Indigenous Agricultural Adaptation to Climate Change: Study of Southeast Nigeria

African Technology Policy Studies Network

RESEARCH PAPER | No. 6

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Published by the African Technology Policy Studies Network
P O Box 10081, 00100 GPO Nairobi Kenya

ISBN: 978-9966-030-00-9

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Acknowledgement

This paper was produced as part of the implementation of the African Technology Policy Studies Network (ATPS) Phase VI Strategic Plan, 2008-2012 funded by ATPS Donors including the Ministerie von Buitenlandse Zaken (DGIS), the Netherlands, Rockefeller Foundation, amongst others. The authors hereby thank the ATPS for the financial and technical support during the implementation of the program. The Authors particularly thank the ATPS Climate Sense Program Director, Dr. Kevin Urama (ATPS), and the program coordinators including Prof. Francis Mutua (ATPS Kenya), Dr. George Owusu Essegbey (Council for Scientific and Industrial Research (CSIR), Ghana, Prof. Eric Eboh (ATPS Nigeria), Dr. Nicholas Ozor (ATPS), and Ms Wairimu Mwangi (ATPS) for their technical support during the research process.

Abstract

Climate change has direct impact on agricultural production, because of the climate-dependent nature of agricultural systems. This impact is particularly significant in developing countries where agriculture constitute employment and income sources for the majority of the population. This project was aimed at promoting understanding of the most cost-effective and sustainable indigenous climate change adaptation practices in southeast Nigeria. The study was conducted in two randomly selected states of the region namely Imo and Enugu, and in four randomly selected agricultural zones, two from each state. The data was analyzed using descriptive and relational statistics and tools. The result of the analysis shows that In the face of extreme weather events occasioned by climate change, and apparently because of its tolerance to these conditions, cassava, has become the dominant food crop in the area. Virtually all the respondents reported that extreme weather events and uncertainties in the onset of farming season have been on the increase. In addition, they were also aware of the effect of climate change on agriculture, but were not aware that some agricultural practices could exacerbate climate change. In general, it was reported that uncertainties in onset of farming season and extreme weather events were significantly higher for Imo than for Enugu state. However, the overall impact (farm yield and income) was significantly higher for Enugu than for Imo state. This is perhaps attributable to the fact that Enugu State has a drier weather; being closer to the North, and hence inherent insufficient rain water for maximum crop yield.

The biggest effect of climate change in the region was reduced farm yield and income, drying up of streams/rivers, reduction in storage quality of crops, loss of pastureland/vegetation and destruction of wildlife ecosystem. Some of the coping strategies adopted by the farmers with a relatively high profitability index include multiple/intercropping, agro-forestry/aforestation, mulching, purchase/harvest of water for irrigation and use of resistant varieties. The major factors identified to be driving farmers' investment in adaptation practices were age, level of formal education and level of awareness of climate change issues. The major factors constraining them from adapting to climate change were poverty; farmland scarcity and inadequate access to more efficient inputs, lack of information and poor skills, land tenure and labour constraints. The findings underscore the need for farmers' education, awareness creation, poverty alleviation and increased access to more efficient inputs as potent tools for climate change adaptation in the area.

1. Introduction

1.1 Background information and Problem Statement

Climate change is perhaps the most serious environmental threat facing mankind worldwide. It affects agriculture for instance in several ways, one of which is its direct impact on food production. Climatic change, which is attributable to natural climate cycle and human activities, has adversely affected agricultural productivity in Africa (Ziervogel et al. 2006). As the planet warms, rainfall patterns shift, and extreme events such as droughts, floods, and forest fires become more frequent (Zoellick 2009), which results in poor and unpredictable yields, thereby making farmers more vulnerable, particularly in Africa (UNFCCC, 2007). Farmers (who constitute the bulk of the poor in Africa), face prospects of tragic crop failures, reduced agricultural productivity, increased hunger, malnutrition and diseases (Zoellick 2009). It is projected that crop yield in Africa may fall by 10-20% by 2050 or even up to 50% due to climate change (Jones and Thornton, 2003), particularly because African agriculture is predominantly rain-fed and hence fundamentally dependent on the vagaries of weather. As the people of Africa strive to overcome poverty and advance economic growth, this phenomenon threatens to deepen vulnerabilities, erode hard-won gains and seriously undermine prospects for development (WBGU 2004, Zoellick 2009).. There is therefore the need for concerted efforts toward tackling this menace.

Much of climatic change agricultural research has tended to concentrate on assessing the sensitivity of various attributes of crop systems (e.g. crop/livestock yields, pest, diseases, weeds etc) - the bio-physical aspects of food production, with little or no regard to the socioeconomic aspects. These partial assessments, most often consider climatic change effects in isolation, providing little insight into the level of awareness of the farmers on the issue, what and how they are doing to cope with climate change, etc. To better address the food security concerns that are central to economic and sustainable development agenda, it is desirable to also address these aspects of climate change and agriculture. Wisner et al (2004) reports that the vulnerability of agriculture is not determined by the nature and magnitude of environmental stress like climate change per se, but by the combination of the societal capacity to cope with and/or recover from environmental change.

While the coping capacity and degree of exposure is related to environmental changes, they are both also related to changes in societal aspects such as land use and cultural practices. This could be at the root of the much talked about poverty alleviation and food security for the vulnerable groups in Africa, who are most at risk when agriculture is stressed by climate change, as noted before. In addition, there is need for increased awareness, teaching, learning and research by Universities and Research Institutes so as to develop a multi-pronged capacity to tackle this imminent danger which is slowly eroding the gains of the fight against starvation, hunger and poverty among farming communities in Africa. This project aims to provide the most cost-effective and sustainable indigenous climate change adaptation practices in southeast Nigeria.

1.2 The Objectives of the Study

(I) Examine the awareness of climate change and its link with agriculture among farmers in the area;
(ii) Identify the activities of farmers that contribute to climate change in the area;
(iii) Examine the patterns of climate change impact on agriculture in the area;
(iv) Identify the indigenous adaptation practices used by farmers in the area
;(v) Estimate the costs and returns of these adaptation practices;
(vi) Identify factors influencing the adoption of these adaptation strategies in the area; and
(vii) Identify the problems encountered by farmers in adapting to the effects of climate change.

1.3 Study Justification

The agrarian rural poor are the target group of this study as they are at the receiving end of climate change impact. This is because they are the people most exposed to the risks involved, as they bear the burden of losses in agricultural productivity. With appropriate cost effective adaptation practices in place, the vulnerability of these farmers to climate change will be minimized. The findings will therefore bring about increased outputs for farmers and hence enhanced income and reduced poverty.

The findings will also be beneficial to researchers and academics because it will provide them with (i) improved capacity to deal with issues of climate change and agriculture; (ii) opportunities for further research in the area and linkages with colleagues, institutions and civil society organizations working in the area. This is because, outside the research team, other academics will be involved in the conferences and workshops to review the findings of the research and disseminate the results. Moreover, the scientific publications that will arise from the study will also be directed at the academic/research community.

