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Analysis of Impact of Climate Change on Growth and Yield of Yam and Cassava and Adaptation Strategies by Farmers in Southern Nigeria

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Abstract

This study determined the adaptation and coping strategies adopted by farmers under yam- and cassava-based farming systems in Ebonyi and Enugu States in Nigeria's derived savannah agro-ecological zone. The study uses data from 400 farmers. The likelihood that the farmers engage in some actions to cushion the effect of climate change was determined using a probit model and a multi-nomial logistic regression. The results of the study revealed that the main outcomes of climate change were flooding (71.29%), decline in crop yields (65.1%), food price increases (62.87%), and food shortages/insecurity (57.92%). The average amount of loss to climate change was ₦164,318.8 naira. To cushion the effect of climate change, the highest proportion (45.05%) of the farmers bought food. In terms of land management practices used, the majority (74.34%, 83.55%, 72.37%, and 60.53%) of the farmers keep their land under fallow, mulch/use surface cover, intercrop, and use farmyard manure, respectively. Number of years in school and household size significantly influence the likelihood of a farmer starting non-farm activity to cushion the effect of climate change. Age, gender of household head, and amount of loss due to climate change significantly influence the decision to plant pest- and disease-resistant crops to cushion climate change effects. Thus, policies to encourage planting of these crops should focus more on male-headed households and on households that have experienced some previous losses due to climate change since they will be more likely to grab any opportunity that will prevent any further loss.

Résumé

Cette étude vise à déterminer les stratégies d'adaptation que les agriculteurs ont adoptées sur les systèmes d'exploitation agricoles portant sur l'igname et le Manioc dans les Etats d'Ebonyi et d'Enugu en zone de savane agro-écologique au Nigeria. L'étude utilise des données sur 400 agriculteurs. La probabilité que les agriculteurs se livrent à certaines actions pour amortir l'effet du changement climatique est déterminée à partir d'un modèle probit et d'une régression logistique multinomiale. L'étude révèle que les résultats les plus significatifs du changement climatique sont les inondations (71,29%), la baisse des rendements des cultures (65,1%), la hausse des prix des denrées alimentaires (62,87%), et la pénurie/insécurité alimentaire (57,92 %). Le montant moyen des pertes dû au changement climatique est estimé à 164.318,8 Nairas. Pour amortir l'effet du changement climatique, la plupart des agriculteurs (45,05%) achètent de la nourriture. En ce qui concerne les pratiques de gestion des terres utilisées, la majorité des agriculteurs gardent leur terre en jachère (74,34%), ou sous paillis (83,55%), ou en culture intercalaire (72,37%), ou utilise du fumier de ferme (60.53%). Le nombre d'années scolaires et la taille des ménages ont une incidence significative sur la probabilité qu'un agriculteur commence une activité non agricole pour amortir l'effet du changement climatique. L'âge, le sexe du chef de ménage, et le montant de la perte due au changement climatique ont une influence significative sur la décision de planter des cultures résistantes aux parasites et aux maladies afin d'amortir les effets des changements climatiques. Ainsi, les politiques visant à encourager la plantation de ces cultures devraient se concentrer davantage sur les ménages dirigés par des hommes et sur ceux qui ont subis des pertes en raison du changement climatique, et donc plus disposés à saisir toute opportunité qui leur permettrait d'éviter toute perte supplémentaire.

1. Introduction

1.1 Background and Problem Statement

Agriculture (comprising crop, livestock, forestry, and fisheries) remains the mainstay of Nigerian economy, contributing over 40% of the country's GDP. It is the lead sector responsible for providing income and employment to rural people; the sector employs 90% of the rural poor and nearly 70% of the total labor force, and generates 90% of non-oil export revenues (Federal Ministry of Agriculture and Water Resources (FMAWR), 2008). Analysis of the real GDP performance in 2007 shows that agricultural sector contributed the largest share, 42.2%, compared to 41.7% in 2006 (CBN, 2007). Of the growth rate during the 2004-2007 period, the crop, livestock, fishery and forestry sub-sectors contributed 90.1%, 5.9%, 2.9%, and 1.1%, respectively (CBN, 2007). Thus the crop production sub-sector is the key source of agricultural growth in Nigeria. The eleven major crops grown in Nigeria are yam, cassava, sorghum, millet, rice, maize, beans, dried cowpeas, groundnuts, cocoyam, and sweet potatoes. These major crops, which account for about 75% of total production, increased from 81,276 thousand tons in 2004 to 95,556 thousand tons in 2007. Of these crops, cassava and yam are the most widely cultivated food and cash crop in southern Nigeria, a zone that accounts for 64% of the country's cassava production (Famine Early System Warning Network (FEWS), 2006). In fact, cassava food products, followed by yams, are the most important staples of rural and urban households in southern Nigeria in terms of both food and cash income generation. Cassava ranks highest among all food crops in terms of cash generation (Nweke et al, 1997) and provides food and income to over 30 million farmers and large numbers of processors and traders.

Despite the importance of cassava and yam to Nigeria's rural economy, the production and yield of these crops are being threatened by climate change. World temperatures have increased by around 0.7^{o}C since the advent of the industrial era (IPCC, 2007), and this will lead to at least a further half degree of warming over the next few decades because of the inertia in the climate system. Scientific evidence links the rise in temperature to increases in the concentration of greenhouse gases, particularly carbon dioxide, in the Earth's atmosphere. It is believed that some of the most profound and direct impacts of climate change over the next few decades will be on agriculture and food systems (Brown and Funk 2008), and all quantitative assessments show that climate change will adversely affect food security (Schmidhuber and Tubiello 2007).

Adaptation is one of the critical tools that can be used to fight the dangers associated with climate change. Adaptation involves adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects. Rosnzweig and Parry, (1994) show that there is great potential to increase food production under climate change in many regions of the world if adaptation is taken into consideration. A similar conclusion was arrived at by Downing (1991), who reports that adaptation has the potential to reduce food deficits in Africa from 50% to 20%. For adaptation to be effective, especially in agriculture, there needs to be a thorough understanding of the potential impacts of climate change, especially on staple food crops. This understanding will help raise awareness of the problem of climate change through increased involvement by policymakers, scientists, and all stakeholders in the climate change debate.

Although cassava is a hardy crop that could have significant potential to adapt to climate change, studies by Gleadow, et al (2009) reveal that the crop actually responded negatively to enhanced CO_2 and that the crop's cyanide concentrations increased with greater CO_2. There is therefore the need to determine the true effects of climate change on cassava in Southern Nigeria, as well as the effects on yams. There has already been serious flooding in the country's southern coastal and delta zones, as well as serious land degradation due to intensive coastline erosion, pervasive gully erosion in eastern parts of the rain forest zone and central guinea savannah zone, and land cover changes due to variability in rainfall induced by climate change. It is also important to further study the effect of local knowledge on climate change adaptation. Nabegu, (2010) notes that although conventional approaches to the study of climate change are useful in depicting general trends and dynamic interactions, the top-down, science-driven approach often fails to address the local impacts of climate change. Understanding climate change from the perception of local people will offer new insights into how individuals and communities are affected and how more effective strategies for adoption and mitigation can be developed. Barros (2007) and Adejuwon et al (2007) suggest that supplementing scientific data with local knowledge could broaden the information base for sustainable environmental management in relation to climate change. The key questions, therefore, are: how will climate change affect cassava and yam yields? Can cassava be the crop that farmers can depend on to cushion climate change effects? How do farmers in cassava- and yam-based farming systems adapt?

1.2 Objectives of the Study

The main objective of this study is to analyze the impact of climate change on growth and yields of yam and cassava and determine the adaptation and coping strategies adopted by farmers in southern Nigeria.

Specifically, the study seeks to:

1. Estimate how climate change may change the production map of yam and cassava, considering different agro-climatic zones.
2. Estimate the change in outputs/yields of the two crops due to climate change.
3. Estimate the impact of climate change on different types of yam and cassava producers e.g. impact on the income of farmers.
4. Determine innovative adaptation measures used by farmers under yam- and cassava-based cropping systems in Southern Nigeria.

2. Brief on Climate Change and its Projected Impact on Agriculture

Scientific evidence links the climate change occasioned by a rise in temperature to increases in the concentration of greenhouse gases, particularly carbon dioxide, in the Earth's atmosphere. The current level or stock of greenhouse gases in the atmosphere is equivalent to around 430 parts per million (ppm) CO2, compared with only 280ppm before the Industrial Revolution (Stern, 2006). Scientists predict that with the current level of accumulation of CO2, there is at least a 77% chance - and perhaps up to a 99% chance, depending on the climate model used - of a global average temperature rise exceeding 2°C (Stern, 2006; UNDP, 2007).

This heating up would lead to a catastrophic, irreversible change in the world's physical geography. Drought-affected areas in Sub-Saharan Africa could expand by 60-90 million hectares, with dry land zones suffering losses of US$26 billion by 2060 (2003 prices), a figure in excess of bilateral aid to the region in 2005 (UNDP, 2007).

Evidence has shown that climate change is already affecting crop yields in many countries (IPCC, 2007; Deressa et al, 2008; BNRCC, 2008). This is particularly true in low-income countries, where climate is the primary determinant of agricultural productivity and where adaptive capacities are low (SPORE, 2008; Apata et al, 2009). Many African countries, whose economies are largely based on weather-sensitive agricultural productions systems, are particularly vulnerable to climate change (Dinar et al, 2006). A change in climate brings about alterations in rainfall patterns, water levels and volumes of lakes, ponds, rivers, and streams, and the frequency of drought and storms. For example, Lake Chad was once one of Africa largest bodies of fresh water. In the 1960s, it had an area of more than 26,000km2, making it the fourth largest lake in Africa. By 2000, the lake had shrunk to 1500km2, only 5% of its original size (Eleri, 2007). Lake Chad borders four countries (Cameroon, Chad, Niger, and Nigeria) and supports the livelihoods of more than 20 million people.

The damage from climate change to African agriculture is expected to range from 0.13 to 2% of GDP by 2100 (Mendelson, et al 2000). The larger effects (1.4 to 2%) come from the predictions of the experimental response function, while the smaller effects (0.13 to .25%) come from the predictions of the cross-sectional response function (Mendelson, et al 2000). With the experimental climate response function, West Africa suffers the greatest losses, amounting to between 36 and 44% of the losses for the entire continent. These damages represent losses between 42 and 60% of agricultural GDP in this region. With the cross-sectional climate response function, West Africa suffers about half of the damages in Africa, even though the losses are less than 10% of the value of its agriculture (Mendelson, et al 2000). With the experimental climate response function and the 14 climate predictions, seven countries are predicted to suffer the largest average losses in the agricultural sector; these countries are, in descending order, Nigeria, Sudan, Algeria, Cameroon, South Africa, Morocco, and Zaire (Mendelson, et al 2000). Together, these seven countries account for 47% of the estimated damages in Africa (Mendelson, et al 2000). Fischer (2005) also predicts that by the 2080s, a significant decrease in suitable rain-fed land and production potential for cereals is estimated. Furthermore, for the same projections and for the same time-horizon, the area of arid and semi-arid land in Africa could increase by 5 to 8% (60-90 million hectares). The study shows that wheat production is likely to disappear from Africa by the 2080s.

The impact of climate change on livestock farming in Africa was examined by Seo and Mendelsohn (2006a, b). They show that a warming of 2.5°C could increase the income of small livestock farms by 26% (+US$1.4 billion). This increase is projected to come from stock expansion. Further increases in temperature would then lead to a gradual fall in net revenue per animal. A warming of 5°C would probably increase the income of small livestock farms by about 58% (+US$3.2 billion), largely as a result of stock increases. By contrast, a warming of 2.5°C would be likely to decrease the income of large livestock farms by 22%(–US$13 billion), and a warming of 5°C would probably reduce income by as much as 35% (–US$20 billion). This reduction in income for large livestock farms would probably result both from a decline in the number of stock and from a reduction in the net revenue per animal. Increased precipitation of 14% would be likely to reduce the income of small livestock farms by 10%(–US$ 0.6 billion), mostly due to a reduction in the number of animals kept. The same reduction in precipitation would be likely to reduce the income of large livestock farms by about 9% (–US$5 billion), due to a reduction both in stock numbers and in net revenue per animal.

There is growing evidence that the frequency and severity of extreme weather events, such as droughts and floods, is increasing due to climate change (Schiermeier, 2012; Coumou and Rahmstorf 2012; Goodess 2013). Such extreme events have a significant impact on Nigeria. Scientific 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, rising to between 6 and 30% by the year 2050 (Federal Ministry of Environment, 2011). This loss is equivalent to between N15 trillion (US$ 100 billion) and N69 trillion (US$ 460 billion). Climate change is evidenced by the unprecedented flooding that occurred in many parts of Nigeria in 2012. The National Emergency Management Agency (NEMA) reported that heavy rains between July and October 2012 led to an overflow of river discharge, aggravated by a breach of irrigation reservoirs, and caused the destruction of roads, bridges, and other infrastructure. This flooding ruined property, killed livestock, and led to the temporary displacement of people whose homes were inundated (FME, 2011). Climate change is likely to make it more challenging to achieve food, energy, and water security in Nigeria. Findings from various climate modeling exercises all point to the severity of the challenge resulting from temperature increases of 1-2°C by 2050 on average, with even higher increases during the winter months (World Bank, 2012).

Crop modeling suggests that even if precipitation increases in several parts of the country, it is unlikely to offset the negative effects of rising temperatures on yields of most rain-fed crops. Climate-induced declines in crop yields are expected to have significant long-term effects on GDP of Nigeria, potentially causing a 4.5% reduction in GDP by 2050 (World Bank, 2012).

