in developing countries where protein deficiency is of priority.

Men

In the case of men: too much rain which results in both decline in livestock productivity (29.21%) and food shortage/insecurity (14.16%) as well as early rainfall that leads to food shortage (9.55%) are the most serious threats. For the elderly, early rainfall that decreases livestock productivity (30%), erratic rainfall causing death of livestock (21.8%) and hailstorm that cause food shortage and insecurity (15.56%) are the climate change threats. This result also stems from the fact that provision of food for the family is the main concern or responsibility of the men and the elderly in the family, it also reinforced the fact that climate changes seriously creates set-back for food security of the households.

All members
For all the household members, the most serious climate change effects are: early rainfall resulting in food price increase (93.98%), less rain resulting in death of livestock (93.49%) and erratic rainfall that leads to food price increase (90.07%). Once again, this emphasises that the major set-backs of climate changes is both food security and nutritional security (protein).

From the above, it is evident that the consequences of climate change factors most often affect all the household members, while it also affects the men, the elderly and the children. This will definitely impaired the agricultural labour supply of the households as well as the non-farm enterprises that usually accompany the household revenue base. The direct implications of this will be food insecurity and low income which will lead to a decline in welfare and standard of living.

4.3.3 Climate change effects and Nigeria Agricultural sector outlook

Decline in crop yield
It is the crop production that contributes most to the agricultural sector growth in Nigeria. We therefore attempt to discover the climate change factors that mostly causes decline in crop yield as it affects all members of household. We observed that early rainfall (86.4%), delayed rainfall (84.86%) and more frequent drought (84.27%) are the major factors that causes decline in crop yield. This is an indication that Nigerian agriculture is still mainly rain-fed and will thus be subjected to the vagaries of climate changes in terms of yield and productivity.

Decline in livestock production
Livestock production comes next to crop production in Nigeria agriculture, making its increased productivity a viable option of reviving the sector in Nigeria. We found higher temperatures (84.33%), less rain (79.49%) and erratic rainfall (72.5%) to be the climate challenges causing the decline in livestock productivity. As such climate change creates an unfavourable environment that is not suited to the well thriving of the livestock in Nigeria.

Death of livestock
Climate change factors that cause high mortality in the livestock industry are: less rain (93.49%), too much rain (84.86%) and early rainfall (85.11%). It can therefore be hypothesised that rainfall is an important factor to the survival of livestock sector in Nigeria agriculture.

The well documented relationship between climate factors and disease incidence lay more credence to this result. While increased temperature will affects the physiological development of the animals thereby inhibiting the productivity, too much rainfall can easily provide a platform for the survival of pathogenic organisms that can cause high mortality.

Food shortage or insecurity
Food security is a primary objective of every household and thereafter leading to national food self-sufficiency and exports. We also explore the climatic factors mitigate against achieving food security for all household members. The factors are: more frequent drought (87.96%), higher temperatures (87.34%) and less rain (84.46%). Once again, this is another pointer to the fact that in as much as farmers in Nigeria relied heavily on rain-fed farming, the challenges of food insecurity both at the household and national level may take a longer time to be conquered. As clearly evident, the environment is getting drier and the rain is not forth-coming as the farmers are used to which seriously affects the farm outputs and subject the agricultural households to food insecurity. In a

country with more than 60 percent of the population being engaged in farming, definitely this will lead to net food insecurity at the national level. This should not be viewed in the microscope of production alone; it is also related to effect of climate changes on the storage of the farm products. Considering the poverty status of the agricultural households in developing countries, it is ordinarily plausible to assume that most of the households may not be able to acquire such technologies that will ensure the proper storage of their outputs. However, several studies have also identified post-harvest losses as one of the major problems facing agriculture in the developing countries.

Food price increase

Food price increase which is also an indicator of food insecurity is very important as it disallows poor household access to adequate food, thus it is an important component of agricultural policies for every nation. Climate factors that cause this among Nigeria farming households are early rainfall (93.98%), erratic rainfall (90.07%) and hailstorm (84.38%).