Young professionals will also gain immensely from the study. For instance, the research team has one graduate student member. The study has therefore not only improved his knowledge of the subject matter, but also exposed him to practical research training including proposal writing. Moreover, the improved capacity of the academics as noted above is also expected to enrich their classroom teaching on the subject, hence improved knowledge for the larger students on climate change and agriculture.

The study will also particularly be beneficial to the research team in the areas of knowledge acquisition/capacity enhancement, linkages and networking opportunities, publications for professional growth, relevance and visibility.

The finding will be highly beneficial to the NGOs for evidence based policy advocacy and public awareness creation on climate change adaptation and mitigation. This is because the information provided by the study will not only make their (the NGOs) message in this area focused but also garnished with concrete evidence on what the situation on ground is. In this way, their climate change activities will be more relevant and with the desired impact of building the support of the masses, government and donor agencies, for sustainable adaptation practices, policy initiatives and further research funding in the area.

Africa already has her hands filled with a lot of crises, such that we need to all work together to ensure that policy makers map out strategies to tackle climate change. This can only be possible with facts from research. This research therefore hopes to equip policy makers with the needed information for appropriate legislation regarding agricultural adaptation to climate change.

2. Study Methods

2.1 The Study Area

Southeast Nigeria is located within Longitudes 5o 30I&9o 30I E and Latitudes 4o 30I &7o 00I N. It occupies a land area of 75,488Km2. and comprises nine states namely Abia, Akwa Ibom, Anambra, Bayelsa, Cross River, Ebonyi, Enugu, Imo, and Rivers. These states fall into two geopolitical zones in Nigeria namely the south-south and southeast. While, Akwa Ibom, Bayelsa, Rivers and Cross River are in the south-south, Abia, Anambra, Ebonyi, Enugu and Imo are in the southeast. The region has a total population of 31,371,941 and an average population density of 416 persons per square kilometer. This average however conceals the true picture of population pressure in the region as Okafor (1991) noted that a prima facie evidence of population pressure has been established and that the region stands out prominently on maps of Sub- Saharan Africa showing population distribution and high crude densities. Similarly, Madu (2005) has shown that population pressure is the most important problem of rural development in the region. The effects of population pressure in the area have been recognized in a broad spectrum of livelihood activities such as intensive agriculture, engagement in non-farm activities and migration.

2.2 Sampling Procedure and Data Collection

This study was done in southeast geo-political zone, comprising Abia, Anambra, Ebonyi, Enugu and Imo. The zone is particularly vulnerable to ecological problems, especially soil erosion in all forms (Ofomata 1985, Oti, 2002); two states were randomly selected from these for the study. These were Enugu and Imo states. In each selected state, two agricultural zones were then randomly selected. These were Owerri and Okigwe in Imo state and Enugu and Nsukka in Enugu state. In each agricultural zone and with the assistance of the extension services Department, farming communities were compiled, from which two communities were randomly selected making a total of eight communities for the study. These were Ugwuene in Agwu and Amaechi in Nkanu, all in Enugu agricultural zone; Umualumo in Okigwe and Okwe in Onuimo, all in Okigwe agricultural zone; Ovoko and Akpa-Edem, in Nsukka agricultural zone; Amaigbo and Okpuala in Owerri agricultural zone. In each selected community, a list of farm households was compiled, also with the assistance of extension agents, from which fifty farmers were randomly selected, bringing the total sampled respondents to four hundred for the study. The data collected include status of awareness of climate change and its link with agriculture, crops grown, animals kept, land use practices that could exacerbate climate change, effects of climate change on the farmers' farm activities, their coping strategies, estimated costs and returns of these strategies, problems encountered in coping with climate change, etc.

2.3 Data Analysis

Objectives (i), (ii), (iv) and parts of (iii) were achieved using descriptive statistics, the other part of objective (iii) was achieved using t-test. Objective (v) was achieved using partial budgeting technique, while objectives (vi) and (vii) were achieved using Ordinary Least Squares regression analysis and factor analysis respectively; while (viii) will be realized using training, workshops, seminars and publications. Format for the partial budgeting: For each adaptation practice, the total positive impacts, comprising of added returns and reduced costs were summed. In addition, the total negative impacts, comprising of added costs and reduced returns were also added up. The later was then subtracted from the former to make the net returns from the practice.

Multiple Regression

A multiple regression analysis involving the use of Ordinary Least Square (OLS) estimation technique was used to determine the effect of household socio-economic variables on the farmer's level of investment in climate change adaptation practices. The implicit form of the regression model used was:

$Y = f(X1, X2, X3, X4, X5, X6, X7, X8, X9) + U$ ....(1)

Where Y = Amount of money invested in adaptation practices (N)

X1 = Age of farmer (years)

X2 = Gender of farmer (1, if male, 0 otherwise)

X3 = Level of education (years)

X4 = average annual return from the adaptation practices (N)

X5 = Average annual income from farming (N)

X6=Farm size (ha)

X7=Household size (number of persons)

X8= whether climate change affects agriculture (1 if yes, 0 otherwise)

X9= whether farming contributes to climate change (1 if yes, 0 otherwise)

U = Error term.

The Exploratory Factor Analysis

Exploratory factor analysis procedure was employed to identify the major problems encountered by farmers in adapting to the effects of climate change. The problems enumerated by the respondents were grouped using principal component analysis with iteration and varimax rotation. The model is represented as:

$$
\begin{array}{ll}
Y1 = & a11X1 + a12X2 + * \ * * + a1nXn \\
Y2 = & a21X1 + a22X2 + * \ * * + a2nXn \\
Y3 = & a31X1 + a32X2 + * * * + a3nXn \\
* = & \qquad\qquad\qquad\qquad * \\
* = & \qquad\qquad\qquad\qquad * \\
* = & \qquad\qquad\qquad\qquad * \\
Yn = & an1X1 + an2X2 + * \ * + annXn
\end{array}
$$

Where: Y1, Y2, …, Yn = observed variables / constraints to adaptation; a1 – an =constraint loadings or correlation coefficients.

X1, X2, … Xn = unobserved underlying problems constraining farmers from adapting to climate change.

3. Review of Related Literature

3.1 Awareness of Climate Change and Link with Agriculture

The awareness of climate problems and the potential benefits of taking action is important determinant of adoption of agricultural technologies (Hassan and Nhemachena, 2002). Maddison (2006) argued that farmer awareness of change in climate attributes (temperature and precipitation) is important to adaptation decision making. For example, Araya and Adjaye (2001) and Anim (1999) stated that farmers awareness and perceptions of soil erosion problem as a result of changes in climate, positively and significantly affect their decisions to adopt soil conservation measures. It is expected that improved knowledge and farming experience will positively influence farmers' awareness and decision to take up adaptation measures. Improved education and disseminating knowledge is an important policy measure for stimulating awareness and local participation in various development and national resource management initiatives (Anley, Bogale and Haile-Gabriel, 2007, Tizal 2007). Farming experience improves awareness of change in climate, the potential benefits and willingness to participate in local natural resource management of conservation activities. However, Maddison (2006) stated that educated and experienced farmers have more knowledge and information about climate change and agronomic practices that they can adopt in response.