Ayinde et al (2010) also show that the change in climate has significant effects on agricultural productivity in Nigeria, clearly revealed in the rainfall variable. However, the study found out that temperature does not seem to be an important variable in the determination of agricultural productivity in Nigeria economy. Another study on the impact of climate change on grain yields in Nigeria (Aye and Ater, 2012) uses an econometric model that employs the historical climate and yield data and shows that the impacts of temperature and precipitation on grain yields vary between maize and rice. The impact of precipitation is very minimal and sometimes insignificant compared to that of temperature. In general, temperature and precipitation decrease maize and rice yields and increase their variability. With the experimental climate response function and the 14 climate predictions, seven countries are predicted to suffer the largest average losses in the agricultural sector; these countries are, in descending order, Nigeria, Sudan, Algeria, Cameroon, South Africa, Morocco, and Zaire. Together, these countries account for 47% of the total estimated damages in Africa (Mendelson, et al 2000). Table 1 shows the projected climate change impacts on agriculture, forestry, and fisheries.

There is still much uncertainty in assessing the role of climate change in complex systems that are shaped by interacting multiple stressors. Preliminary investigations give some indications of these interactions, but further analysis is required (Boko et al, 2007).

Table 1: Projected Climate Change Impact on Agriculture, Forestry, and Fisheries

Weather and climate events	**Possible impacts on agriculture, forestry, fisheries and ecosystems**
Warmer and fewer cloud days and nights; warmer and more frequent hot days and nights over most land areas (virtually certain)	Increased yields in colder environments; decreased yields in warmer environments; increased insect pest outbreaks
Warm spells and heat waves increasing in frequency over most land areas (very likely)	Reduced yields in warmer regions due to heat stress; increased danger of wildlife
Heavy precipitations events increasing in frequency over most areas (very likely)	Damage to crops; soil erosion; inability to cultivate land due to water logging of soils
Drought-affected area increases (likely)	Land degradation and soil erosion, lower yields from crop damage and failure; increased livestock deaths; increased risk of wildlife; loss of arable land
Extremely high sea level increase in incidence (excludes tsunamis) (likely)	Salinization of irrigation water, estuaries and freshwater systems; loss of arable land and increase in migration

Based on IPCC, 2007

3. Literature Review on Adaptation

Adaptation has been defined by the IPCC (2001) as the adjustment in natural or human systems in response to actual or expected climate hazards or their effects. Adaptation is usually a long-term livelihood activity and is a continuous process where results are sustained; it uses resources efficiently and sustainably and involves planning and combining of new and old strategies and knowledge, and is focused on finding alternatives (Federal Ministry of Environment, 2011). Adaptation includes all activities that help people and ecosystems reduce their vulnerability to the impact of climate change and that minimize the costs of natural disasters. Because of the speed at which change is happening due to global temperature increases, it is urgent that the vulnerability of developing countries is reduced, while their capacity to adapt is increased and while national adaptation plans are implemented (UNFCCC, 2007). There is no universal way to adapt; specific measures need to be tailored to specific contexts. Adaptation to climate change is a complex, multidimensional, and multi–scale process (Bryant et al. 2000). As reported in Brian and Behrman (2013), Agrawal and Perrin (2008) group adaptation strategies according to their form or type—mobility, storage, diversification, communal pooling, and exchange—and function with respect to risk (that is, pooling, avoiding, or reducing risk). Heltberg, Siegel, and Jorgensen (2009) use a social risk management framework to group adaptation strategies into three categories according to their timing and effect: those that prevent or reduce risk, those that mitigate risk, and those that compensate for risk. The first two are ex ante measures while the third is an ex post measure which they call "risk coping." Given that adaptation strategies often overlap with development objectives, McGray et al. (2007) place adaptation activities on a development continuum from pure adaptation on the one hand to pure development on the other. On the development side of the continuum, they place measures that reduce poverty and vulnerability; these measures may also help buffer households against climate shocks and changes. On the adaptation side, measures that incorporate information to reduce climate risk or protect against the negative impacts of climate change also have development benefits under future climate change (McGray et al. 2007). Adaptation options for ecosystems include control of deforestation, improved range land management, expansion of protection areas, and sustainable management of forests (IPCC, 1997).

Adaptation to climate stress is a local process (de Perthuis *et al*., 2010; Locatelli, 2011) that is rooted, according to Ader and Kelly (1999), in socialisation and learning. Therefore, it is not possible to implement an adaptation policy without considering the social context in which local knowledge is developed (Kpadonou, et al 2012). Easton (2004) portrays the significance of traditional or Indigenous knowledge in the management of climate variability and identifies three different ways of understanding the concept of indigenous knowledge. The first approach considers this knowledge as an inheritance from the past. The second approach describes it as a representation of an alternative way of thinking, typical of African cultures, and the third definition considers indigenous knowledge as a means to express what people know and to create new knowledge from the intersection of their capacities and development challenges. Egeru (2012) conducted a study of the role of indigenous knowledge in climate change adaptation in the Teso Sub-Region of Eastern Uganda and found out that 48% of the respondents applied indigenous knowledge in crop production by way of seed selection, seed storage, weeding patterns, and planting mode (broadcast method for finger millet); 12% applied it in livestock treatment, and 13% in monitoring rainfall. Early planting and planting of fast-maturing varieties was undertaken by 43% of respondents, and 31% undertook a multiplicity of coping strategies including saving planting materials (seeds), offering casual labor, begging, trading livestock with other food stuffs, and bunkering their compound to prevent heavy runoff during floods. Kpadonou et al (2012) observes that finger ponds are one of the oldest innovations developed by Oueme valley people to cope with climate vulnerability, as is the building of dykes in flood plains for crop production; the dykes are covered with mulch for holding water and reducing moisture loss.

In the same vein, a study in the Niger Delta region of Nigeria (Nzeadibe, et al, 2012) reveals that farmers in this region have adopted a range of strategies for climate change adaptation, some of which can be grouped into soil and water management, the use of improved variety/ crop protection, and farm management practices. Deressa et al (2010), in their study of farmers in the Nile basin of Ethiopia, find that different socioeconomic and environmental factors affect the way in which farmers cope with extreme climate events. These include the household head being male, the age of the head of household (which approximates experience), farm income, farm size, livestock ownership, extension on crop and livestock production, farmer-to-farmer extension, local agroecology *kolla* (lowlands), local agroecology *weynadega* (midlands), temperature, and precipitation. Madison (2006) reports that farmers' experience, as well as access to free extension services and markets, is an important determinant of adaptation. In a study of the determinants of farmers' choice of adaptation methods and perceptions of climate change in the Nile Basin of Ethiopia, Dressa, et al (2008) finds that the age of the household head, wealth, information on climate change, social capital, and agroecological settings were found to have significant effects on farmers' perception of climate change. In a micro-level analysis of farmers' adaption to climate change in Southern Africa, Nhemachena and Hasan (2007) find that 40% of the farmers studied did not adopt any adaptation strategies, Dressa et al (2008) find that the factors that affect farmers' choice of adaptation method include use of different crop varieties, tree planting, soil conservation, early and late planting, and irrigation. In a study of smallholder farmers in the Nigeria savannah, Akpene and Abdoulaye (2013) observ that the main adaptation methods used include varying planting dates, use of drought-tolerant and fast-maturing varieties, and tree planting.

In a study of farmers' perception of coping strategies from six agro-ecological zones of Uganda, Okonya et al (2013) find that only one variable, gender of household head, positively and significantly influenced adaptation to climate change. Male-headed households responded faster in developing coping strategies. Other factors that positively affected the development of coping strategies were household size, livestock ownership, access to credit, irrigation practice, ability to hire farm labor at peak seasons, education of household head, and access to an off-farm income source. Larger size of land owned negatively and significantly affected adaptation. Other factors that had a negative relationship to climate change adaptation included intercropping practices, higher number of farm workers, and access to extension information. Dami et al (2011) observe the various types of adaptation used by local people in coping with the harsh conditions resulting from the declining volume of water in the Lake Chad basin. A little more than one-fifth of the respondents (21.9%) engaged in rearing animals to cope with crop failure. Almost one-fifth (17.8 and 17.2%, respectively) involved in activities like buying and selling of non-agricultural products and fishing. About 1 in 20 persons (4.1%) migrated to nearby countries in search of food, while a larger proportion (24.7%) relied on the food they stored during previous good harvest. Closer to a tenth of respondents (7.5%) said that they did nothing to cope with adverse conditions, while 6.9% had other means of coping e.g. engaging in handcrafts such as weaving and mat making, hunting of wild animals, and selling of fuel wood (Dami, 2008). In light of the findings of these previous studies on climate change adaptation, this study seeks to understand how the farmers in derived savannah region of Nigeria cushion the effect of climate change and to determine the factors that influence climate change adaption in the study area. The study also seeks to determine the impact of climate change on cassava and yam output in the agro-ecological zone.

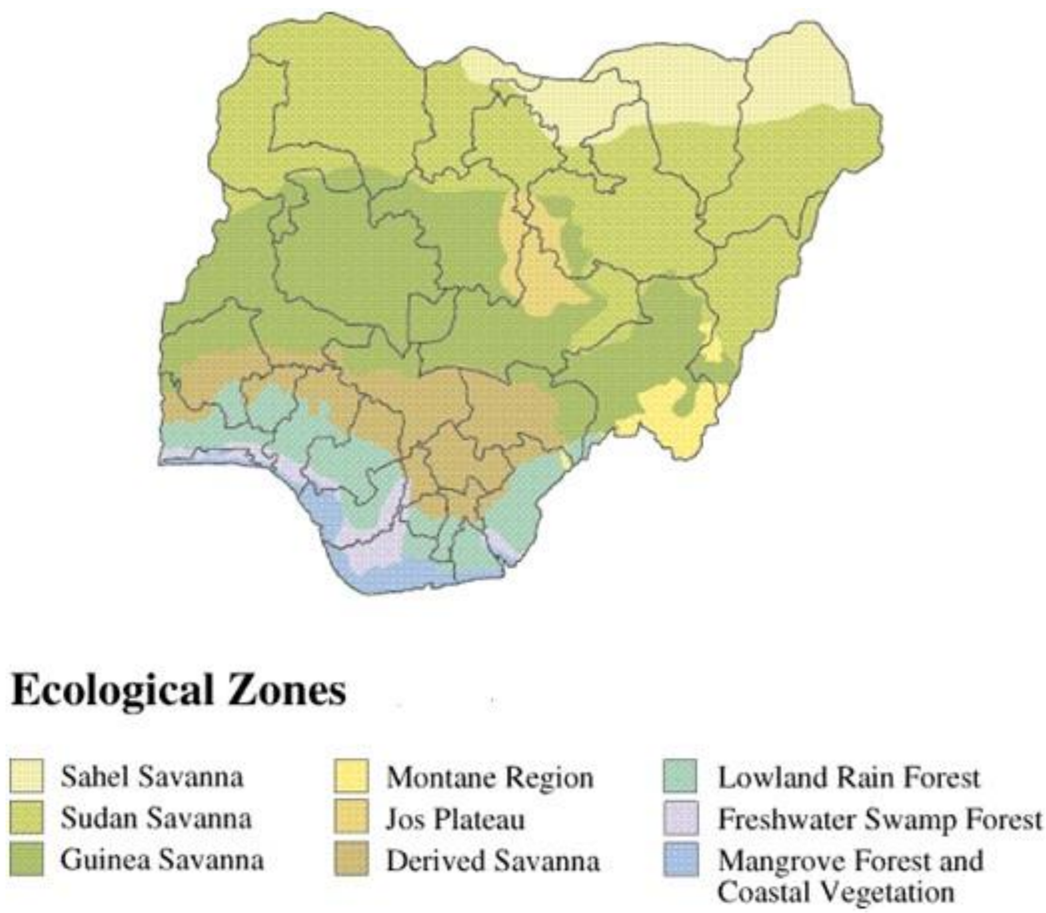
4. Data and Methodology

Nigeria Ecology Zones: The Nigeria ecological zone covers the derived savannah, the low land, fresh water swamp forest, and mangrove forest/coastal vegetation. Figure 1 shows the map of Nigeria indicating the ecological zones.

The derived savannah was originally the drier part of the high forest. Due to bush burning and overgrazing, as well as cultivation and hunting activities over a long period, the high forest trees were destroyed and the forest that used to exist has now been replaced with a mixture of grasses and scattered trees. However, along the streams and in wet low-lying areas where surface water accumulates, there are still some traces of forests.

The lowland forest zone is the major source of timber for all large construction and cabinet-making. This zone contains the most valuable species of vegetation. However, due to human activities, this one-time forested area has been drastically reduced. Bush fallows, villages, and farms are found scattered throughout the zone. The drier end of its inland side is becoming reduced to derived guinea savanna because of felling and clearings. In the humid rain forest can be found economic cash crops such as oil palm, (*Elaeis guineensis*), cocoa (*Theobroma cacao*), rubber (*Hevea brasiliensis*), banana/plantain (*Musa* spp.), and cola nut (*Cola nitida*). Some principal staple food crops such as yam, cocoyams, sweet potato, maize, rice, groundnut, cowpeas, and beans can also be found in this zone, as well as a number of fruits. This zone is also good for sylviculture; a number of timber trees such as the African mahogany (*Khaya ivorensis* and *K. grandifoliola*), the scented sapele wood (*Entandrophragma cylindricum*), and iroko (*Chlorophora excelsa*) can be found here. This zone is clearly very important in terms of food production and timber production (Oyenuga, 1967).

Figure 1: Map of Nigeria indicating the ecological zones.