Since Nigeria is rain-fed based agriculture, it is not surprising that we observe the results above for the food shortage or insecurity as well as food price increase. If the food staples are not available in the market or are very scarce due to climate challenges, definitely the prices of the staples will also go up vis-à-vis the economic law of demand and supply with respect to price movement. Therefore it is also rationale to confirm that the climate factors responsible for the two anomies are related in terms of drought (temperature) and rainfall.

Table 3: Climate change results and impacts on household members.

CC factors	CC result	Household members affected					TOTAL
		Children(<15)	Women	Men	Elderly	All	
More frequent drought	1	8.43	0.89	3.52	2.89	84.27	100
	2	13.3	3.32	9.21	5.88	68.29	100
	3	22.03	12.71	7.63	3.39	54.24	100
	4	6.39	1.47	2.46	1.72	87.96	100
	5	14.70	5.73	5.02	5.38	69.18	100
	Sub-total	9.29	1.65	4.04	3.17	81.84	100
Delayed rainfall	1	6.17	1.18	4.61	3.18	84.86	100
	2	8.99	2.66	4.33	13.81	70.22	100
	3	4.08	4.08	2.04	6.12	83.67	100
	4	4.02	0.43	6.33	7.78	81.44	100
	5	4.23	0.44	7.45	4.09	83.80	100
	Sub-total	5.91	1.19	4.95	4.54	83.42	100
Early rainfall	1	3.09	1.24	5.72	3.55	86.40	100
	2	0	6.67	0	30.00	63.33	100
	3	8.51	0.71	4.26	1.42	85.11	100
	4	7.08	0	14.16	13.27	65.49	100
	5	2.41	0	1.20	2.41	93.98	100
	Sub-total	4.14	1.08	5.92	5.03	83.83	100
Erratic rainfall	1	4.54	1.46	5.35	5.30	83.35	100
	2	16.67	2.50	8.33	0	72.50	100
	3	8.27	4.51	6.02	21.80	59.40	100
	4	1.56	2.23	1.56	10.91	83.74	100
	5	3.08	3.08	1.37	2.40	90.07	100
	Sub-total	4.60	1.92	4.54	6.38	82.56	100
Hailstorm	1	10.42	2.08	2.08	12.50	72.92	100
	2	21.43	21.43	0	0.0	57.14	100
	3	28.57	0	0	0.0	71.43	100
	4	8.89	0	2.22	15.56	73.33	100
	5	1.56	3.13	9.38	1.56	84.38	100
	Sub-total	9.19	3.24	4.32	7.57	75.68	100
Too much rain	1	13.90	5.43	6.0	6.66	68.02	100
	2	7.22	3.78	29.21	0.69	59.11	100
	3	4.42	0.63	5.68	4.42	84.86	100
	4	5.73	2.55	9.55	2.23	79.94	100
	5	7.32	4.14	8.60	9.87	70.06	100
	Sub-total	11.03	4.44	8.57	5.81	70.15	100
Less rain	1	5.89	1.32	5.69	3.33	83.77	100
	2	10.26	1.03	6.67	2.56	79.49	100
	3	2.79	0	3.26	0.47	93.49	100
	4	4.97	1.66	2.80	6.11	84.46	100
	5	6.69	3.11	4.98	2.33	82.89	100
	Sub-total	5.86	1.53	5.05	3.56	84.01	100
Higher temperatures	1	7.31	0.52	4.18	4.31	83.68	100
	2	9.97	1.42	2.28	1.99	84.33	100
	3	12.09	0	6.32	2.20	79.40	100
	4	2.56	2.40	3.85	3.85	87.34	100
	5	6.62	4.66	5.88	1.96	80.88	100
	Sub-total	7.14	1.43	4.36	3.45	83.62	100
Others	1	4.76	0	14.29	0.0	80.95	100
	2	0	0	0	0.0	100	100
	3	0	0	0	0.0	100	100
	4	0	0	0	0.0	0	100
	5	0	0	0	0.0	100	100
	Sub-total	3.51	0	10.53	0.0	85.96	100

1= Decline in crop yield, 2= Decline in l/stock productivity, 3= Death of l/stock, 4= Food insecurity, 5= Food price increase.