3.2 Activities of Farmers that Contribute to Climate Change

Climate change is a natural process but recent trends related to climate change are alarming mainly due to anthropogenic reasons (Khanal, 2009). Agriculture is an important contributor of greenhouse gas emissions at the global scale. According to World Bank (2008), agriculture contributes about half of the global emissions of two of the most potent non-carbon dioxide greenhouse gases: nitrous oxide and methane. FAO (2008) reported that agriculture contributes over 20% of global anthropogenic greenhouse gas emissions.

The ongoing build up of greenhouse gases in the atmosphere is prompting shifts in climate across the globe that will affect agro-ecological and growing conditions. Application of fertilizers, rearing of livestock and related land clearing are some agricultural activities that influence both levels of greenhouse gases in the atmosphere and the potential for carbon storage and sequestration (Mark, et al. 2008). The report of World Bank (2008) also showed that the use of livestock manure, nitrogenous fertilizers, irrigated paddy, burning of biomass and ruminant's centric fermentation and animal waste treatment are responsible for producing most agricultural nitrous oxide and methane emissions. International Federation of Organic Agriculture Movement (IFOAM) (2007) highlighted that conventional agricultural activities of farmers contribute to climate change because it: (a) uses synthetic fertilizers and pesticides that require significant amount of energy to manufacture; (b) applies excessive amounts of nitrogen fertilizer that is released as nitrous oxide; (c operates intensive livestock holdings that overproduce manure and methane; (d) relies on external soy-based animal feeds that require the burning of huge amount of fuel that releases carbon monoxide to the atmosphere creating climatic problems; (e) mines the earth of the nutrients needed to sustain production thereby leading to the clearing of rainforest and slash and burn techniques that reduce carbon storage and release huge amounts of carbon dioxide from burning vegetation.

As a result, it is of interest to stakeholders in the agricultural sector to understand the kinds of impact their agricultural activities will have on sustainable food and crop production due to effect of climate change (Mark et al. 2008) There will undoubtedly be shifts in agro-ecological conditions that will warrant changes in processes and practices and adjustments in widely accepted truths in order to meet daily food requirements.

3.3 Patterns of Climate Change Impact on Agriculture

The Intergovernmental Panel on Climate Change, IPCC's Fourth Assessment Report summary for Africa describes a trend of warming at a rate faster than the global average, and increasing aridity (see Text Box). Climate change exerts multiple stresses on the biophysical as well as the social and institutional environments that underpin agricultural production (IPCC, 2007). That is, socio-economic factors, international competitions, technological development as well as policy choices will determine the pattern and impact that agro-climatic changes will have on agriculture (Brussel, 2009). In all, Khanal (2009) classified the patterns of impact of climate change on agriculture into biophysical and socio-economic impact. The biophysical impacts include; physiological effects on crop and livestock, change in land, soil and water resources, increased weed and pest challenges, shifts in spatial and temporal distribution of impacts, sea level rise and changes to ocean salinity and sea temperature rise causing fish to inhabit in different ranges. The socio-economic impacts result in decline in yield and production, reduced marginal GDP from agriculture, fluctuation in world market price, changes in geographical distribution of trade regime, increased number of people at risk of hunger and food insecurity, migration and civil unrest. According to Khanal (2009), the patterns of the effects of climatic change are however dependent on latitude, altitude, type of crop grown and livestock reared. Mark et al. (2008) highlighted some of the direct impacts of climate change on agricultural system as: (a) seasonal changes in rainfall and temperature, which could impact agro-climatic conditions, altering growing seasons, planting and harvesting calendars, water availability, pest, weed and disease populations; (b) alteration in evapotranspiration, photosynthesis and biomass production; and (c) alteration in land suitability for agricultural production; Some of the induced changes are expected to be abrupt, while others involve gradual shifts in temperature, vegetation cover and species distributions. However, when looking critically on plant production, the pattern of climate change has both positive and negative impacts. Rises in temperature for example helps to grow crops in high altitude areas and towards the poles. In these areas, increases in temperature extend the length of the potential growing season, allowing earlier planting, early harvesting and opening the possibility of completing two crop cycles in the same season (Khanal, 2009). The warmer conditions support the process of natural decomposition of organic matter and contribute to the nutrient uptake mechanisms. The process of nitrogen fixation, associated with greater root development is also predicted to increase in warmer conditions and with higher CO_2, if soil moisture is not limiting (FAO, 2007). The increased CO_2 levels lead to a positive growth response for a number of staples under controlled conditions also known as the carbon fertilizations effect (Mark et al. 2008). But when temperatures exceed the optimal level for biological process, crops often respond negatively with a steep drop in net growth and yield. Khanal (2009) stated that heat stress might affect the whole physiological development, maturation and finally reduces the yield of cultivated crop. The negative effects on agricultural yields will be exacerbated by more frequent weather events. For example, Brussel (2009) stated that rising atmospheric CO_2 concentration, higher temperatures, changes in annual and seasonal precipitation patterns and in the frequency of extreme events will affect the volume, quality, quantity, stability of food production and the natural environment in which agriculture takes place. Climatic variations will have consequences for the availability of water resources, pest and diseases and soils leading to significant changes in the conditions for agriculture and livestock production. In extreme cases, according to Brussel (2009), the degradation of agricultural ecosystems could mean desertification, resulting in a total loss of the productive capacity of the land in question. This is likely to increase the dependence on food importation and the number of people at risk of famine.

The developing world already contends with chronic poverty and food crisis. The estimate for Africa is that 25-42% of species habitat could be lost, affecting both food and non-food crops (Khanal 2009). Habitat change is already underway in some areas, leading to species range shifts and changes in plant biodiversity which include indigenous foods and plant-based medicines. FAO (2007) reported that up to 11% of arable land could be highly affected by climatic change in the developing world. There will be a reduction of cereal production in 65 countries and retardation of about 16% of agricultural GDP. A decrease of up to 30% in world food production due to effects of climate change on agriculture is generally predicted (IPCC 2007).

In Africa, climate change is expected to, and in some parts, it has already begun to, alter the dynamics of drought, rainfall and heat waves, and trigger secondary stresses such as the spread of pests, increased competition for resources, the collapse of financial institutions, and attendant biodiversity losses. Predicting the impact of climate change on complex biophysical and socio-economic systems that constitute agricultural sectors is difficult. In many parts of Africa it seems that warmer climates and changes in precipitation will destabilize agricultural production.

This is expected to undermine the systems that provide food security (Gregory et al., 2005). Whilst farmers in some regions may benefit from longer growing seasons and higher yields, the general consequences for Africa, as reported in Text Box below, are expected to be adverse, and particularly adverse for the poor and the marginalized that do not have the means to withstand shocks and changes. Evidence from the IPCC suggests that areas of the Sahara are likely to emerge as the most vulnerable to climate change by 2100 with likely agricultural losses of between 2 and 7% of affected countries GDP. Western and Central Africa are expected to have losses ranging from 2 to 4% and Northern and Southern Africa are expected to have losses of 0.4 to 1.3% (Mendelsohn et al., 2000). Maize production is expected to decrease under possible increased (El Nino-Southern Oscillation (ENSO) conditions which are expected in southern Africa (Stige et al., 2006).