Source: Nigeria Biodiversity Strategy and Action Plan (NBSAP), 2007

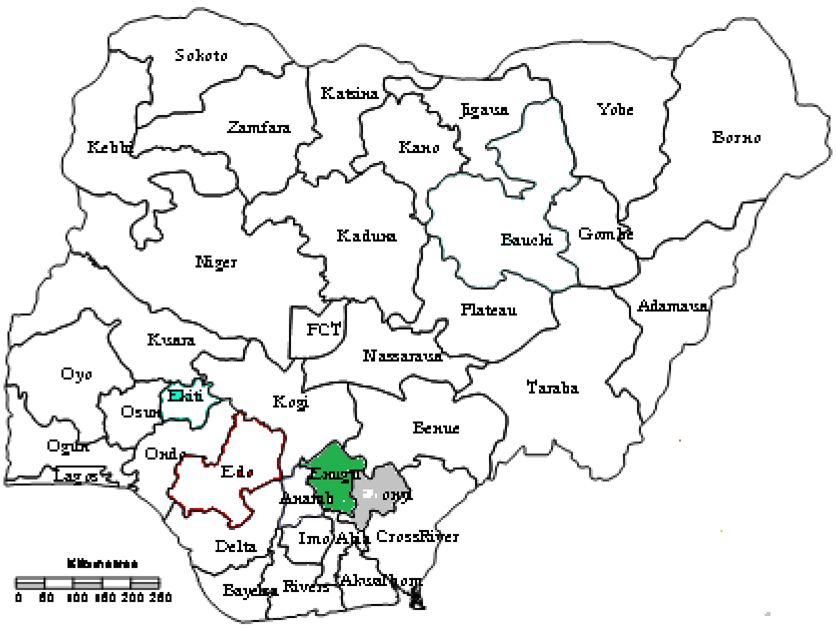
The freshwater swamp communities: This area, which originally occupied 18,130 km2, lies immediately inland of the mangrove swamp but on a slightly higher ground. The lagoons or the rivers that overflow their banks in the wet season supply it with fresh water; because the area is low-lying, it is flooded with rain water and lies under rain for sometimes eight or nine months of the year. The periodical flooding gradually deposits new layers of alluvial soils on the surface of the land, a deposit that leads to the formation of more solid ground behind the swamp, where we find the beginning of the rain forest. This zone consists of a mixture of trees and contains various important palm and fiber plants such as Raphia spp. Fishing and fiber-making are the important products of the fresh-water swamp community.

The mangrove forest and coastal vegetation: This occupies the coastal areas and consists of tidal swamps, interspersed with numerous creeks and lagoons. The mangrove swamp is noted for the mangrove species of trees (Rhizophora) that dominate the swamp and to a much less extent by Conocarpus erectus and

Laguncularia racemosa (white mangrove). Among the Rhizophora spp. Rhizophora racemosa dominates, occupying an estimated 99% of the entire mangrove area. The coastal swamp area is not widely cultivated except for swamp rice in places where the swamp is stabilized and non-saline.

Study Area: The states in the south-east geopolitical zone belonging to the derived savannah ecological zone of Nigeria are Abia, Anambra, Ebonyi, Enugu, and Imo States. The two States from the derived savannah agro-ecological zones (Figure 2) were randomly selected for this study.

Figure 2: Map of Nigeria showing the two states studied – Enugu and Ebonyi States



Enugu State is located between latitudes 5º 56'N and 7º 06'N and longitudes 6º 53'E and 7º 55'E. It is bounded by Abia State to the south, Anambra to the west, Kogi and Benue States to the north, and Ebonyi to the east. The State has a total of 17 local government areas: Enugu South, Igbo Eze South Enugu North, Nkanu, Udi, Agwu, Oji-River, Ezeagu, Igboeze North, Isiuzo, Nsukka, Igbo-Etiti, Uzouwani, Enugu East, Aninri, Nkanu East, and Udenu. Its main daily temperature lies between 27^0C and 28^0C. The two prominent climatic seasons in the area are the rainy season (April-October) and the dry season (November-March). Predominantly, farmers practice subsistence farming and produce crops like yam, cassava, maize, sweet potatoes, grain legumes, pawpaw, banana and plantain, and vegetables. Farm incomes are supplemented by earnings from the sale of products from local tree crops like oil palm, cashew, kola nut, coconut, mangoes, bread fruit (ukwa), castor beans, oil beans, etc.

Ebonyi State was created on 1st October, 1996 out of the former Abia and Enugu States. Geographically, the state lies between latitudes 7º 30' N and 8º 30' N and longitudes 5º 40' E and 6º 45' E. It is bounded on the southeast by Cross River State, northeast by Benue State, west by Enugu State, and southwest by Abia State. The state has a landmass of 5,935 km^2, most of which is fertile and arable. Although moderate rainforest vegetation is found in the southern part of the state, the central and northern parts are dominated by derived guinea savannah. The mean annual temperature is about 80ºF, and the mean annual rainfall varies between 1700mm to 2500mm. The state is also blessed with an abundance of food plains and a good number of perennial and seasonal rivers. Over 80% of the population is engaged in agriculture, growing different types of food and cash crops including rice, yam, cassava, cocoyam, and maize, as well as keeping some small ruminants and rearing cattle. The state is divided into 13 local government areas by the Federal Government of Nigeria. The Ebonyi State Agricultural Development Programme (EBADEP) divided the state into three agricultural zones. These zones are:

- Ebonyi North Agricultural Zone, which comprises Abakaliki, Ebonyi, Izzi, and Ohaukwu Local government areas.
- Ebonyi Central Agricultural Zone, which comprises Ezza North, Ezza South, Ikwo, and Ishielu local government area.
- Ebonyi South Agricultural Zone, which comprises Afikpo North, Afikpo South, Ivo, Ohaozara, and Onicha local government areas.

Model for Climate Change Impact Study: Crop model – DSSATv4 was used to evaluate cassava and yams for their vulnerability to climate change, as well as for the implications for future climatic change and the expected magnitude of impacts. The climate data is from experimental sites that are representative of the climatic conditions across the state.

Data for Climate Change Impact Study: Data for the calibration for cassava was obtained from the Root Crop Research Institute Umudike experimental plot located at the crop experimental site of University of Nigeria Nsukka, Enugu State, South East, Nigeria. Daily climatic data was sourced from the metrological records obtained from the experimental site. National climatic data from 1960-2010 will be sourced from Nigeria Metrological Institute (NIMET), while scenarios will be created for 2020, 2050, and 2080.

Sampling of Farmers for the Study: Farmers were sampled from two randomly selected States, namely Enugu and Ebonyi State of Southeast Nigeria. A multi-stage random sampling technique was used for the selection of farmers. First, two agricultural zones were selected in each of the two states. For Ebonyi, these were Ebonyi North and Ebonyi Central, while for Enugu, they were Enugu East and Enugu North zones. This gave a total of four (4) zones. From each of the four zones, two (2) local government areas were randomly selected, giving a total of eight local government areas, four for each State. The local government areas for Ebonyi State were Afikpo South, Ishielu, Afikpo North, and Ezza South, while the local government areas for Enugu were Enugu North, Enugu East, Nsukka, and Uzouwani. From each of the eight (8) local government areas, five (5) farming communities were randomly selected, resulting in 40 farming communities. Finally, from each of the 40 farming communities selected, 10 farmers were randomly selected, giving 400 farmers for the study. The selection and interviewing of farmers was done with the help of agricultural extension agents in the areas. All of the farmers selected were involved in cassava- and yam-based cropping, and other crops planted are rice and vegetables.

Data Collection from farmers for Adaptation Study: A semi-structured interview protocol was used in data collection. The nature of climate change, and of innovations to adapt to it, warrants an approach that emphasizes local-level knowledge and experience, which should be gathered through a participatory process. SSI is often regarded as the "workhorse" of participatory research because it is used both on its own and as part of other tools, requiring teams to ask questions and probe issues in a sensitive way. SSI was used to gather information on farmers' socio-economic attributes, their knowledge and awareness of climate change issues, adaptive measures and innovations against climate change risks, and constraints to climate change adaptation. Data on the cost and returns of farming under cassava- and yam-based cropping systems was also collected.

Measurement of Variables

Firstly, the composition of each household interviewed was determined, as was the knowledge of the respondents and their adaptation to climate change. The respondents were asked to indicate if they have noticed a significant change in temperature or rainfall in their locality. Respondents were also requested to indicate the extent to which they were aware of climate change by selecting response options of "don't know", "know little", ''reasonable extent", and "great extent." They were also asked to select the appropriate responses/options in terms of type of climate change observed, whether "more frequent drought", "delayed on-set of rainfall", erratic rainfall pattern", "hailstorm", "normal", or "higher temperature", among others. Normal condition implied that no change was observed.

The respondents who indicated that they received information about climate change were asked to indicate the source of information. In addition, they were asked to choose from options on the outcome of climate change, including "decline in crop yield", "increase in crop yield", and "food shortage/insecurity", among others. They also indicated the actions they have taken to adapt to climate change. Moreover, the respondents were asked to indicate yes or no regarding land management practices they have used to address climate change, as well as the year when they started using the practice. The type of climate change addressed by the land management practices in terms of rainfall change and temperature change was also ascertained by asking the respondents to select the type of land management practice used for each climate change type.

The constraints to climate change adaptation and the cost and returns from crop farming (yam and cassava) were also ascertained. The details of the questionnaire are presented in the Appendix. The socioeconomic attributes of the farmers sampled are presented in Table 2.

Table 2: Value means and standard deviation of the variables used in the model

Variable	Mean	Standard Deviation	Minimum	Maximum
Age of household head	51.71	14.34	14	98
Age2	2879.30	1500.30	196	9604
Number of years in school	8.84	5.37	0	24
Household Size	7.14	3.38	1	28
Males over age 15	2.42	1.36	0	7
Gender of respondent household head–Males[b]	0.84	0.37	0	1
Agric Production [c]	0.50	0.50	0	1
Amount lost due to climate change	164,318.8	290,761.6	400	2700000
Access to information on climate change	0.806	0.396	0	1
Occupation (1 if agriculture, 0 otherwise)	0.505	0.500	0	1

Source: Field survey data 2012
a 1 if land management score is greater than 50%; 0 otherwise.
b 1 if Gender is male ; 0 otherwise (female)
c 1 if involved in agric production activity (crop and livestock); 0 otherwise

The results show that the average age of the farmers under cassava- and yam-based cropping system is 51.71 years, the average household size of the farming households is 7.14 persons, and the farmers spent an average of 8.84 years in school.

Data Analysis: Objectives 1 and 2 were to be realized based on runs using the DSSATv4 crop model. The DSSAT-CSM (Decision Support System for Agro-technology Transfer – Cropping System Model), is structured using a modular approach described by Jones et al. (2001) and Porter et al. (2000). The DSSAT-CSM includes models for cassava but it does not incorporate the model for yam. The scheme is presented in Figure 1.

The DSSAT-CSM model simulates growth, development, and yields of a crop growing on a uniform area of land under prescribed or simulated management, as well as the changes in soil water, carbon, and nitrogen that take place under the cropping system over time. Databases describe weather, soil, experiment conditions and measurements, and genotype information for applying the models to different situations (Jones et al., 2003). It includes improved application programs for seasonal and sequence analyses that assess the environmental impacts associated with irrigation management, climate change, and variability and precision management. Moreover, it allows for changing the ambient CO2 concentration, which is very important in climate change impact studies because it has effects (in particular for C3 crops) on photosynthesis (i.e., biomass accumulation) and water use efficiency (considering stomatal conductance). DSSAT-CSM software defines "Minimum data set" (MDS) as the minimum set of data required to run the crop models and validate the outputs.

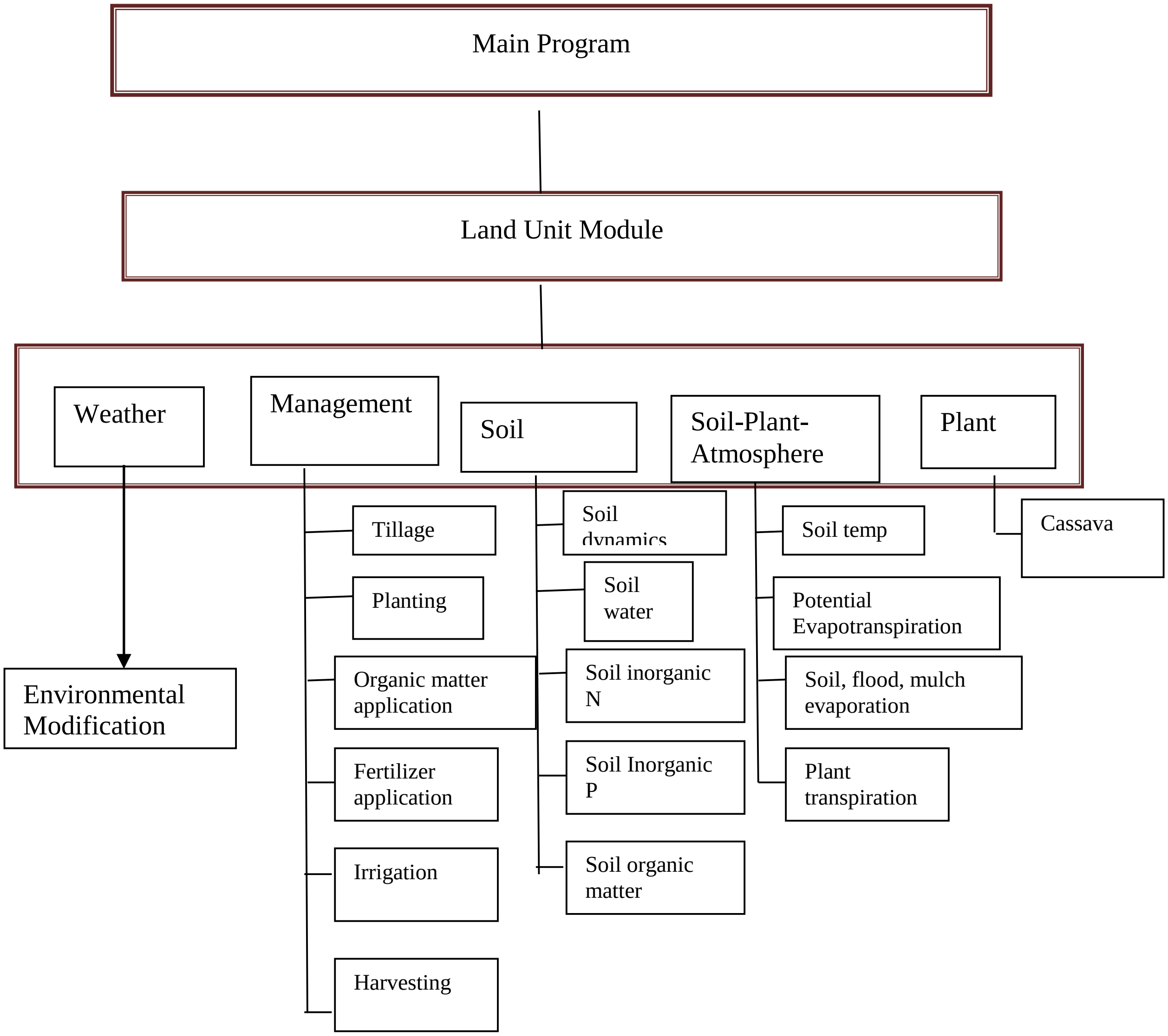
The MDS includes:

- Site weather data for the duration of the growing season. The MDS Weather data includes:
  - latitude and longitude of the weather station,
  - daily values of incoming solar radiation (MJ/m^2-day),
  - maximum and minimum air temperature (°C), and
  - rainfall (mm).
- Site soil data: The MSD Soil data includes soil classification (e.g. USDA/NRCS), surface slope, soil color, permeability, and drainage class. Soil profile data by soil horizons include upper and lower horizon depths (cm), percentage sand, silt, and clay (%), 1/3 bar bulk density, organic carbon, and pH in water.
- Management and observed data from an experiment: Information on planting date, dates when soil conditions were measured prior to planting, planting density, row spacing, planting depth, crop variety, irrigation, and fertilizer practices.

DSSAT software allows for changing the ambient CO2 concentration, which is very important in climate change impact studies because the ambient CO2 concentration has effects (in particular for C3 crops) on photosynthesis (i.e., biomass accumulation) and water use efficiency (considering stomatal conductance).

Although the minimum data set required for carrying out the analysis for cassava have been collected, the analysis has not been achieved completely due to the fact that the researcher requires some technical assistance and some level of capacity-building to be able to effectively use the DSSAT software. Objective 3 was realized using gross margin analysis, while objective 4 will be realized using the descriptive statistics, namely, means and frequency distribution and percentages.

Figure 3: DSSAT-CSM scheme



Source: Modified from Porter et al., 2000

The likelihood that the farmers engage in some actions to cushion the effect of climate change was determined using a probit model. The probit model is generally given as

$$\Pr(Y = 1 \mid X) = \Phi(X'\beta),$$

where Pr denotes probability, Φ is the Cumulative Distribution Function (CDF) of the standard normal distribution, and β is a vector of parameter estimates. The probit here is estimated in form of a latent variable model:

$$Y^* = X'\beta + \varepsilon, \text{ where } \varepsilon \sim N(0, 1).$$

Y* is the critical threshold level which, if exceeded, will indicate that the farmer employs the particular climate change cushioning effect, in this case, 1 for those that employ and zero otherwise. Thus, use of a cushioning effect against climate change Y=1 if the critical threshold is 1, zero otherwise.

The t decision to adopt a particular climate change cushioning effect was determined using a probit model. The cushioning activity, which over 30% of the farmers are practicing, was considered in the probit analysis. The description of the explanatory variables used in the model is presented in 3.

Polytomous or multinomial logistic regression was employed in the study to uncover the determinants of involvement in different farm management adaptive practices. The practices considered were those that over 40% of the farmers practiced. These include planting pest- and disease-resistant crops, use of early-maturing crop varieties, proper preservation of seeds and plant seedling used for planting, proper preservation of seeds and plant seedling used for planting, mixed farming practices, use of crops varieties that are well-acclimated, increase in number of weedings of cropped land, and listening to information about climate change. Those who are not practicing any other practices were included as the base variable. In general, the multiple polytomous logistic regression model for a categorical dependent variable with M levels is a series of M-1 equations, one for each independent odds, with each equation consisting of an intercept and K predictors. Assuming that the last or, M^{th}, category of the dependent variable is the reference category, the equations are of the form:

$$Log\ O_1 = \alpha^{1} + \beta_1^{1} X1 + \beta_2^{1}X_2 + \text{- - -}\ \beta_k^{1}X_k$$

$$Log\ O_2 = \alpha^{2} + \beta_1^{2}X_1 + \beta_2^{2}X_2 + \text{- - -} + \beta_k^{2}X_k$$

$$Log\ O_{m-1} = \alpha^{m-1} + \beta_1^{m-1}X_1 + \beta_2^{m-1}X_2 + \text{- - -}\ \beta_k^{m-1}X_k.$$

The Xs in the equation above are independent variables. As in logistic regression with binary response, parameters are estimated by maximizing the likelihood function for the sample responses on the dependent variable (Demaris, 1992). Also, the likelihood that the farmers use some land management practices to cushion the effect of climate change was also estimated using a probit model.

5. Results

5.1 Knowledge and Adaptation to Climate Change by Yam and Cassava Farmers

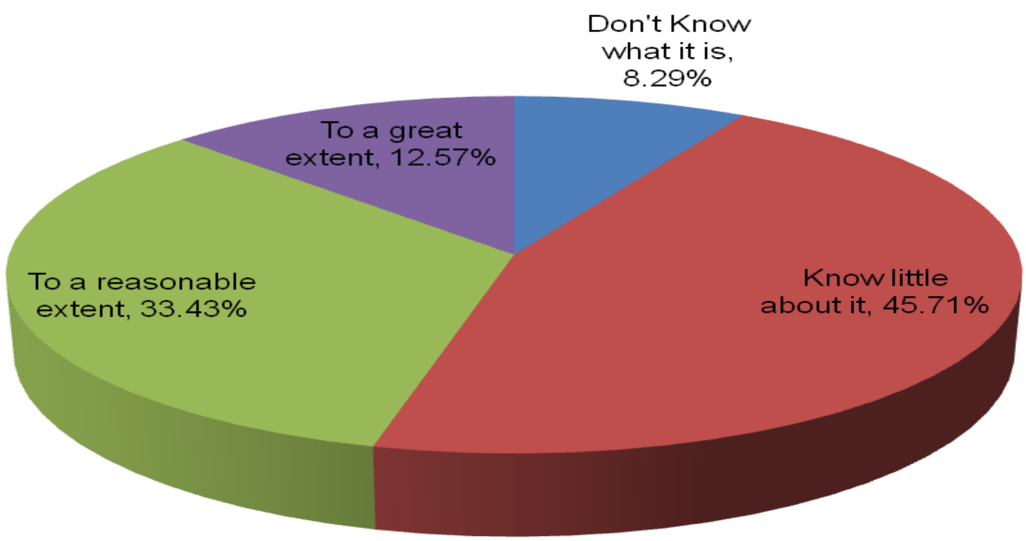
The results show that the majority (92.29%) of the respondents have noticed a significant temperature change. Also, the majority (96.76%) of the respondents have noticed a significant change in rainfall, and the majority (90.20%) had heard of climate change before the interview. However, the results presented in

Figure 4 shows that among those that had heard of climate change, the highest proportion (45.71%) know little about climate change.

Table 3: Description of the explanatory variables used in the model

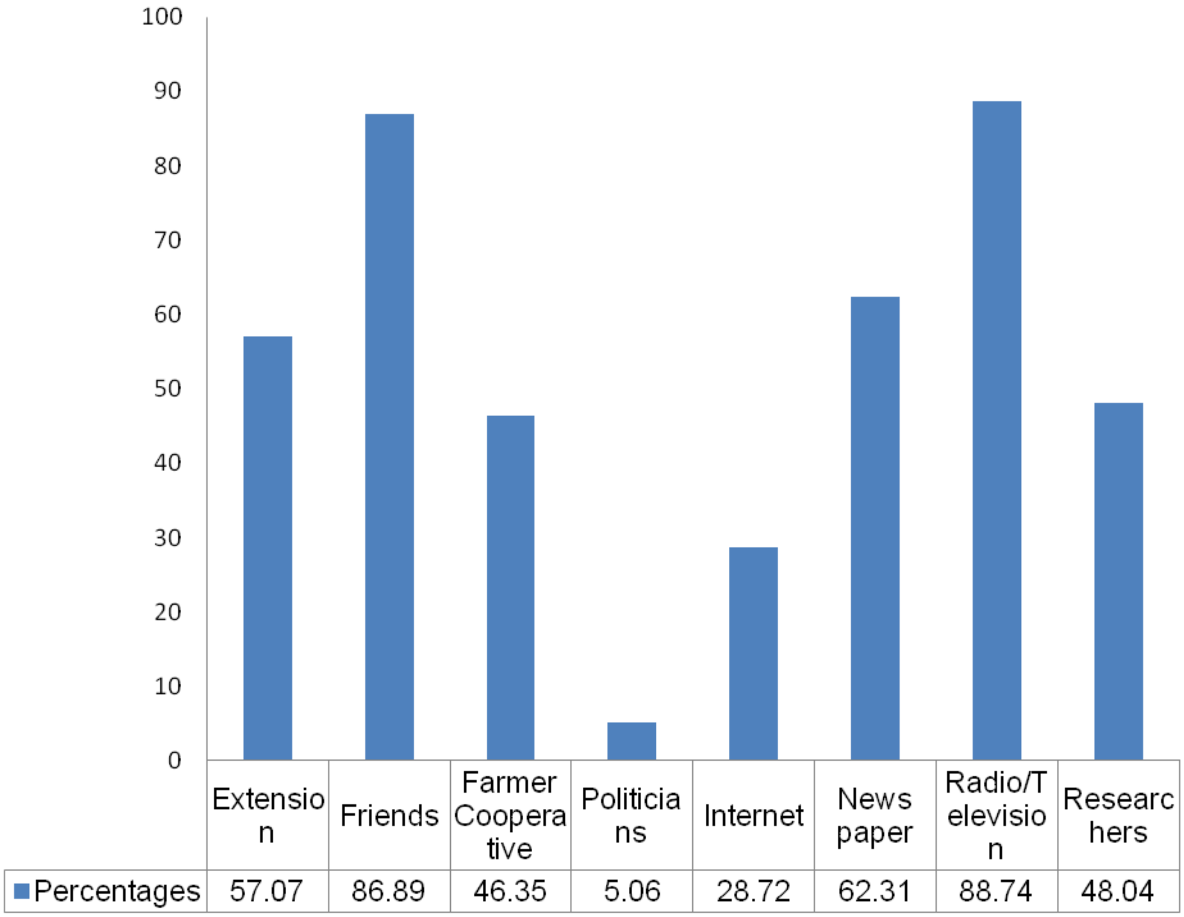
Variable	Description
Age of Household head	In number of years
Age2	In squared number of years
Number of years in school of household head	Number of years spent in school
Household Size	Household size of members of the household
Males over age 15	Number of males in the household that are above 15 years of age
Gender of household head – Malesb	Dummy takes the value of 1 if male and 0 otherwise
Agric Production activity	Dummy takes the value of 1 if household head involved in agric production activity (crop or livestock), 0 otherwise
Access to climate change information	Dummy takes the value of 1 if household head has access to climate change information, 0 otherwise
Amount loss due to climate change	The value of what the household head indicated he/she lost due to climate change (this is subjective)
Occupation -	Dummy takes the value of 1 if household head is Involved in agriculture (crop/animal production), 0 otherwise, non agric occupation.
Crop grown is both	Dummy takes the value of 1 if famer grows both cassava and yam, 0 otherwise, only one.

Figure 4: Extent of knowledge of climate change by respondents who have heard about it



The majority of respondents (80.56%) obtain information about climate change, while only 19.44% of the farmers do not get information about climate change. Figure 5 presents the channels through which farmers receive information regarding climate change.

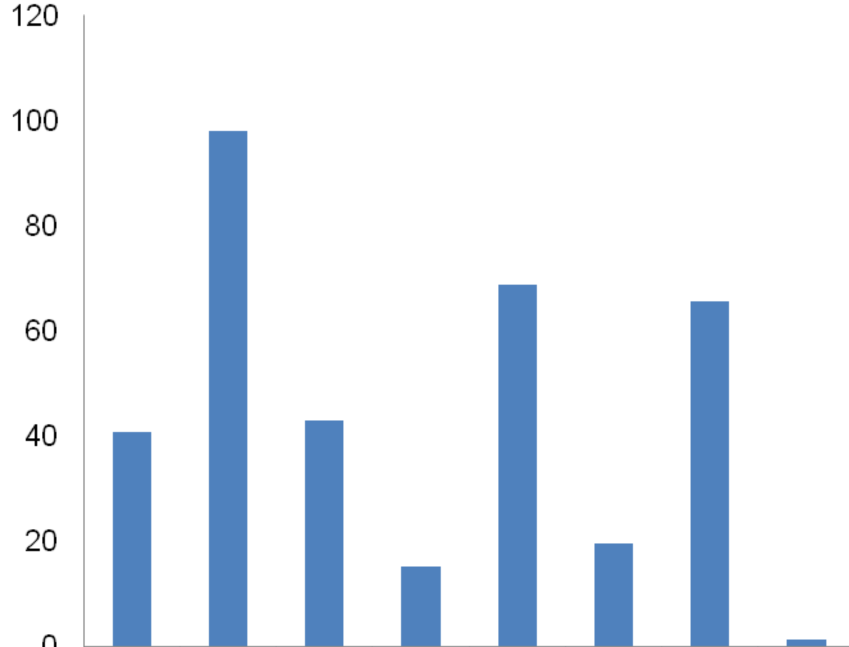
Figure 5: Famer's Sources of Information on Climate Change



The results show that the majority (88.74%) of the farmers obtain information on climate change through radio/television, 86.89% obtain information through friends, and 57.07% obtain information through agricultural extension workers. The smallest number of farmers (5.06%) obtain information on climate change through politicians.