5.0 Results and Discussion

5.1 Vulnerability of agricultural households to climate change

The result of the Instrumental Variable (Two Stage Least Square) regression modelled to capture the vulnerability of agricultural households to climate change is presented below in table 4.

Table 4: Result of Two-Stage Least Square IV Regression

Instrumental variables (2SLS) regression

Number of observations = 9026
Wald chi2 (11) = 71.48
Prob > chi2 = 0.0000***

lnTccloss	Coefficient	Robust S.E.	Z stat	P > I z I	[95% Conf. Interval]	
Education	-1.443076**	.5838905	-2.47	0.013	-2.58748	-.2986718
Tempchange	-.3098794**	.1518276	-2.04	0.041	-.6074561	-.0123027
Rainchange	-.0172018	.1489388	-0.12	0.908	-.3091165	.2747128
Crophh	.7155892**	.3341196	2.14	0.032	-.0607269	1.370452
Livhh	-.637478**	.2870897	-2.22	0.026	-1.200163	-.0747926
Fishh	-.5283377***	.1980419	-2.67	0.008	-.9164926	-.1401828
Agrophh	-.2646387	.1967539	-1.35	0.179	-.6502693	.1209918
Hhsize	.0347671***	.0077773	4.47	0.000	.0195239	.0500102
Age	-.0275917***	.0101664	-2.71	0.007	-.475176	-.0076659
Gender	-.6746599**	.2902767	-2.32	0.020	-1.243592	-.1057279
Nonfarm	.2600224***	.071261	3.65	0.000	.1203535	.3996914
_Const	21.7395***	3.989929	5.45	0.000	13.91939	29.55962

*** means significant at 1% level, while ** is significant at 5% level.
Instrumented: Education

The result above shows that the model fits the data well and is generally significant with the independent variables having effects on the vulnerability level of the households as captured by the total revenue loss due to climate change by the households. The variables that significantly determine the vulnerability of agricultural households to climate change are: education, household experiencing temperature change, crop based household, livestock based household, fishing household, household size, age and gender of the respondents as well as the involvement of the households in non-farm activities.

In agreement with the apriori expectation, the more educated the agricultural household the less vulnerable they are to climate change, likewise for those households who have not noticed significant changes in temperature (Tempchange) in the past 30 years.

We also observe that households who are into livestock (Livhh) and fish (Fishh) production are highly vulnerable to climate change effects than those who are not but the crop production households (Crophh) were less vulnerable than those who are not. It shows that households who are not into cropping loses more revenue (Coefficient = 0.72) which may be due to food price increase and food insecurity as reflected in other results above since cropping households can produce some of their food needs.

Thus it can be inferred from the estimate that climate change will hamper the commercialization of the livestock and fishery sector in Nigeria in terms of revenue loss and profitability. It will also affect the nutritional security of the country (protein deficiency) as these are the complimentary source of protein in the household diets.

Larger households as well as those not involved in non-farm activities are also more vulnerable than those who were not. While large households will spend more to meet their needs, those who are not into non-farming will be short of financial strength as their agricultural income would have suffer greatly due to climate change effects.

Older farmers are less vulnerable which may be due to their experience and likewise the female farmers. Once again this brought out the efficiency and ingenuity of the female farmers, but it should be noted that land ownership bias against females in the Nigerian culture may limit the farm size of the female farmers, as a result of which the will be able to manage effectively their small plots.

5.2 Adaptive capacity or response of agricultural households to climate change.

We constructed the Climate Change Adaptive Index (CCAI) for the households with a view to classify the households into different classes of adaptation levels. This was based on the number of actionable steps against the climate changes factors as provided in the instrument for the survey. The maximum number of actionable steps allowed to state in the instrument is three, so those households who did not take any action get score of zero and were classified to be of "No adaptive capacity", if 1 action was taken such get a score of 1, 2 actions get a score of 2 and maximum of 3 actions get a score of 3. Score of 1 means low adaptive capacity, 2 is medium adaptive capacity while 3 means high adaptive capacity.