A South African study undertaken by the University of Pretoria and focusing at the provincial level, found a significant correlation between higher historical temperatures and reduced dryland staple production, and forecast a fall in net crop revenues by as much as 90% by 2100. The study found small-scale farmers to be worst affected by the decrease.

Text Box: Key attributes of the IPCC's Fourth Assessment Report for Africa

Warming is very likely to be larger than the global annual mean warming throughout the continent and in all seasons, with drier subtropical regions warming more than the moister tropics.

Annual rainfall is likely to decrease in much of Mediterranean Africa and the northern Sahara, with a greater likelihood of decreasing rainfall as the Mediterranean coast is approached.

Rainfall in southern Africa is likely to decrease in much of the winter rainfall region and western margins.

There is likely to be an increase in annual mean rainfall in East Africa.

It is unclear how rainfall in the Sahel, the Guinean Coast and the southern Sahara will evolve.

Source: Christensen et al. 2007, p.850

A Nigerian study applied the Erosion Productivity Impact Calculator (EPIC) crop model to give projections of crop yield during the 21st century. The study modeled worst case climate change scenarios for maize, sorghum, rice, millet and cassava (Adejuwon, 2006). The indications from the projections are that, in general, there will be increases in crop yield across all low land ecological zones as the climate changes during the early parts of the 21st century. However, towards the end of the century, the rate of increase will tend to slow down. This could result in lower yields in the last quarter than in the third quarter of the century. The decreases in yield could be explained in terms of the very high temperatures which lie beyond the range of tolerance for the current crop varieties and cultivars. An Egyptian study compared crop production under current climate conditions with those projected for 2050, and forecast a decrease in national production of many crops, ranging from –11% for rice to –28% for soybeans (Eid et al., 2006). Other potential impacts linked to agriculture include erosion that could be exacerbated by expected increased intensity of rainfall and the crop growth period that is expected to be reduced in some areas (Agoumi, 2003). Changes are also expected in the onset of the rainy season and the variability of dry spells (Reason et al., 2005). Thornton et al., (2006) mapped climate vulnerability with a focus on the livestock sector. The areas they identified as being particularly prone to climate change impacts included arid-semiarid rangeland and the drier mixed agro-ecological zones across the continent, particularly in Southern Africa and the Sahel, and coastal systems in East Africa. An important point they raise is that macro-level analyses can hide local variability around often complex responses to climate change.

3.4 Indigenous adaptation practices used by farmers

Adaptation is an adjustment made to a human, ecological or physical system in response to a perceived vulnerability. Specifically, IPCC (2001) described adaptation to climate change as adjustment in natural or human systems in response to actual or expected climatic stimuli and their effects which moderates harm or exploits beneficial opportunities. Adaptation is an important component of climatic change impact and vulnerability assessment and is one of the policy options in response to climatic change impacts (Smith and Lenhart, 1996, Fankhauser 1996). Adaptation to climatic change is therefore critical and of concern in developing countries, particularly in Africa where vulnerability is high because ability to adapt is low (Hassan and Nhemachena 2008). In agriculture, adaptation helps farmers achieve their food, income and livelihood security objectives in the face of changing climatic and socio-economic conditions including climatic variability, extreme weather conditions such as droughts and floods and volatile short term changes in local and large-scale markets (Kandlinkar and Risbey, 2000). Farmers can reduce the potential damage by making tactical response to these changes.

According to Brussel (2007) adaptive measures to climatic change in agriculture range from technological solutions to adjustments in farm management or structures and to political changes such as adaptation plans. Barry and Mark (2002) categorized agricultural adaptation options into technological development, government programmes and insurance; farm production practices, and farm financial management. The first two categories are principally the responsibility of public agencies and agri-business and adaptation here could be thought of as system-wide or macro scale. The last two categories mainly involve farm level decision making by farmers. In the short run, autonomous farm level adaptation may be sufficient but in the longer run, adaptation in the form of technological and structural changes will be necessary. This will require planned strategies based on analysis of local and regional conditions (Brussel 2002)

At farm level, the practice of organic agriculture is one of the most important measures for adaptation to climate change by farmers. Organic agriculture according to IFOAM (2007) is a holistic production management system which enhances agro-ecosystem health, utilizing both traditional and scientific knowledge. It prevents nutrient and water loss through high organic matter content and soil covers, thus making soils more resilient to floods, drought and land degradation processes. In organic agriculture, soil fertility is maintained mainly through farm internal inputs (organic manures, legume production, wide crop rotation), rejection of energy demanding synthetic fertilizers and plant protection agents with less or no use of fossil fuel (FAO 2008).

The process of organic agriculture, being a holistic approach in climatic change adaptation can be classified as two major kinds of modification in the production systems: (a) increased diversification and (b) protecting sensitive growth stages by managing the crops to ensure that these critical stages do not coincide with very harsh climatic conditions such as mid-season droughts (Hassan and Nkemechena 2008). Under these two modification techniques according to the authors, the adaptation strategies farmers perceive as appropriate include crop diversification using different crop varieties, varying the planting dates, harvesting dates, increasing the use of irrigation, increasing the use of water and soil conservation techniques, shading and shelter, shortening the length of the growing season and diversifying from farming to non-farming activities.

Some strategies that serve as an important form of insurance against rainfall variability are: increasing diversification by planting crops that are drought tolerant and/or resistant to temperature stresses, taking full advantage of the available water and making efficient use of it, and growing a variety of crops on the same plot or on different plots, thus reducing the risk of complete crop failure since different crops are affected differently by climate changes (Benhin, 2006). Such farm-level adaptations aim at increasing productivity and dealing with existing climatic conditions and draw on farmers' knowledge and farming experience. Kurukulasurya and Rosental (2003) noted that the short-term adaptation measures for climate change by farmers include crop insurance for risk coverage, crop/livestock diversification to increase productivity and protection against diseases, adjusting the timing of farm operations to reduce risks of crop damage, change crop intensity and adjust livestock management to new climatic conditions, food reserves and storage as temporary relief, changing cropping mix, permanent migration to diversify income opportunities, defining land use and tenure rights for investments. On a long term note, the authors stated the following as best adaptation options for climate change: development of crop and livestock technology adapted to climate change stress, develop market efficiency, irrigation and water storage expansion, efficient water use, promoting international trade, improving forecasting mechanisms, institutional strengthening and decision-making structures.