Figure 6 presents the type of climate change observed by the farmers.

Figure 6: Type of Climate Change Observed

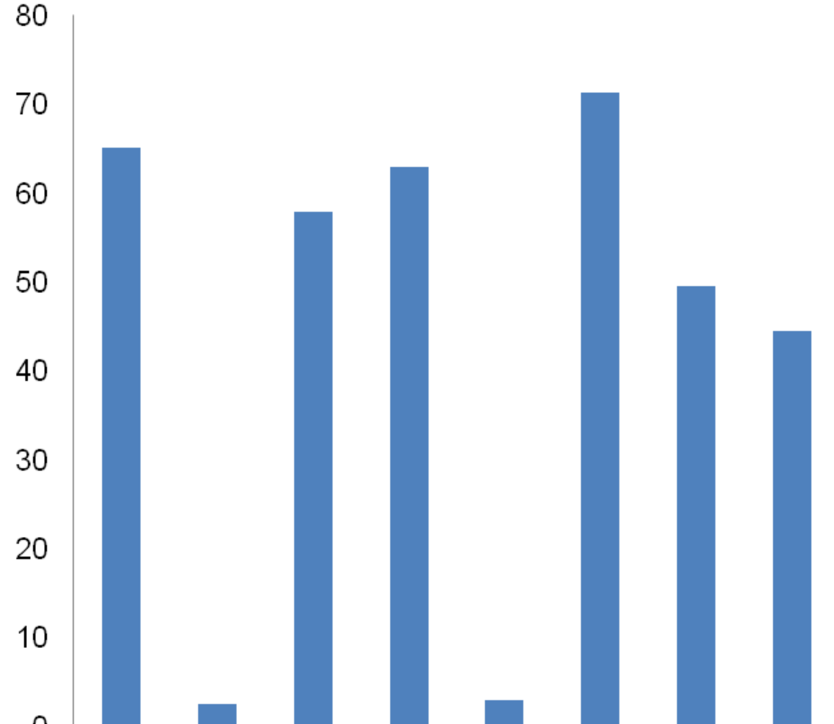


	More frequent drought	Delayed on-set of rainfall	Erratic rainfall patterns	Hailstorm	Too much rain	Less rain	Higher temperaturs	Normal
Type of Climate Change (in percentage)	40.84	97.97	42.82	15.1	68.81	19.55	65.59	1.24

The results show that the majority (97.97%) of the farmers observed delayed on-set of rains, too much rain (68.81%), and higher temperatures (65.59%). Only 1.24% reported no change in climate conditions.

Figure 7 presents the outcome of climate change.

Figure 7: Outcome of Climate Change

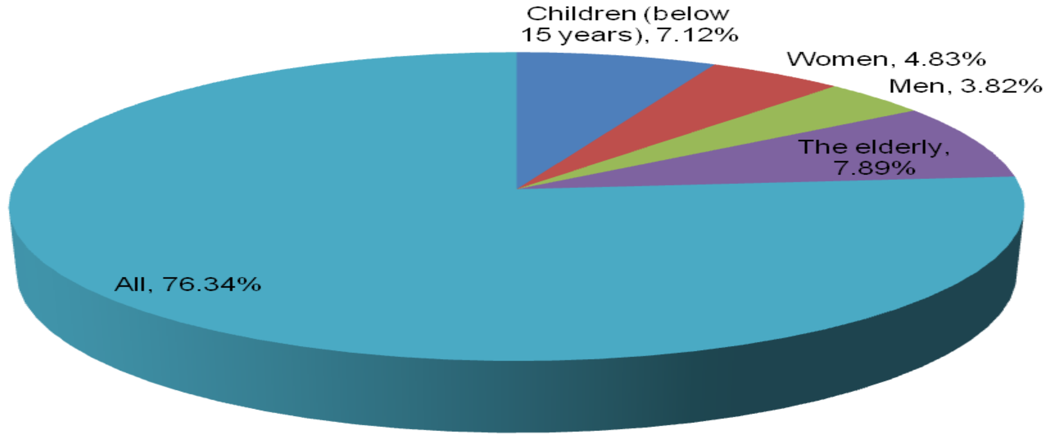


	Decline in crop yield	Increase in crop yield	Food shortage/insecurity	Food price increase	Early productivity	Flooding	Erosion harzard	Soil nutrient depletion
Outcome of Climate Change (in percentages)	65.1	2.48	57.92	62.87	2.97	71.29	49.5	44.55

The results show that the main outcomes of climate change were flooding (71.29%), decline in crop yields (65.1%), food price increase (62.87%), and food shortages/insecurity (57.92%). Very few farmers reported positive impacts of climate change, such as increased crop yields (2.48%). The average amount of loss to climate change was ₦164,318.8 naira.

On those most affected by climate change, the results presented in Figure 8 show that all the categories, as observed by the majority (76.34%) of the farmers, are affected by climate change.

Figure 8: Category of People Mostly Affected by Climate Change



On the actions taken to cushion the effect of climate change, the results presented in Figure 9 show that the highest proportion (45.05%) of farmers bought food, while 37.62% of them started using new farm management practices, 29.95% started non-farm activity, and 0.99% participated in food-for-work programs.

Figure 9: Actions taken by the farmers to cushion the effect of climate change

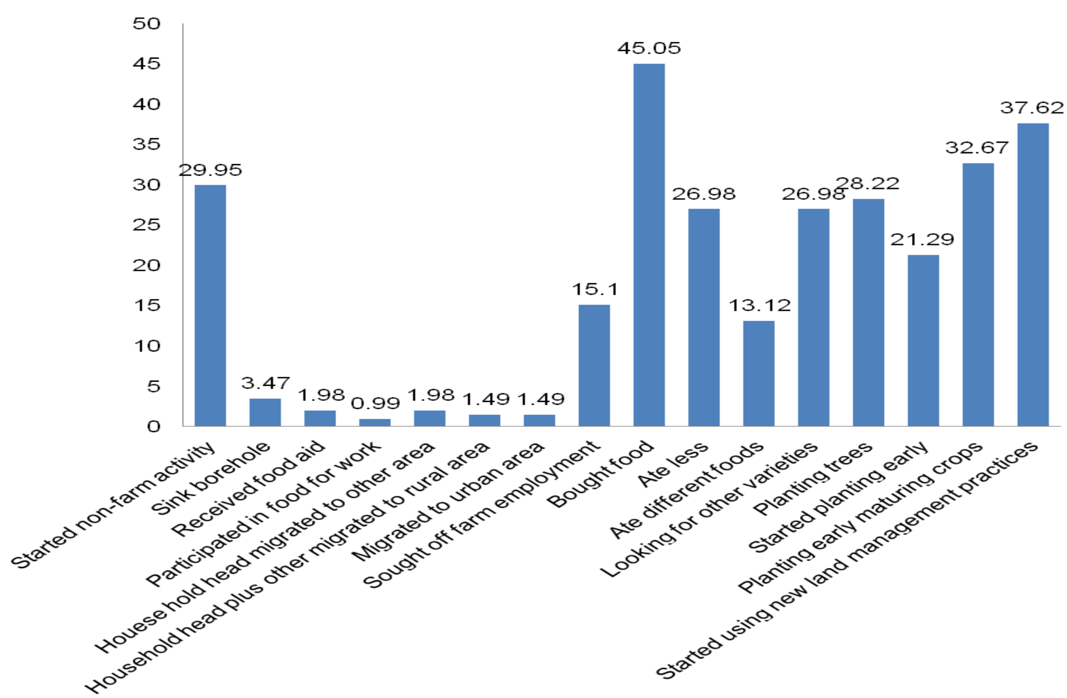


Table 4 presents farm management practices used by the farmers to adapt to climate change.

The major farm management adaptation practices used by farmers to cushion the effect of climate change include planting pest- and disease-resistant crops (56.68%), using crop varieties that are well-acclimatized (48.27%), proper preservation of seeds and plant seedling used for planting (49.75%), mixed farming practices (49.01%), and listening to information about climate change (47.03%).

Table 4: Adaptive Farm Management Strategies Used by the Farmers in Cushioning the Effects of Climate Change in Cassava/Yam Farming

S/No	Adaptive Strategies	% of farmers using the practice
1	Planting pest and disease resistant crops	56.68
7	Use of early maturing crop varieties	50.50
9	Proper preservation of seeds and plant seedling used for planting	49.75
12	Mixed farming practices	49.01
2	Use of crops varieties that are well acclimated	48.27
6	Increase in number of weeding of cropped land	47.28
15	Listening to information about climate change	47.03
5	Use of chemicals like herbicide, insecticide	38.61
8	Protection of water sheds and mulching	34.90
17	Changing harvesting dates	32.18
13	Change of planting date	31.93
19	Processing of crops to minimize post-harvest losses	31.93
16	Changing the timing of land preparation	30.69
14	Use of recommended planting distance	26.73
11	Reducing access to eroded and erosion prone area	25.99
4	Reforestation/Afforestation	25.25
20	Use of windbreaks/shelter belts	21.04
10	Use of weather-resistant variety	20.05
3	Use of irrigation system/water storage	8.91
18	Out migration from climate risk areas	2.48

Table 5 presents details of the land management practices used by those farmers who indicated that they engaged in such practices (38%).

Table 5: Percentage of Farmers Using Different Types of Land Management Practices to Adapt to Climate Change

S/No		% of farmers using the practice
1	Mulching/surface cover	83.55
19	Fallowing	74.34
12	Intercropping	72.37
10	Crop rotation	63.16
6	Increased Fertilizer	62.50
9	Cover crops	61.84
5	Farm yard manure	60.53
16	Erosion control	39.47
14	Removal of unwanted bush	38.16
8	Agroforestry	36.84
15	Soil improvement	35.53
4	Composting	34.87
11	Crop rotation with legumes (nitrogen fixing)	34.21
17	Replenishing soil fertilizer	26.32
18	Border cropping	7.24
13	Enclosure of the land	2.63
2	Trash line	1.97
7	Water harvesting	1.97
3	Infiltration ditches	1.32

Source: Field survey data 2012

The results show that the majority (74.34%, 83.55%, 72.37%, ad 60.53%) of the farmers keep their land under fallow, mulch/use surface cover, intercrop, and use farm yard manure, respectively, as a means of adapting to climate change.

5.2 Constraints to Climate Change adaptation

Farmers reported several constraints to climate change adaptation. The results presented in Table 6 show that the highest proportion of the farmers indicated that a lack of information (53.30%), no subsidies for inputs (40.66%), irregularity of extension services (30.69%), lack of access to improved crop varieties (30.87%), and poor government attention to climate change problems (31.55%) were to a very great extent constraining climate change adaptation.

Table 6: Constrains to Climate Change Adaptation

S/No	Problems	VGE	GE	TSE	LE	NE
1	Lack of information	53.30	26.65	8.12	11.42	0.51
2	Ineffectiveness of indigenous strategies	21.43	40.56	24.49	10.46	3.06
3	Irregularity of extension services	30.69	27.62	19.69	16.11	5.88
4	No subsidies for inputs	40.66	33.50	15.35	7.16	3.32
5	Lack of access to improved crop varieties	30.87	29.59	31.63	5.10	2.81
6	Absence of water management techniques	23.77	32.30	21.71	17.05	5.17
7	Poor government attention to climate problems	31.55	30.03	26.46	8.14	3.82
8	Low awareness level	26.48	33.42	29.82	5.66	4.63
9	Limited knowledge on adaptation measures	22.16	27.58	35.57	11.86	2.84
10	Cultural influence	14.10	14.36	18.21	24.10	29.23
11	Taboos	9.04	9.30	21.45	22.48	37.73
12	Inability to give up traditional values	8.46	20.00	23.59	21.28	26.67
13	Low institutional capacity	20.67	18.86	33.59	17.31	9.56
14	Absence of government policy on climate change	19.74	28.83	33.25	13.51	4.68
15	Others, specify	22.22	18.52	14.81	22.22	22.22

Source: Field survey data 2012

Note 5 = VGE (To A Very Great Extent), 4 = GE (To A Great Extent), 3= TSE (To Some Extent), 2= LE (To A Little Extent) and 1=NE (To No Extent)

5.3 Determinants of Adaptation Strategies Used by Farmers to Cushion the Effect of Climate Change

5.3.1 Determinants of Actions Taken by Farmers to Cushion the Effects of Climate Change

The study analyzed the actions taken by yam and cassava farmers to cushion the effects of climate change. This was done by first determining the number/percentage of actions taken by the farmers to cushion the effects of climate change and using probit analysis to find out the variables that influenced the different adaptation actions used by the famers. The parameter estimates are presented in Table 7, while the marginal effects are presented in Table 8. The actions considered were those that about 30% of the farmers practiced. These include starting non-farm activity, buying food, planting early-maturing crops, and using new land management practices.