Having constructed this Index, an ordered Logit regression was estimated to determine the factors that affect the adaptation capacity of the agricultural households and the result is as presented in the table following this discussion.

The estimated model fit and the independent variables actually determine the climate change adaptive capacity of the households (probability value of 0.0000). The factors that significantly influence the capacity of the households to adapt to climate change factors as reflected in the result are: significant change in temperature (tempchange), significant change in rainfall (rainchange), fishing households (fishh), participation in agric research and extension (agresearch), age, gender, credit and total credit amount (Tcreditamt).

The ordered Logit for households that were not exposed to significant temperature and rainfall changes over the last 30 years being in a higher adaptive capacity index is less than for those who were by values of -1.31 and -2.72 respectively. However the log-odd of being in a higher CCAI category increases by 0.706 for households that are not into fishery. The more credit the farmers got (Tcreditamt), the higher the log-odd of moving up the CCAI at 10 percent level.

For the households that did not participate in agric-extension, the log-odd of being in a higher CCAI is reduced by -0.38. Likewise a year increase in age of the farmer reduces the log-odd of being in a higher CCAI by -0.008. We also observed a lesser log-odd of moving to a higher CCAI for female farmers by a value of -0.34 which is in agreement with the result in table 2 where women are the least affected by climate change factors. So also not having access to credit increases the log-odd of moving to a higher CCAI by 0.35 but very surprisingly every naira increase in credit amount given to farmers will increase the log-odd of their moving to higher level of CCAI by 4.27e-07.

Table 5: Ordered Logit regression result

Ordered logistic regression

Number of obs= 3352
LR chi2 (18)= 1689.21
Prob > chi2 = 0.0000***

Log_{10} likelihood = -3646.5919

CCAI	Coefficient	Stand. Err.	Z stat	P > I z I	[95% Conf. Interval]	
Tempchange	-1.309725***	.1530708	-8.56	0.000	-1.609739	-1.009712
Rainchange	-2.716224***	.1778368	-15.27	0.000	-3.064778	-2.36767
Crophh	-.0483155	.084855	-0.57	0.569	-.2146283	.1179974
Livhh	.0152531	.1609757	0.09	0.925	-.3002536	.3307597
Fishh	.705773***	.1633809	4.32	0.000	.3855522	1.025994
Agrophh	-.3123406	.2065808	-1.51	0.131	-.7172314	.0925502
Tcreditamt	4.27e-07*	2.45e-07	1.74	0.082	-5.40e-08	9.08e-07
Tassetpast	-1.23e-09	9.35e-10	-1.32	0.188	-3.06e-09	6.01e-10
Agresearch	-.3830559***	.991909	-3.86	0.000	-.5774665	-.1886454
Towndist	-.0011034	.001489	-0.74	0.459	-.0040219	.0018151
Hhsize	.0081416	.0113391	0.72	0.473	-.0140827	.0303659
Nonfarm	-.0469528	.0743804	-0.63	0.528	-.1927358	.0988302
Age	-.0081691***	.0026689	-3.06	0.002	-.0134001	-.002938
Gender	-.3407873***	.0763775	-4.46	0.000	-.4904845	-.1910901
Education	.0026994	.009481	0.28	0.776	-.015883	.0212817
Groupassoc	.6128814	.4487456	1.37	0.172	-.2666439	1.492407
Credit	.3464572***	.0870719	3.98	0.000	.1757994	.517115
Mktdist	.0015681	.0013155	1.19	0.233	-.0010103	.0041465
/cut 1	-5.496848	.9545435			-7.367719	-3.625977
/cut 2	-3.851193	.9516573			-5.716407	-1.985979
/cut 3	-3.169359	.9515676			-5.034397	-1.304321

*** means significant at 1% level, while ** is significant at 5% level and * is significant at 10% level.

Interpretation and policy issue from the O Logit result

The result above implies that preventing agricultural households from exposure to climate change factors (rain and temperature) through early warning systems and communication or creating awareness about it will improve their adaptive capability. It also shows that fishing folks are in good position to tackle the vagaries of climate change. While offer of credit to farmers will improve their adaptive skills, there is caution on the amount to be given as too much credit value will hinder their adaptive capacity, this can be traced to diversion of fund for other uses by farmers rather than to the agriculture business.