Brussel (2009) highlighted the possible short to medium term adaptation practices to changes in climate by farmers to include: (i) adjusting the timing of farm operations such as planting or sowing dates and treatments; (ii) technical solutions such as protecting overheads from frost damage or improving ventilation and cooling systems in animal shelters; (iii) choosing crops and varieties better adapted to the expected length of the growing season and water availability and more resistant to new conditions of temperature and humidity; (iv) adapting crops with the help of existing genetic diversity and new possibilities offered by biotechnology; (v) improving the effectiveness of pest and disease control through for instance better monitoring, diversified crop rotations, or integrated pest management methods; (vi) using water more efficiently by reducing water losses, improving irrigation practices and recycling or storing water; (vii) improving soil management by increasing water retention to conserve soil moisture and landscape management such as maintaining landscape features providing shelter to livestock; (viii) introducing more heat-tolerant livestock breeds and adapting diet patterns of animals under heat stress conditions.

Individually or the combination of these adaptation practices by farmers have substantial potential to counterbalance adverse climatic changes and to take advantage of positive ones.

3.5 Problems Encountered By Farmers in Adapting to Effects of Climate Change

Recognizing, most especially the negative impacts of climate change on agriculture, farmers as victims of these impacts continuously try out some adaptation strategies to reduce the effects on yields and farm income. However, in carrying out adaptation measures to reduce the effects of climate variations on agricultural production, the farmers encounter some obvious challenges or problems. Mark et al. (2008) argued that a lack of adaptive capacity due to constraints on resources like access to weather forecasts or better seed varieties may result in further food insecurity. The result of a study conducted by Centre for Environmental Economics and Policy in Africa across African countries showed that lack of access to credit or saving, water, appropriate seeds, security of property rights, market access and lack of adequate information about climate change are some of the major problems encountered by farmers in adapting to the effects of climate change (CEEPA, 2006). According to Deresso (2008), the analysis of barriers to adaptation to climate change in the

Nile basin of Ethiopia indicates that there are five major constraints to adaptation by farmers. These, as reported by the author are lack of information, lack of money, shortage of labour, shortage of land and poor potential for irrigation. CEEPA (2006) added that farm size, tenure status, level of education of the farmers and access to extension service are major determinants of speed adoption of adaptation measures to climate change.

Most of the problems or constraints encountered by farmers in adaptation to climate change are associated with poverty (Deressa 2008). For instance, lack of information to adaptation options could be attributed to the fact that research on climate change and adaptation options have not been strengthened in the country and thus information is lacking in the area. Lack of money hinders farmers from getting the necessary resources and technologies which assist in adapting to climate change. Adaptation to climate change is costly (Mendelson, 2004) and this cost could be revealed through the need for intensive labour use. Thus, if farmers do not have sufficient family labour or the financial capacity to hire labour, they cannot adapt to climate change. Shortage of land has been associated with high population pressure. High population pressures forces farmers to intensively farm over a small plot of land and make them unable to conserve from further damages by practices such as planting trees which competes for agricultural land. According to FAO (1997), poor irrigation potential can most probably be associated with the inability of farmers to use the already existing water due to technological incapability. Most African farmers are resource poor and cannot afford to invest on irrigation technology to adapt to climate change in order to sustain their livelihood during harsh climate extremes such as drought which often causes famine.

4. Results & Discussion

4.1 Socioeconomic Characteristics of Respondents

Majority (69%) of the respondents were male heads of households, while about 31% of them were women heads of households. Nweke and Enete (1999) made similar observation across six countries of sub-Saharan Africa. Bukh (1979) reported that men are most often the heads of households in Africa. They were aged about 52 years on the average with the oldest being 90 years and the youngest being 25 years. This suggests that the farmers were within the economically active age of below 60 years. This is contrary to the expectation that as a result of rural-urban migration, farming has been left to the very old. However, with the current high rate of unemployment, young people may have been resorting to farming. Their average years of farming experience was 28 years with the most and least experienced farmer having 60 and 5 years respectively. Majority (74%) of the respondents were married while the remaining 26% were distributed between Single (8%), divorced (3%) and separated (15%).

About 23% of the respondents had no certificate to show for their level of education, while majority (26%) had First School Leaving Certificate. About 25% of them had secondary school certificate, 10% had Ordinary National Diploma, 10% had first degree, 1% had Master degree while another 5% had other certificates. On the average, the respondents had about 10 years of formal education. This is in line with the above observation that unemployment may have driven educated young people back to the farm.

The average household size was about six persons with a minimum of one person and a maximum of 18 persons per household. Farming was the major occupation for 67% of the respondents while 2% reported that they were artisans as major occupation. Those who were traders were about 9% of the respondents while 22% were public servants. This is not surprising as the study was targeted at full time farmers. However, one is surprised at the high number of the respondents who were public servants, but with the eroding purchasing power of the average public servant as a result of inflation, farming is usually used to compliment the family's income..

Crop farming was the predominant activity for about 55% of the respondents. The remaining percentage was shared between livestock farming (5%) and mixed farming (40%). Crop is generally the most popular farming activity in the country, particularly in the Southeast.

4.2 Crops and Animals Grown/Reared In the Area

The first most important food crop in the area was cassava, as ranked by 64% of the respondents (table 1). Cassava is not only a major staple but also a major source of farm income for the Nigerian farmers (Nweke 1996). And compared to other crops, cassava is the most resistant to extreme weather events. It is therefore most often described as a hardy crop and may in this sense be the most adaptable crop to climate variations (Enete 2003). Benhin (2006) reports that one of the strategies which serve as an important form of insurance against rainfall variability is increasing diversification by planting crops that are drought tolerant and/or resistant to temperature stresses. Cassava was followed by Yam and Cocoyam with about 23% and 4% respectively of the respondents ranking them as the first most important crop. Yam is the second most important root crop after cassava, especially in southeast Nigeria, where there is generally an annual celebration in honour of the crop. This was followed by vegetables as ranked by 3%, maize and rice by 2% and 1% respectively, Oil palm by 1% and other unspecified crops ranked by 2% of the respondents as the first most important crop. From the second to the fourth most important crops, the respondents just listed variations of the above crops, hence discussions were limited to the first most important crop.

In terms of livestock reared in the area, 50% of the respondents' ranked goat as the first most important domesticate animal (table 1). About 38% ranked poultry, 6% ranked sheep, 5% ranked pig, while 1% each ranked Cattle and fish as the first most important animal reared in the area. From the second through the fourth most important animals in the area, the respondents also listed various combinations of the above animals.

4.3 Awareness of Climate Change and Its Link with Agriculture

The respondents were asked whether they have heard of climate change before. About 96% of them responded in the affirmative (table 2). This suggests a high level of awareness of the subject matter in the area. The awareness of climate problems and the potential benefits of taking action is an important determinant of adoption of agricultural technologies (Hassan and Nhemachena, 2002). Maddison (2007) argued that farmer awareness of change in climate attributes (temperature and precipitation) is important to adaptation decision making. For example, Araya and Adjaye (2001) and Anim (1999) reported that farmers awareness and perceptions of soil erosion problem as a result of changes in climate, positively and significantly affect their decisions to adopt soil conservation measures. On the source of information, majority (36%) of the respondents indicated that they heard from friends, about 26% of them heard from Extension workers, 24% from radio/television, 2% from researchers, 1% from farmers' cooperatives, while 6% heard from other sources not specified in the survey instrument (table 2).