Table 7: Parameter Estimates of the Probit Model of Determinants of Actions Taken by Farmers to Cushion the Effects of Climate Change

Explanatory Variable	**Coefficients**			
	Started non-farm activity	Bought food	Planted early maturing crops	Started new land management practices
Age of Household head	_0.028 (0.026)	0.040 (0.030)	0,151 (0.042)***	0.056 (0.030)*
Age2	0.0003 (0.0003)	-0.0005 (0.0003)	-0.0016 (0.0004)***	-0.0004 (0.0003)
Number of years in school	0.040 (0.015)***	0.038 (0.015)***	0.056 (0.015)***	0.059 (0.014)***
Household Size	0.036 (0.021)*	0.066 (0.021)***	0.064 (0.023)***	0.009 (0.021)
Occupation	0.016 (0.143)	0.043 (0.141)	-0.102 (0.150)	-0.212 (0.141)
Gender – Males	0.140 (0.214)	-0.307 (0.210)	0.024 (0.231)	-0.283 (0.206)
Grows both yam and cassava or otherwise	-0.076 (0.157)	0.667 (0.156)***	0.549 (0.171)***	0.297 (0.156)*
Constant	-0.564 (0.640)	-1.822 (0.668)	-5.226 (1.042)***	-2.388 (0.737)***

Source: Calculations from field survey data 2012
*, **, *** implies significance at 10%, 5% and 1% probability levels respectively, standard errors in parenthesis.

The results show that some factors significantly influenced the likelihood of famers getting involved in some actions to cushion and adapt to the effect of climate change. Number of years in school and household size significantly influenced the likelihood of a farmer starting non-farm activity, suggesting that farmers who spent more years in school, which is equivalent to those with more education, are more likely to engage in adaptation and mitigation practices. This also applies to those with large household size. The marginal effect presented in Table 8 shows that number of years spent in school influences the likelihood of a farmer starting a non-farm activity to cushion the effect of climate change by 1.4%. The interpretation of the effects of the remaining explanatory variables on adapting to farm management practices follows the same procedure.

Table 8: Marginal Effects of the Probit Model of Determinants of Actions Taken by Farmers to Cushion the Effects of Climate Change

Explanatory Variable	**Coefficients**			
	Started non-farm activity	Bought food	Planted early maturing crops	Started new land management practices
Age of Household head	-0.010 (0.009)	0.016 (0.011)	0.052 (0.014)***	0.021 (0.011)*
Age2	0.00009 (0.00009)	-0.00019 (0.0001)*	-0.00053 (0.00014)***	-0.00017 (0.00011)
Number of years in school	0.014 (0.005)***	0.015 (0.006)***	0.0.19 (0.005)***	0.022 (0.0054)***
Household Size	0.013 (0.007)*	0.026 (0.008)***	0.022 (0.008)***	0.0032 (0.0079)
Occupation	0.005 (0.049)	0.017 (0.056)	-0.-35 (0.051)	-0.080 (0.053)
Gender – Males	0.047 (0.069)	-0.122 (0.083)	0.0085 (0.079)	-0.109 (0.081)
Grows both yam and cassava or otherwise	-0.0.027 (0.054)	0.253 (0.055)***	0.177 (0.509)***	0.109 (0.056)**

Source: Calculations from field survey data 2012
*, **, *** implies significance at 10%, 5% and 1% probability levels respectively, standard erros in parenthesis.

5.3.2 Determinants of Farm Management Practices Used by Farmers to Cushion the Effects of Climate Change

The determinants of farm management practices used by farmers to adapt to climate change were also determined. The dependent variable is the choice of explanatory variables as detailed in Table 9: planting pest- and disease-resistant crops, use of early-maturing crop varieties, proper preservation of seeds and plant seedling used for planting, mixed farming practices, use of crops varieties that are well-acclimated, increase in number of weedings of cropped land, and listening to information about climate change. Those who are not practicing any other were included as the base variable.

Table 9: Description of Farmers' Adaptive Farm Management Practices

S/No	Adaptive farm management practices	Number of Farmers
1	Did Nothing	58
2	Planting pest and disease resistant crops	52
3	Use of early maturing crop varieties that are well acclimated	41
4	Proper preservation of seeds and plant seedling used for planting	45
5	Mixed farming practices	48
6	Use of crops varieties that are well acclimated	53
7	Increase in number of weeding of cropped land	69
8	Listening to information about climate change	38

Source: Calculation from field survey data, 2012

The estimation of the multinomial logit model for this study was undertaken by normalizing one category, which is normally referred to as the "reference state" or the "base category." In this analysis, the first category (did nothing) is the reference state. The result of the parameter estimates is presented in Table 10, while the result of the marginal effects is presented in Table 11.

The results show that some factors influenced the ability of the farmers to adapt to farm management practices like planting pest- and disease-resistant varieties. These are age of household head and gender (being male as against being female) (Table 10).

It is important to note that the parameter estimates of the MNL model provide only the direction of the effect of the independent variables on the dependent (response) variable; estimates do not represent actual magnitude of change or probabilities. Thus, the marginal effects from the MNL, which measure the expected change in probability of a particular choice being made with respect to a unit change in an independent variable, are reported and discussed. In all cases, the estimated coefficients should be compared with the base category of doing nothing in response to climate extreme events. Table 11 presents the marginal effects along with the levels of statistical significance. Being a male household head increases the probability of practicing mixed farming as a climate change adaptive practice by 9% (Table 11). The interpretation of the effects of the remaining explanatory variables on adapting to farm management practices follows the same procedure.

Table 10: Parameter Estimates of the Multinomial Logit of Adaptive Farm Management Practices by Famers to Climate Change

Explanatory Variable	**Coefficients**						
	Planting pest and disease resistant crops	Use of early maturing crop varieties	Proper preservation of seeds	Mixed farming practices	Use of crops varieties	Increase in number of weeding	Listening to information about cc
Age of Household head	-0.052 (0.209)***	-0.237 (0.209)	-0.101 (0.217)	-0.426 (0.186)**	-0.299 (0.188)	-0.446 (0.201)	0.018 (0.372)
Access to information on cc	-0.248 (1.140)	0.768 (1.124)	1.238 (1.290)	0.988 (1.016)	1.015 (1.060)	1.764 (1.161)	-0.520 (1.661)
Number of years in school	0.077 (0.113)	0.0076 (0.098)	0.0114 (0.086)	0.023 (0.082)	0.033 (0.080)	0.190 (0.080)**	0.202 (0.165)
Age2	0.007 (0.002)***	0.003 (0.002)	0.0006 (0.0024)	0.005 (0.002)**	0.0031 (0.0019)	0.0017 (0.0021)	-0.0006 (0.0042)
Gender – Males	21.343 (4.770)***	-0.511 (1.188)	0.716 (1.218)	1.308 (1.176)	0.359 (1.091)	-1.129 (1.086)	-1.704 (1.469)
Grows both yam and cassava or otherwise	0.805 (0.950)	0.737 (0.864)	1.099 (0.783)	0.860 (0.720)	0.789 (0.715)	1.813 (0.778)**	1.380 (1.422)
Occupation	0.0873 (1.067)	0.081 (0.876)	-0.533 (0.833)	0.296 (0.751)	0.098 (0.738)	-0.462 (0.770)	0.297 (1.313)
Amount of loss	-0.00001 ($6.27x10^{-6}$)*	$-4.42x10^{-6}$ ($2.99x 10^{-6}$)	$-1.76x10^{6}$ ($1.19 x 10^{6}$)	$--2.53x10-^{6}$ ($1.59x10-^{6}$)	$-5.46x10-^{7}$ ($7.14x10-^{7}$)	$-4.39x10^{-6}$ ($1.88x10-^{6)}$ **	$-3.26x10^{-6}$ $4.68x10^{-6}$)
Household size	-0.132 (0.176)	0.151 (0.145)	0.040 (0.134)	0.138 (0.123)	0.228 (0.121)*	0.410 (0.127)***	0.109 (0.212)
Constants	-0.7.573	3.051 (4.474)	0.285 (4.489)	6.327 (3.927)	3.741 (4.018)	-2.375 (4.432)	-2.462 (7.224)

Source: Calculations from field survey data 2012
*, **, *** implies significance at 10%, 5% and 1% probability levels respectively, standard errors in parenthesis.

Table 11: Marginal Effects of the Probit Model of Determinants of Actions Taken by Farmers to Cushion the Effects of Climate Change

Explanatory Variable	**Marginal Effects (dy/dx)**						
	Planting pest and disease resistant crops	Use of early maturing crop varieties	Proper preservation of seeds	Mixed farming practices	Use of crops varieties	Increase in number of weeding	Listening to information about cc
Age of Household head	-0.00038 (0.0004)	-0.0006 (0.010)	0.0158 (0.0143)	-0.042 (0.015)***	-0.0159 (0.0164)	0.0209 (0.0208)	0.0043 (0.0051)
Access to information on cc	-0.0018 (0.0029)	-0.0193 (0.082)	0.0282 (0.1008)	0.0011 (0.1307)	0.0074 (0.1451)	0.148 (0.110)	-0.0493 (0.0779)
Number of years in school	-1.154x10-6 (0.00009)	-0.0060 (0.0056)	0.0043 (0.0067)	-0.0118 (0.009)	-0.0106 (0.009)	0.0281 (0.0097)***	0.0021 (0.0028)
Age2	4.19x10-6 (0.00000)	0.00003 (0.0001)	-0.0002 (0.0002)	0.00046 (0.000016)***	0.00016 (0.00017)	-0.00018 (0.00022)	-0.00005 (0.000006)
Gender – Males	0.0287 (0.0221)	-0.031 (0.081)	0.077 (0.060)	0.192 (0.0678)***	0.0935 (0.1011)	-0.325 (0.164)**	-0.046 (0.0818
Grows both yam and cassava or otherwise	-0.00017 (0.00079)	-0.0217 (0.0568)	0.0131 (0.060)	-0.0272 (0.0852)	-0.047 (0.0913)	0.174 (0.082)**	0.0061 (0.022)
Agric production or other business	0.00097 (0.0015)	0.0130 (0.053)	-0.054 (0.0595)	0.0812 (0.0877)	0.0397 (0.0867)	-0.093 (0.0876)	0.0066 (0.0221)
Amount of loss	7.82x10-9 (0.00000)	-1.68x10-7 (0.0080)	8.20x10-8 (0.00000)	-2.12x10-8 (0.00000)	4.35x10-7 (0.00000)**	-4.95x10-7 (0.00000)	-1.44x10-8 (0.00000)
Household size	-0/0003 (0.0003)		-0.0203 (0.0094)**	-0.0142 (0.0122)	0.0054 (0.0123)	0.0517 (0.0142)***	-0.0017 (0.0031)

Source: Calculations from field survey data 2012

*, **, *** implies significance at 10%, 5% and 1% probability levels respectively, standard errors in parenthesis.

5.3.3 Determinants of Level of Land Management Practices Used by Cassava and Yam Farmers to Cushion the Effect of Climate Change

The study found the determinants of level of land management practices used by the farmers under cassava- and yam-cropping systems to cushion the effect of climate change. This was done by first determining the number/percentage of land management practices used by the farmers and using probit analysis to uncover the variables that influenced the different land management practices used by the farmers. The result of the parameter estimates of the determinants of land management practices employed by the farmers against climate change is presented in Table 12, while the marginal effect is presented in Table 13. The land management practices which over 50% of the farmers practicing land management used were considered in the probit analysis. The land management practices considered include mulching/surface cover, farmyard manure, increased fertilizer, cover crops, fallowing, crop rotation, and intercropping.

The results in Table 12 show that household size positively and significantly influenced the likelihood of the households practicing all the land management practices considered. The results also show that that a household head with more education is likely to be more experienced in land management. Also, access to climate change information positively and significantly influenced the use of increased fertilizer and crop rotation. Age and squared age variables significantly (at 10% probability level) influenced the likelihood of the household head practicing crop rotation. Considering that the age variable was included in the equation in linear and quadratic forms, the result shows that age had a negative effect on the likelihood of a household being involved in crop rotation practice until the age of 40 years ($X = -\beta_1/2\beta_2$; where β_1 = -0.158 and β_2 = 0.002), after which the effect becomes positive. These findings generally support those of Deressa et al (2008), who found that socioeconomic factors influenced coping with extreme climate events.

The results in Table 13 generally suggests that government policies and investment strategies that support the provision of and access to education, and information on climate and adaptation measures, labour provision measures (as reflected on large household size being positive to land management), are necessary for better land management to cushion the effects of climate change in the region.