Once again, experience of the farmers by age and the female farmers are important factors that can be tap on to improve farmers' adaptation to climate change. The negative influence of participation in extension on the adaptive potential was surprising, but it questions the quality of the extension service and the areas of priorities on which the extension services were based.

6.0 Conclusions and Recommendation.

Conclusions

Several policy related conclusions that can be derived from this empirical research are as follows:

- Climate change effects on agricultural sectors in Nigeria have once again highlights the importance of agricultural insurance scheme in Nigeria and should be urgently addressed.
- Climate change affects largely all household members but with higher impacts on men, children and the elderly which can reduce the farm labour and increase child mortality.
- Climate change poses serious threat of both food insecurity and nutritional insecurity (protein deficiency) to agricultural households in Nigeria.
- Direct policies to address the vulnerabilities of agricultural households should incorporate the local knowledge of farmers into an informal educational package as well as promote non-farm enterprises.
- Since livestock and fish farming households are highly vulnerable, there is need for more research to introduce species that are tolerant to such climate challenges in Nigeria and promotion of protein fortified crops to aid protein inclusion in foods and diets.
- Adaptations to climate change in Nigeria will be greatly improved if the early warning signals on climate changes can be communicated on to the farmers effectively and in time.
- Agricultural extension systems in Nigeria need to be re-evaluated and re-packaged in tune with realities of today's challenges in respect of climate change.

Recommendations

With an avowed determination of Nigerian government to resuscitate the Agricultural sector through the "Agricultural Transformation Agenda", the goal may be truncated if a thorough understanding of the climate change effects and impacts is missing in such policy document. Therefore efforts should be geared towards understanding the effects of climate change deeply on each sub-sector and by geo-political zones. Surveys that are climate change based should be conducted to generate a longitudinal data for such analysis so as to capture the inter-temporal changes over time.

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APPENDIX 1: Variables used in the study.

No	Variable	Definition	Classification into shocks	Conceptual Basis
1	lnTcloss	Log of total climate change loss	Hazard loss	Vulnerability
2	Tempchange	Temperature change over the last 30 years	Covariate	Sensitivity
3	Rainchange	Rainfall change over the last 30 years	Covariate	Sensitivity
4	Crophh	Cropping household	Idiosyncratic	Exposure
5	Livhh	Livestock keeping household	Idiosyncratic	Exposure
6	Fishh	Fishing household	Idiosyncratic	Exposure
7	Agrophh	Agro-processing household	Idiosyncratic	Exposure
8	Hhsize	Household size	H/hold xtics	Adaptive capacity
9	Education	Respondents education level	H/hold xtics	Adaptive capacity
10	Age	Age of the respondents	H/hold xtics	Adaptive capacity
11	Gender	Gender of the respondents	H/hold xtics	Adaptive capacity
12	Nonfarm	Engagement in non-farm activities	H/hold xtics	Adaptive capacity
13	Researchpart	Engagement in research	H/hold xtics	Adaptive capacity
14	Tcreditamt	Total credit amount	H/hold xtics	Adaptive capacity
15	Tassetpast	Total value of production assets as at time of purchase	H/hold xtics	Adaptive capacity
16	Agresearch	Involvement in agric extension	H/hold xtics	Adaptive capacity
17	Towndist	Distance to the nearest town	H/hold xtics	Adaptive capacity
18	Groupassoc	Member of group association	H/hold xtics	Adaptive capacity
19	Credit	Access to credit facilities	H/hold xtics	Adaptive capacity
20	Mktdist	Distance to market	H/hold xtics	Adaptive capacity
21	CCAI	Climate change adaptation index	H/hold xtics	Adaptive capacity