Similarly, on the question of whether climate change will affect agriculture, the respondents overwhelmingly (97%) said yes. Most governments in Nigeria already have agencies charged with environmental issues including climate change and they most often sensitize the people through the radio and television. This may explain the high level of awareness of the respondents.

However, majority (52%) of the respondents do not agree that farming contributes to climate change. The responses to these questions suggest that the farmers were aware of climate change and its effect on agriculture, but were unaware that some of their agricultural practices could exacerbate climate change. This underscores the need for educating the farmers on the consequences of some of their actions. However, FAO (2000) reports that although climate change affects agriculture and vice versa, a lot of uncertainties pervade each step of the logic from economic activity to climate change.

4.4 Patterns of Climate Change Effects on Agriculture

The respondents were asked to indicate the direction of change (increasing, decreasing, no change) of some climate change variables. The information collated from the field survey show (table 3) that those associated with uncertainties in the onset of farming season, except heavy/long period of rainfall and no/reduced hamattan, have all been increasing as indicated by majority of the respondents. These are unusual early rains that are not sustained, erratic rainfall, delay in the onset of rain, long period of dry season, less rainfall, long period of hamattan and higher temperature. The two exceptions are to be expected as all the other indices show predominance of dry periods.

For the variables associated with extreme weather events, responses from majority of the respondents indicate (table 3) that heavy winds, drought and decreasing soil moisture have been on the increase. This agrees with the above observation on the predominance of indices of dry periods associated with uncertainties in the onset of farming season. The respondents however suggest that thunderstorm, heat waves, desertification and loss of forest resources have shown no change, while floods, heavy rainfall and soil erosion have been decreasing.. This is surprising because, the indices of dry periods discussed above are supposed to drive the later variables in the same direction, particularly for heat waves, which should be driven by the higher temperature as noted above. We note however that the information being solicited from these individual farmers, who keep no records, concerns more general weather change (and not farm specific characteristics) spanning over ten year period. There is therefore bound to be some elements of mix up here and there. The inconsistency was further confirmed by looking at their ranking of the extent to which climate change was contributing to the changes. The variable with the highest mean was thunderstorm, which they earlier indicated above as having shown no change.

The information from our pilot survey/FGD was more consistent and realistic because the farmers were brought together in a group, where they discussed at length before arriving at a conclusion. We therefore adapt that result for this section. The information from that survey showed that those associated with uncertainties in the onset of farming season, except heavy/long period of rainfall, and extreme weather events, except long harmattan, have all been increasing as indicated by majority of the respondents. These include early rains that are not sustained, erratic rainfall, delay in the onset of rain, long period of dry season, thunderstorms, heavy winds, intense heat wave and so on. This was also the same trend for pests, diseases, weeds and signals of land degradation such as declining soil fertility and drying up of steams/rivers. Science in Africa (2007) observed that the effects of these extreme weather events and uncertainties in the onset of rainy season on agriculture are particularly more pronounced in the developing world. The elements of climatic change that affects agricultural productivity includes prolonged drought, thunderstorms, flooding of crops fields, erosion of fertile soil, landslides and falling of tender crop such as maize by wind (Magadza, 2000). The two exceptions are to be expected as all the other indices show predominance of dry periods, accompanied with heat waves, erratic rainfall, thunderstorms and floods/erosion.

The respondents were asked to indicate the extent to which they think climate change was responsible for the changes in the variables above. Their responses (table 3) show that all the changes discussed above regarding uncertainties in the onset of farming season, extreme weather events and pests, diseases, weeds and land degradation have all to do with climate change. IPCC (2007) reports that there have been noticeable impacts of climate change on plant production, insect, disease and weed dynamics. Moreover, rising atmospheric CO2 concentration, higher temperatures, changes in annual and seasonal precipitation patterns and in the frequency of extreme events are the usual features of climate change phenomenon (Brussel 2009). Mark et al. (2008) observed that seasonal changes in rainfall and temperature, which are features of climate change could impact agro-climatic conditions, altering growing seasons, planting and harvesting calendars, water availability, pest, weed and disease populations;.

A t-test was also conducted on the mean responses of the farmers between Enugu and Imo states regarding the extent to which climate change was responsible for the stated changes in the above variables. The result (table 4) show that there was no significant difference between the two states regarding the extent to which climate change was contributing to the following variables: early rains that were not sustained, long period of dry season, less rainfall, no/reduced hamattan, heavy rainfall, soil erosion, decreasing soil moisture, pest, disease and weed infestation, and declining soil fertility

However, in virtually all the other variables considered above, the considered impact of climate change was significantly higher for Imo state than for Enugu State. This is to be expected because Imo is closer to the sea than Enugu and climate change induced sea level rises and associated inland effects will be more pronounced in Imo than Enugu. For example, Climate Institute (2010) reports that the melting back of sea ice leads to a reduction in albedo (surface reflectivity) and allows for greater absorption of solar radiation, which will accelerate warming, thus increasing the melting back of snow and ice on land.

Although these variables were reportedly changing faster in Imo than Enugu , it may not necessarily imply that the overall impact of climate change on food production for instance will be higher in Imo than Enugu. Enugu is relatively closer to the Northern part of Nigeria than Imo, its climate is therefore naturally drier and more variable. The impact of further climate change induced variability, no matter how small may therefore be more pronounced.

Using a 5–point Likert Rating Scale (LSR), the respondents were asked to indicate the extent to which suggested farm characteristics have changed over the past ten years. Table 5 presents the result of the analysis and it shows that the biggest effect of climate change on agriculture was reduced income (mean = 3.90) and reduced yield (mean = 3.71). The other big effects of climate change were streams/rivers drying up (mean = 3.58), reduction in storage quality of crops (mean = 3.30), loss of pastureland/vegetation (mean = 3.22) changes in the population of fish (mean=3.17), destruction of wildlife ecosystem (mean= 3.19) and reduction in farm size (mean = 3.14). Brussel (2009), who noted the usual features of climate change as stated above also reports that these characteristics will affect the volume, quality, quantity, stability of food production and the natural environment in which agriculture takes place. Khanal (2009) also noted that heat stress might affect the whole physiological development, maturation and finally reduces the yield of cultivated crop.

A t-test was then conducted between the two states to determine whether there were differences in the level of changes of these farm characteristics. The results (table 6) show that there was no significant difference between the two states regarding decreasing soil drainage and reduced production cycle. But, these two farm characteristics have generally not changed over the past ten years. On the other hand, reduction in the storage quality of crops, destruction of wildlife ecosystem, drying up of steams/rivers, reduction in the population of fish, loss of pasture land/vegetation and reduction in farm size were all significantly higher in Imo state than Enugu while reduction in farm yield and income were significantly higher for Enugu than for Imo state. This is in line with our earlier observation above regarding uncertainties in the onset of farming season.