Table 12: Parameter Estimates of the Probit Model of Determinants of Different Land Management Practice

Explanatory Variable	**Coefficients**						
	Mulching/surface cover	Farm yard manure	Increased Fertilizer	Cover crops	Fallowing	Crop rotation	Inter cropping
Age of respondents	-0.459 (0.089)	0.065 (0.066)	0.104 (0.075)	0.038 (0.074)	0.118 (0.070)	-0.158* (0.091)	0.0005 (0.078)
Age2	0.0004 (0.0008)	-0.0005 (0.0006)	-0.0008 (0.0007)	-0.0006 (0.0007)	-0.001 (0.0007)	0.002* (0.0009)	0.0001 (0.0007)
Number of years in school	0.016 (0.036)	0.067** (0.032)	0.186*** (0.043)	0.088*** (0.033)	0.044 (0.032)	0.044 (0.033)	0.050 (0.039)
Household Size	0.123** (0.060)	0.079* (0.047)	0.179*** (0.062)	0.206*** (0.058)	0.092* (0.050)	0.186*** (0.057)	0.328*** (0.077)
Number of household member aged 15 with primary education	-0.471*** (0.170)	-0.219 (0.151)	-0.287 (0.182)	0.022 (0.151)	0.141 (0.167)	-0.070 (0.146)	-0.063 (0.171)
Number of household member aged 15 with secondary education	0.115 (0.150)	-0.301** (0.118)	-0.550*** (0.163)	-0.128 (0.123)	0.207 (0.146)	-0.053 (0.127)	0.388 (0.183)
Number of household member aged 15 with university education	-0.054 (0.142)	-0.194 (0.118)	-0.510*** (0.159)	-0.191 (0.124)	-0.083 (0.129)	-0.222* (0.128)	-0.211 (0.152)
Males over age 15	-0.141 (0.168)	0.81 (0.140)	0.286 (0.172)	0.134 (0.149)	-0.095 (0.158)	0.123 (0.156)	-0.115 (0.182)
Gender – Males	0.716 (0.465)	0.198 (0.405)	-0.584 (0.526)	0.144 (0.448)	-0.371 (0.455)	0.111 (0.478)	-0.211 (0.571)
Agric trading business activity	-	-	-	-0.304 (0.602)	-0.383 (0.568)	0.088 (0.608)	0.173 (0.813)
Non-agric trading business activity	-0.800 (0.547)	-0.426 (0.512)	0.233 (0.574)	-0.605 (0.510)	-1.230** (0.521)	-0.581 (0.531)	-1.247** (0.596)
Public sector employment	-0.100 (0.411)	0.062 (0.334)	0.220 (0.449)	-0.445 (0.364)	0.201 (0.379)	0.282 (0.371)	-0.222 (0.431)
Artisan	-0.328 (0.714)	0.722 (0.723)	0.780 (0.940)	-1.077 (0.713)	-0.640 (0.705)	-0.047 (0.654)	0.819 (0.969)
Formal private employment	-1.179 (0.766)	-0.347 (0.704)	-0.947 (0.771)	0.004 (0.805)	-1.544** (0.688)	-0.675 (0.771)	-1.814** (0.898)
Access to climate change information	-0.501 (0.352)	0.308 (0.284)	0.942*** (0.328)	-0.224 (0.303)	0.049 (0.319)	0.641** (0.296)	0.382 (0.339)
Constant	1.537 (2.227)	-2.464 (1.662)	-5.153*** (1.985)	-2.016 (1.838)	-2.944* (1.735)	2.060 (2.202)	-2.209 (1.956)

Source: Calculations from field survey data 2012; *, **, *** implies significance at 10%, 5% and 1% probability levels respectively, standard errors in parenthesis.

Table 13: Marginal Effects from Probit Model of Determinants of Different Land Management Practice

Explanatory Variable	**Marginal Effects (dy/dx)**						
	Mulching/surface cover	Farm yard manure	Increased Fertilizer	Cover crops	Fallowing	Crop rotation	Inter cropping
Age of respondents	-0.009	0.025	0.035	0.013	0.033*	-0.055*	0.0001
Age2	0.00009	0.-0.0001	-0.0003	-0.0002	-0.0003	0.0005*	0.00002
Number of years in school	0.003	0.026**	0.062***	0.031***	0.012	0.015	0.011
Household Size	0.263**	0.031*	0.059***	0.072***	0.026*	0.064***	0.075***
Number of household member aged 15 with primary education	-0.100***	-0.084	-0.096	0.008	0.039	-0.024	-0.014
Number of household member aged 15 with secondary education	0.0245	-0.116**	-0.184***	-0.044	0.058	-0.018	0.088**
Number of household member aged 15 with university education	-0.011	-0.075	-0.170***	-0.066	-0.023	-0.077	-0.047
Males over age 15	0.030	0.031	0.095*	0.047	-0.026	0.043	-0.026
Gender – Males	0.196	-0.074	-0.168	0.051	-0.092	0.039	-0.044
Agric trading business activity	-	-0.168	-	-0.112	-0.121	0.029	0.035
Non-agric trading business activity	-0.236	0.023	0.073	-0.231	-0.444	-0.220	-0.416*
Public sector employment	-0.022	0.023	0.071	-0.161	0.541	0.094	-0.053
Artisan	-0.082	-0.237	0.196	-0.409*	-0.218	-0,016	0.119
Formal private employment	-0.386	-0.137	-0.360	0.001	-0.557**	-0.o258	-0.625**
Access to climate change information	-0.097	0.119	0.333***	-0.076	0.014	0.232**	0.093

Source: Calculations from field survey data 2012

*, **, *** implies significance at 10%, 5% and 1% probability levels respectively

6. Discussion of Findings and Conclusion

The study analyzed the impact of climate change on growth and yield of cassava and yam and determined the adaptation and coping strategies adopted by farmers in southern Nigeria. The study of farmers' adaptation to climate change was conducted using data from 400 farmers randomly selected from two States, Ebonyi and Enugu States of Southeast Nigeria. Crop model – DSSATv4 was used to evaluate cassava and yam for their vulnerability, the implications for future climatic change, and the expected magnitude of impacts.

The findings of the study revealed that the majority (92.29% and 96.76%) of the respondents have noticed a significant temperature change and a significant change in rainfall, while the majority (90.20%) had heard of climate change before the interview; however, the highest proportion (45.71%) of those who had heard about climate change know little about it. The climate change effects observed by the majority of the crop farmers are delayed on-set of rains (97.97%), too much rains (68.81%), and higher temperatures (65.59%). The main outcomes of climate change were flooding (71.29%), decline in crop yields (65.1%), food price increase (62.87%), and food shortages/insecurity (57.92%). The average amount of loss to climate change, as indicated by the farmers, was ₦164,318.8 naira. To cushion the effect of climate change, the highest proportion (45.05%) of the farmers bought food, while 37.62% of them started using new farm management practices and 29.95% started non-farm activity. In terms of land management practices used, the result shows that the majority (74.34%, 83.55%, 72.37%, ad 60.53%) keep their land under fallow, mulch/use surface cover, intercrop and use farmyard manure, respectively. In addition, planting pest- and disease-resistant crops (56.68%), using crop varieties that are well-acclimated (48.27%), proper preservation of seeds and plant seedling used for planting (49.75%), mixed farming practices (49.01%) and listening to information about climate change (47.03%) were the other adaptation mechanisms used by yam and cassava crop farmers. Number of years in school and household size significantly influenced the probability of starting non-farm activity to cushion the effect of climate change. Thus, policies to support non-farm activities and the provision of alternative livelihoods to farmers should focus more on educated farmers. It is expected that elderly people, farmers with good education, and those with large household size will plant early-maturing crops in order to cushion the effect of climate change. Policy measures that encourage access to education and those targeted at elderly people and large households should encourage the practice of planting these early-maturing crops.

Age, gender of household head (household head being a male), and amount of previous loss due to climate change significantly influenced the decision to plant pest- and disease-resistant crops as an adaptive farm management practice. Elderly farmers and male-headed households, as well as households that have lost a lot of money due to climate change, are more likely to plant pest- and disease-resistant crops. Thus, policies to encourage planting of these crops should focus more on male-headed households and households that have experienced some losses due to climate change since they will more likely to grab any opportunity to prevent further loss.

The results also show that household size positively and significantly influenced the likelihood of the households practicing all the land management practices considered, namely, mulching/surface cover, farmyard manure, increased fertilizer, cover crops, fallowing, crop rotation, and intercropping. Constraints to climate change adaptation in the agro-ecology zone include a lack of information about climate change, irregularity of extension services, poor government attention to climate problems, a lack of access to improved varieties, and no subsidies for inputs. Efforts should be made by governments to provide farmers with improved crop varieties, information on climate change, and subsidized inputs to help them cushion the effects of climate change.

References

Adger, W.N., and P. M. Kelly. 1999. "Social Vulnerability to Climate Change and the Architecture of Entitlements." *Mitigation and Adaptation Strategies for Global Change* 4(1999): 253-266.

Agrawal, A., and N. Perrin. 2008. "Climate Adaptation, Local Institutions, and Rural Livelihoods." Working Paper. Ann Arbor, Michigan: International Forestry Resources and Institutions Program and University of Michigan.

Akpene T., and Abdoulaye. 2013. "Smallholders Farmers' Perception of and Adaptations to Climate Change in the Nigerian Savannah." *Regional Environmental Change* 13(2): 375-388.

Apata, T.G., K.D. Samuel, and A.O. Adeola. 2009. "Analysis of Climate Change Perception and Adaptation among Arable Food Crop Farmers in South Western Nigeria." Contributed paper prepared for presentation at the International Association of Agricultural Economists' 2009 Conference, Beijing, China, August 16-22, 209.

Aye, G.C., and P.I. Ater. 2012. "Impact of Climate Change on Grain Yield and Variability in Nigeria: A Stochastic Production Model Approach." *European Scientific Journal*, Special Edition 89(25).

Ayinde, O. E. et al. 2010. "Empirical Analysis of Agricultural Production and Climate Change: A Case Study of Nigeria." *Journal of Sustainable Development in Africa* 12(6).

Boko, M. et al. 2007. "Africa Climate Change 2007: Impacts, Adaptation and Vulnerability." Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge UK, 433-467.

Brown, M.E., and C.C. Funk. 2008. "Food Security under Climate Change." *Science* 319: 580-581.

Bryant, R.C. et al. 2000. "Adaptation in Canadian Agriculture to Climate Variability and Change." *Climate Change* 45: 181-201.

Building Nigeria's Response to Climate Change (BNRCC). 2008. 2008 Annual Workshop of Nigerian Environmental Study Team (NEST): The Recent Global and Local Action on Climate Change, held at Hotel Millennium, Abuja, Nigeria; 8-9th October, 2008.

Central Bank of Nigeria (CBN). 2007. Statistical Bulletin, Publication of CBN, Nigeria.

Dami, A., F.A. Adesina, and S.S. Garba. 2011. "Adaptation Strategies to Environmental Change in the Nigeria's Section of the Chad Basin." *Journal of Geography and Geology* 3(1).

De Perthuis, C., S. Hallengatte, and F. Lecocq. 2010. Economie de L'adaptation au changement climatique, Conseil économique pour le développement durable, France.

Demaris, A. 1992. *Logit Modelling: Practical Applications*. Newbury Park: Sage Publications.

Deressa, T.T. et al. 2009. "Determinants of Farmers' Choice of Adaptation Methods to Climate Change in the Nile Basin of Ethiopia." *Global Environmental Change*, 248-255.

Deressa, T.T. et al. 2008. "Analyzing the Determinants of Farmers' Choice of Adaptation Measures and Perceptions of Climate Change in the Nile Basin of Ethiopia." International Food Policy Research Institute (IFPRI) Discussion Paper No. 00798. Washington, DC: IFPRI.

Deressa, T.T., and T. Hassan. 2010. "Economic Impact of Climate Change on Crop Production in Ethiopia: Evidence from Cross-section Measures." *Journal of African Economies* 18(4): 529–554.

Easton, P. B. 2004. "Education and Indigenous knowledge." In *Indigenous Knowledge. Local Pathways to Global Development. Marking Five Years of the World Bank Indigenous Knowledge for* Development Program. Eds. R. Woytek, P. Shroff-Mehta, and P. C. Mohan. Knowledge and Learning Group Africa Region: The World Bank. Retrieved from: http://worldbank.org/afr/ik/default.htm.

Egeru, A. 2012. "Role of Indigenous Knowledge in Climate Change Adaptation: A Case Study of Teso Sub-Region of Eastern Uganda." Indian Journal of Traditional Knowledge 11(2): 217-224.

Federal Ministry of Environment- Climate Change Department. 2011. National Adaptation Strategy and Plan of Action on Climate Change for Nigeria (NASPA-CCN). Abuja, Nigeria.

FEWS Net. 2006. Trip Report: Northern Nigeria Joint Food Supply Assessment Mission, Abuja, Nigeria.

Gleadow, R.M. et al. 2009. "Growth and Nutritive Value of Cassava (Manihot esculenta Cranz.) Are Reduced When Grown in Elevated CO2." *Plant Biology (Stuttg)*. 11 Suppl 1:76-82.

IPCC. 2001. Climate Change 2011. Syntheis report. Cambridge University Press.

IPCC. 2007. "Climate Change 2007: Impacts, Adaptation and Vulnerability." Contribution of Working Group II to the Forth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press. Cambridge.

Jones J.W., B.A. Keating, and C.H. Porter. 2001. "Approaches to Modular Model Development." Agricultural Systems 70:421-443.

Kapadonou, R.A.B, P.Y. Adegbola, and S.D. Tovignan. 2012. "Local Knowledge and Adaptation to Climate Change in Oueme Valley Benin." *African Crop Science Journal*, 20 (Supplement s2): 181-192.

Locatelli, B. 2001. Climate Change and Forests in the Congo Basin: Synergies between Adaptation and Mitigation. COBAM Project Brochure.

Madison, D. 2006. "The Perception of an Adaptation to Climate Change in Africa." CEEPA Discussion Paper N0. 10. Centre for Environmental Economics and Policy in Africa. South Africa, University of Pretoria.

Mendelsohn, R., A. Dinar, and A. Dalfelt. 2000. "Climate Change Impacts on African Agriculture." http://www.ceepa.co.za/Climate_Change/pdf/(5-22-01)afrbckgrnd-impact.pdf.

Nhemachena, C., and R. Hassan. 2007. "Micro-level Analysis of Farmers' Adaptation to Climate Change in South Africa." International Food Policy Research Institute Discussion Paper No. m00714. Washington DC: IFPRI.

Nweke, F. I. et al. 1997. "Cassava Production in Nigeria: A Function of Farmer Access to Market and to Improved Production and Processing Technologies." COSCA Working Paper No. 21. Collaborative study of cassava in Africa, International Institute for Tropical Agriculture, IITA, Ibadan, Nigeria.

Nzeadibe, T. C. et al. 2011. "Climate Change Awareness and Adaptation in the Niger Delta Region of Nigeria." African Technology Policy Studies Network (ATPS) Working Paper No. 57. Nairobi: ATPS. Available at www.atpsnet.org/Files/wps57.pdf.

_____. 2012. Indigenous innovations to climate change adaptation in the Niger Delta Region of Nigeria. Environment, Development and Sustainability, Vol 14, No 6.

Okonya, J.S, K. Syndikus, and J. Kroschel. 2013. "Farmers' Perception of and Coping Strategies to Climate Change: Evidence from Six Agro-ecological Zones of Ugada." Journal of Agricultural Science 5(8).

Oyenuga, V.A. 1967. Agriculture in Nigeria. Rome: Food and Agriculture Organization of the United Nations.

Porter, C., J.W. Jones, and R. Braga. 2000. "An Approach for Modular Crop Model Development." International Consortium for Agricultural Systems Applications. Available from http://icasa.net/modular/index.html.

Schmidhuber, J., and F.N. Tubiello. 2007. "Global Food Security under Climate Change." Proceedings of the National Academy of Sciences 104: 19703-19708.

Seo, S.N. and R. Mendelsohn. 2006a. "Climate Change Impacts on Animal Husbandry in Africa: A Ricardian Analysis." Centre for Environmental Economics and Policy in Africa (CEEPA) Discussion Paper No. 9. University of Pretoria, Pretoria: CEEPA.

_____. 2006b: "Climate Change Adaptation in Africa: A Microeconomic Analysis of Livestock Choice." Centre for Environmental Economics and Policy in Africa (CEEPA) Discussion Paper No.19. University of Pretoria, Pretoria: CEEPA.

SPORE. 2008. "Climate Change." Spore Special Issue, August 2008.

Stern, N. 2006. The Economics of Climate Change. Cambridge University Press.

UNFCC. 2007. Climate Change: Impacts, Vulnerabilities and Adaptation in Developing Countries. Bonn, Germany: Climate Change Secretariat (UNFCCC).

United Nations Development Programme (UNDP). 2007. “Fighting Climate Change: Human Solidarity in a Divided World.” Human Development Report 2007/2008. UNDP.

Appendix

Research Study: Analysis of Impact of Climate Change on Growth and Yield of Yam and Cassava and Adaptation Strategies by the Crops Farmers in Southern Nigeria

Name of Enumerator: ……………………………………………………………………..

Name of Supervisor: ……………………………………………………………………….

State: ………………………………………………………………………………………

Location: ………….…. Name: …………. Code: ……………

Name of Respondent ___________________ Person id _________

SECTION A: HOUSEHOLD COMPOSITION

Please report the household composition. Please note: A "household" includes all members of a common decision making unit (usually within one residence) that are sharing the same household resources. These include dependents who are away from home.

PID*	Name of hh member above 14 years old	Age	Relationship to household head[1](HH)	Gender 1=male 2=female	Level of education[2]	Primary Activity[3]	Number of years in school
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							

* PID = Personal identification number

[1] **Relationship to head:** 1=head, 2=spouse, 3=child, 4=siblings, 5=other family member, 6=non-family member, 99=others

[2] **Level of education:** 1=no formal education, 2= adult literacy training, 3=some primary education, 4=completed primary education, 5=some secondary education (incl. junior secondary school), 6=completed secondary education, 7=post-secondary education, 8=Koranic education, 99=others

[3] **Primary activity**: 1=crop production, 2=livestock production, 3= fisheries, 4=forest production and/or harvesting 5=Agricultural Trading business 6=Non-Agricultural Trading business 7 = Transportation business 8 = Agricultural processing 9 = Formal private employment 10= Construction 11 = Mining/quarrying 12 = Public sector employment/ 13 = Domestic duties 14 = student In school (any type), 15=Retired, 16= unemployed, 17=handcraft, 18=artisans (incl. mechanics), 19=traditional medical practitioners 99=Others (specify

Children below 15 years

	Total	Female	Male
1. Household members 10 - 14 years old			
2. Household members 6 -9 years old			
3. Household members below 6 years old			

Marital status of household head - 1) married (monogamous) ----- (2) married (polygamous -------- (3) Informal/loose union ------- (4) Divorced --------- (5) Separated ----------- (6) widowed --------------------- (7)Never married --

Religion of head_______________________________

SECTION B: KNOWLEDGE AND ADAPTATION TO CLIMATE CHANGE

Have you noticed a significant temperature change yes --------- No-----------

Have you noticed a significant change in rainfall yes ---------- No -------------

Have you heard of climate change before now? Yes ( ) No ( )

8. If yes, to what extent do you know about climate change? (a) Don't know what it is ( )

(b) Know little about it ( ) (c) To a reasonable extent ( ) (d) To a great extent ( )

9. From your understanding how will you describe it to a friend? ______________________

____

____

10. Does information regarding climate change get to you? (a) Yes ( ) (b) No ( )

If yes, from which sources/channels do you get information on climate change?

Sources	Yes	No
Extension workers		
Friends		
Farmer's cooperatives		
Politicians		
Internet		
Newspapers		
Radio/Television		
Researchers		
Others (specify)		

11. Type of climate change observed: (i) More frequent drought --------------------------- (ii) Delayed on-set of rainfall --------------------------- (iii) Erratic rainfall patterns ------------------- (iv) Hailstorm ---------------------

(v) Too much rain ---------------- (vi) Less rain ---------------- (vii) Higher temperatures -------------------------- (viii) Normal ----------------- (ix) Others (specify) --

12. What has been the outcome from climate change (i) Decline in crop yield -------------------- (ii) Increase in crop yield (iii) Food shortage/insecurity----------------------------------- (iv) Food price increase ------------------- (v) Early productivity --------------------- (vi) Flooding -------------------- (vii) Erosion hazard --------------------- (viii) Soil nutrient depletion -------------------------- (ix) Others (specify) --

13. Who has been the most affected by climate change (i) children (below 15 yrs) ----------------- (ii) Women ----------------------- (iii) Men -------------------------- (iv) the elderly ------------------------ (v) All -----------------------

14. What action have you taken (i) Started non-farm activity -------------- (ii) Started using new land management practices ---------------- (iii) Received food aid ----------------------- (iv) Participated in food for work ----------------- (v) HH head migrated to other rural area --------------- (vi) HH head plus other migrated to rural area ------------------------ (vii) Migrated to urban area ------------------- (viii) Sought off-farm employment ---------------------------- (ix) Bought food --------------------- (x) ate less ------------------ (xi) ate different foods ---------------- (xii) looking for other varieties --------------------- (xiii) Planting trees --------------- (xiv) Started planting early ------------------ (xv) planting early maturing crops ------------------- (xvi) Sink borehole ----------------

15. Amount of loss due to climate change (Naira) --

16. What (if any) land management practices have you used to address climate change:

S/No	Land management Practice	Response (Yes/No)	Year respondent started using the practice
1	Mulching/surface cover		
2	Trash line		
3	Infiltration ditches		
4	Composting		
5	Farm yard manure		
6	Fertilizer		
7	Water harvesting		
8	Agroforestry		
9	Cover crops		
10	Crop rotation		
11	Crop rotation with legumes (nitrogen fixing)		
12	Intercropping		
13	Enclosure of the land		
14	Removal of unwanted bush		
15	Soil improvement		
16	Erosion control		
17	Replenishing soil fertilizer		
18	Border cropping		
19	Fallowing		

17. Type of climate change addressed by above management practice

S/No		Type of climate change		
		Rainfall change	Temperature change	Other changes (specify)
1	Mulching/surface cover			
2	Trash line			
3	Infiltration ditches			
4	Composting			
5	Farm yard manure			
6	Fertilizer			
7	Water harvesting			
8	Agroforestry			
9	Cover crops			
10	Crop rotation			
11	Crop rotation with legumes (nitrogen fixing)			
12	Intercropping			
13	Enclosure of the land			
14	Removal of unwanted bush			
15	Soil improvement			
16	Erosion control			
17	Replenishing soil fertilizer			
18	Border cropping			
19	Fallowing			

18. Adaptive Farm Management Strategies Adopted by the Respondents in Cushioning the Effects of Climate Change on Cassava/Yam Farming

S/No	Adaptive Strategies	Used	Year started
1	Planting pest and disease resistant crops		
2	Use of crops varieties that are well acclimatized		
3	Use of irrigation system/water storage		
4	Reforestation/Afforestation		
5	Use of chemicals like herbicide, insecticide		
6	Increase in number of weeding of cropped land		
7	Use of early maturing crop varieties		
8	Protection of water sheds and mulching		
9	Proper preservation of seeds and plant seedling used for planting		
10	Use of weather-resistant variety		
11	Reducing access to eroded and erosion prone area		
12	Mixed farming practices		
13	Change of planting date		
14	Use of recommended planting distance		
15	Listening to information about climate change		
16	Changing the timing of land preparation		
17	Changing harvesting dates		
18	Out migration from climate risk areas		
19	Processing of crops to minimize post-harvest losses		
20	Use of windbreaks/shelter belts		
21	Others specify		

SECTION C: CONSTRAINTS TO CLIMATE CHANGE ADAPTATION

Tick under the appropriate options, problems encountered in climate change adaptation.

KEY: 5: To A Very Great Extent (VGE), 4: To A Great Extent (GE), 3: To Some Extent (TSE), 2: To A Little Extent (LE) 1: To No Extent

S/No	PROBLEMS	VGE	GE	TSE	LE	NE
1	Lack of information					
2	Ineffectiveness of indigenous strategies					
3	Irregularity of extension services					
4	No subsidies on planting materials					
5	Lack of access to improved crop varieties					
6	Absence of water management techniques					
7	Poor government attention to climate problems					
8	Low awareness level					
9	Inability to access available information					
10	Limited knowledge on adaptation measures					
11	Cultural influence					
12	Taboos					
13	Inability to give up traditional values					
14	Low institutional capacity					
15	Absence of government policy on climate change					
16	Others, specify					

SECTION D: COST AND RETURNS FROM FARMING

Report the Cost of Seed/Planting Material and Fertilizer that you Bought

Crop (i) Yam------------------------------ (ii)Cassava ------------------ (iii) Both --------------

Seed/planting material Variety: (i) Improved -------------------------------- (ii) Unimproved -------------------- ------------------

Quantity Bought --------------------------------------

Units for yam – (i) bags ----- (ii) Tubers ----- (iii) Heap ------ (iv) Pick-up ------ (v) Basin ----- (vi) wheelbarrow -----

Units for cassava - (i) bags ----- (ii) Tubers ----- (iii) Heap ------ (iv) Pick-up ------ (v) Basin ----- (vi) wheelbarrow -----

Quantity Sold ---

Units for yam – (i) bags ----- (ii) Tubers ----- (iii) Heap ------ (iv) Pick-up ------ (v) Basin ----- (vi) wheelbarrow -----

Units for cassava - (i) bags ----- (ii) Tubers ----- (iii) Heap ------ (iv) Pick-up ------ (v) Basin ----- (vi) wheelbarrow -----

Fertilizer (i) NPK --------- (ii) Urea --------- (iii) SSP ----------- (iv) Sulphate of Ammonia -------------- (v) Lime -------- (vi) CAN----------- (vii) Busta ----------- (viii) Manure ------------ (ix) NPK+Urea Mixture ---- ----------

Unit for fertilizer - (i) bags ----- (ii) tons ----- (iii) litres ------ (iv) Pick-up ------ (v) kg ----- (vi) wheelbarrow -----

Price of fertilizer (Naira per unit) --

Cost of no fertilizer agrochemical ---

Cost of all other inputs ---

Labour Input

What is your land preparation method (i) hand hoe ------------------- (ii) Oxen ------------------ (iii) tractor/mechanized -------------------- (iv) Chemical ------------------ (v) tractor and oxen ----------- (vi) Slash and burn ----------------------------- (vii) Others (specify) -------------------------------------

Land preparation family labor (total labour days) ---

Land preparation hired labour (total labour days) --

Weeding family labor (total labour days) --

Weeding hired labour (total labour days) --

Chemical fertilizer application hired labor (total labour days) ----------------------------------

Chemical application family labour (total labour days) --

Organic input application hired labour (total labour days) ---------------------------------------

Organic input application family labour (total labour days) -------------------------------------

Pest control family labour (total labour days) ---

Pest control hired labour (total labour days) ---

Harvesting family labour (total labour days) ---

Harvesting hired labour (total labour days) ---

Labour input in all activities family labour (total labour days) -------------------------

Labour input in all activities hired labour (total labour days) -----------------------------------

Cost of labour day in your locality (average daily wage) --

Crop Marketing

Crop grown (i) Yam --------------- (ii) Cassava ------------------ (iii) Both ----------------

Quantity produced in the last season (i) yam ------ (ii) Casava ----- (iii) Both -----

Units for yam – (i) bags ----- (ii) Tubers ----- (iii) Heap ------ (iv) Pick-up ------ (v) Basin ----- (vi) wheelbarrow -----

Units for cassava - (i) bags ----- (ii) Tubers ----- (iii) Heap ------ (iv) Pick-up ------ (v) Basin ----- (vi) wheelbarrow -----

Quantity sold: ---

Quantity stored: --

Farm gate price (Naira/unit) ---

Which household member decides to sell (i) Household head --------------------- (ii) Household head and spouse ----------------- (iii) Spouse only --------------------- (iv) Entire family ----------------- (v) Female household member ------------ (vi) Male household member -------------------- (vii) Household member other than household head and spouse ----------------- (viii) Non-household member ----------------------

What's your marketing method (i) individual ------------------------- (ii) through a group ---------------------

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