4.5 Activities of Farmers That Contribute to Climate Change

The respondents were asked to indicate the extent to which they practice some suggested farm related activities that could contribute to climate change on a 3-point LSR. The information collected (table 7) show that the most often practiced activities by the respondents were burning of wood fuel (mean = 2.70), the use of fertilizers (mean=2.16), and Bush burning (Mean = 2.07). With the widely reported rising poverty in Nigeria, especially among farming households, and the also rising prices of cooking gas and kerosene, burning of wood fuel as cooking energy has become the predominant practice, not only in rural farming communities but also among the urban poor. Moreover, decreasing soil fertility is one of the extreme weather events that nearly all the farmers (84%) said it has been on the increase in the past ten years. The natural tendency would therefore be to increase the application of fertilizer in order to maintain soil fertility, which contributes to greenhouse gases. In addition, bush burning is generally the preferred traditional means of clearing farmland for seedbed preparation, which increases the concentration of greenhouse gases and particulate matter in the atmosphere (Wikipedia 2009). The International Federation of Organic Agriculture Movement (IFOAM)(2007) reports that conventional agricultural activities of farmers contribute to climate change because it applies excessive amounts of nitrogen fertilizer that is released as nitrous oxide and mines the earth of the nutrient needed to sustain production through rainforest clearing and slash and burn techniques that reduce carbon storage and release huge amounts of carbon dioxide from burning vegetation.

4.6 Indigenous Climate Change Adaptation Practices and Their Cost and Returns

Table 8 presents the costs and returns from some of the adaptive measures using the results of the field survey. The table shows that the adaptation measure with the highest profitability index (PI) was multiple/intercropping (mean = 3.01). Multiple/intercropping, though a tradition for smallholder farming in Nigeria may have been intensified as a result of climate change. This is because different crops have different levels of resilience to weather variability, hence, planting many crops in a field could ensure that the farmer get some output in the face of extreme weather situations. Benhin (2006) reports that growing a variety of crops on the same plot is an appropriate adaptation strategy for farmers because it helps to avoid complete crop failure as different crops may be affected differently by climate change. It is also a measure of diversification by the farmers. Hassan and Nkemechena (2008) had reported that increased diversification is a strong climate change adaptation measure.

The next adaptation measure with high PI was the use of agro-forestry (mean = 2.69). Similarly, Aforestation, with a PI of 1.91 ranks 5th in terms of profitability. One of the appropriate adaptation strategies by farmers according to Hassan and Nkemechena (2008) is shading and shelter, which can only be provided through agro-forestry and aforestation. In one of the focus group discussions, a farmer reported that he has planted trees around his farms to provide shade during dry periods, which has become very regular. Agro-forestry and aforestation may therefore have become particularly needed because of the prevailing predominance of dry periods, accompanied with heat waves, erratic rainfall, thunderstorms and floods/erosion, as earlier observed. The foregoing also explains the high PI associated with mulching (mean=1.89). Downing et al. (1997) reported that increasing the use of organic matters such as mulch could prevent excessive soil moisture loss, increase soil aeration and soil moisture holding capacity.

The next to agro-forestry is expansion of cultivated land area (mean = 2.64). This has always been the traditional means of expanding production and augmenting output from impoverished land by farmers. Yirga (2007) reported that farmers often moved to fertile soils to ensure better yield and escape the vagaries of weather accessioned by climate change.

The use of herbicides and pesticides also had a high PI of 2.08. As noted above, the farmers reported that the attack of pests, diseases and weeds have all been increasing in the past ten years. It is therefore logical that farmers who simultaneously raise the level of use of pesticides and herbicides may sufficiently be able to counter the offensive.

The next was purchase/harvesting of water for irrigation (mean = 1.86). Hassan and Nkemechena (2008) noted that one of the appropriate adaptation practices for farmers include the use of water for irrigation and soil conservation practices. Use of resistant varieties was next in terms of PI (mean=1.77). High yielding and fast growing crops can easily escape the vagaries of climate change by completing their growth cycle before storm and drought sets-in, thereby checking the impact of climate change. Moreover, the use of heat tolerant and drought resistance crops is also effective adaptation practices (Downing et al. 1997). In addition, some strategies that serve as an important form of insurance against rainfall variability are: increasing diversification by planting crops that are drought tolerant and/or resistant to temperature stresses (Benhin, 2006). Increased use of fertilizers including organic manure, also had high PI (mean=1.45). Declining soil fertility is one of the land degradation sources that was overwhelmingly (84% of the farmers) reported to have been on the increase in the last ten years. High fertilizer application is therefore expected as an adaptation practice in order to maintain soil fertility. In addition, the above observation by Downing et al. (1997) on the need for organic matter as an adaptation practice also refers.

4.7 Household Level Factors Affecting Investment in Adaptation Practices

In assessing the factors that influence the level of investment in climate change adaptation practices, the ordinary least squares regression analysis was used. The result of the analysis (table 9) show that the explanatory powers of the specified variables seem low (24%), but this is not uncommon in cross sectional analysis. Other works with similar coefficient of determination include Nweke (1996) and Enete (2003). The overall goodness of fit as reflected by the F-value of (2.93) was however highly significant at ($p<0.01$).

Four of the nine explanatory variables were significant. Age of the farmer was positively and highly significantly related with the level of investment in climate change adaptation practices by the farmers. This is surprising because older farmers are more likely to be risk averse, especially regarding climate change matters, than younger ones. However, age may likely endow the farmers with the requisite experience that will enable them make better assessment of the risks involved (Panin and Brummer 2000) in climate change adaptation investment decisions. Enete et al. (2002) noted that older farmers have more experience and are able to take healthier production decisions than younger ones.

The farmer's number of years of formal education was also positive and highly significantly related with the level of investment in indigenous climate change adaptation practices. This is to be expected as educated farmers may better understand and process information provided by different sources regarding new farm technologies, thereby increasing their allocative and technical efficiency (Panin and Brummer 2000).

The two variables on level of awareness of climate change effects were all positive and significantly related with the level of investment in adaptation practices. These were “whether the farmer knows that climate change will affect agriculture” and “whether the farmer knows that agriculture contributes to climate change” This underscores the importance of awareness in adaptation measures. The awareness of climate problems and the potential benefits of taking action is an important determinant of adoption of agricultural technologies (Hassan and Nhemachena, 2002). Maddison (2007) argued that farmer awareness of change in climate attributes (temperature and precipitation) is important to adaptation decision making. For example, Araya and Adjaye (2001) and Anim (1999) reported that farmers awareness and perceptions of soil erosion problem as a result of changes in climate, positively and significantly affect their decisions to adopt soil conservation measures.

4.8 Societal Constraints to Climate Change Adaptations

Table 10 shows the varimax-rotated factors constraining farmers in the area from climate change adaptations. From data in the table, five factors were extracted based on the responses of the respondents. Only variables with factor loadings of 0.40 and above at 10% overlapping variance were used in naming the factors. Variables that have factor loading of less than 0.40 and those that loaded in more than one factors were not used (Madukwe 2004). The next step was to give each factor a denomination according to the set of variables or characteristics it was composed of. In this regards, the variables were grouped into five major factors as; factor 1 (poverty constraints), factor 2 (land and more efficient input constraints) and factor 3 (information and training factor), factor 4 (land tenure constraint), and factor 5 (labour constraints).

Under factor 1 (poverty constraints), the specific constraining variables against climate change adaptation include high cost of farmland (0.580), high cost of irrigation facilities (0.483), non-availability of storage facilities (0.648), limited income (0.782), non-availability of processing facilities (0.668), high cost of processing facilities (0.808), and lack of access to weather forecast technologies (0.751). With limited income (poverty), the acquisition of necessary facilities will be difficult. They may not only be costly, but may also appear scarce for poor farmers. In addition, the farmers may not also have the necessary facilities for current information like radio and television to obtain weather forecasts. This underscores the problems of under capitalization of farmers (Enete and Achike 2008) and suggests the need to improve the availability of credit to them. Benhin (2006) reports that lack of access to credit or saving and adequate information about climate change are some of the major problems encountered by farmers in adapting to climate change in Africa. Deressa (2008) reported that most of the problems or constraints encountered by farmers in adaptation to climate change are associated with poverty.

Under factor 2 (Land and more efficient input problem), the constraining variables against climate change adaptation were: limited availability of land for farming (0.558), non-availability of improved seeds (0.598), high cost of fertilizer (0.761), and high cost of improved varieties (0.725). Benhin (2006) noted that farm size is a major determinant of speed of adoption of adaptation measures to climate change. Moreover, Downing et al (1997) reported that high yielding and fast growing crops can easily escape the vagaries of climate change by completing their growth cycle before storm and drought sets-in, thereby checking the impact of climate change. The use of heat tolerant and drought resistance crops is also effective adaptation practices.

The factors that loaded under factor 3 (information and training constraints) include poor access to information sources (0.588) and inadequate knowledge of how to cope (0.771). In the present information age, information problems could pose serious challenges to the farmers coping strategies as they may not be aware of recent developments regarding climate change adaptations and the necessary readjustments needed. Mark et al. (2008) argued that a lack of adaptive capacity due to constraints on resources like information may result in further food insecurity. In addition, Benhin (2006) noted further that farmers' level of education and access to extension service are major determinants of speed of adoption of adaptation measures to climate change.

Under factor 4 (land tenure constraints), the constraining variables were inherited system of land ownership (0.786) and communal system of land ownership (0.775). In traditional societies, individual farmers do not usually have title to farmland but enjoy user rights, which could be withdrawn at any time by the custodian of the communal land. One of the factors identified by Benhin (2006) as determining the speed of adoption of climate change adaptation measures is land tenure status.

Under factor 5 (labour constraints), only one variable loaded – high cost of farm labour (0.743). Previous analyses of barriers to climate change adaptation show that shortage of farm labour is one of the major constraints to adaptation by farmers (Deressa 2008, Adger 2001).

5. Conclusion

In the face of extreme weather events occasioned by climate change, and apparently because of its tolerance to these conditions, cassava has become the dominant crop in southeastern Nigeria. Virtually all the respondents were, not only aware of climate change, but also aware that some of its variables like extreme weather events and uncertainties in the onset of farming season have been on the increase. In addition, they were also aware of the effect of climate change on agriculture, but were not aware that some agricultural practices could exacerbate climate change. Although there was no significant difference between Enugu and Imo states regarding the extent to which climate change was contributing to early rains that were not sustained, long period of dry season, less rainfall, no/reduced hamattan, heavy rainfall, soil erosion, decreasing soil moisture, pest, disease and weed infestation, and declining soil fertility, the considered effect of climate change on most of the other variables were more pronounced in Imo than Enugu. However, the overall impact (farm yield and income) was significantly higher for Enugu than for Imo state, essentially because of Enugu's inherently drier weather; being closer to the North. The biggest effect of climate change in the region was reduced farm yield and income, drying up of streams/rivers, reduction in storage quality of crops, loss of pastureland/vegetation and destruction of wildlife ecosystem.. Some of the coping strategies adopted by the farmers with a relatively high PI include multiple/intercropping, agro-forestry/aforestation, mulching, purchase/harvest of water for irrigation and use of resistant varieties. The major factors identified to be driving farmers' investment in adaptation practices were age and level of education of the farmer as well as his/her level of awareness of climate change issues. At the societal level, the major factors constraining them from adapting to climate change were poverty; farmland scarcity and lack of more efficient input, information and training constraints, land tenure and labour constraints. The foregoing further underscores the need for farmers' education, awareness creation, poverty alleviation and the provision of more efficient inputs to them as potent tools for climate change adaptation in the area.

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Tables

Table 1: Percentage distribution of respondents by most important crops/ animals grown/reared

Most important crop	Percentage*	Most important animal	Percentage*
Cassava	64	Goat	50
Yam	23	Poultry	38
Cocoyam	4	Sheep	6
Vegetables	3	Pig	5
Maize	2	Cattle	1
Rice	1	Fish	1
Oil palm	1		
Others	2		

*Note: * the number of respondents (N) = 382*

Table 2: Percentage distribution of respondents by whether or not they are aware of some climate change issues

Questions on awareness of climate change	Yes*	No
Have heard of climate change before now?	96	6
Source of information:		
(i) Friends	36	
(ii) Extension workers	26	
(iii) Farmers cooperatives	1	
(iv) Newspapers	5	
(v) Radio/Television	24	
(vi) Researchers	2	
Do you think climate change will have anything to do with your agriculture or with you?	97	3
Do you think that some of your farming activities can contribute to climate change?	48	52

*Note: * Number of respondents is 382*

Table 3: Data on direction of change of climate change phenomena and extent of contribution of phenomena to climate change

Phenomena you think have been getting worse over the past ten years		Increasing (IC)	Decreasing (DC)	No change (NC)	Mean extent of contribution of climate change to the phenomenon
Uncertainties in the onset of farming season					
(i)	Unusual early rains that are not sustained	83	13	4	3.5
(ii)	Erratic rainfall pattern	83	13	4	3.3
(iii)	Delay in the onset of rain	89	7	3	3.6
(iv)	Long peri od of dry season	80	16	4	3.4
(v)	Heavy and long period of rainfall				
(vi)	Less rainfall	15	82	3	3.0
(vii)	No harmattan	75	17	8	3.2
(viii)	Reduced harmattan	30	28	42	2.6
(ix)	Long harmattan	68	22	10	2.6
(x)	High Temperature	16	70	14	3.4
Extreme weather events					
(i)	thunderstorms	36	19	46	4.1
(ii)	heavy winds	45	22	33	3.9
(iii)	floods	42	47	11	3.6
(iv)	drought	58	14	28	3.3
(v)	heat waves	31	19	50	3.2
(vi)	heavy rainfall	21	73	6	3.4
(vii)	desertification	25	16	59	3.5
(viii)	loss of forest resources	35	25	40	3.3
(ix)	Soil erosion	38	47	15	3.1
(x)	Decrease in soil moisture	71	20	9	3.3
Pests		59	32	9	3.5
Diseases		58	27	15	3.5
Weeds		38	26	36	3.1
Land degradation					
(i)	Decreasing soil fertility	84	9	7	3.5
(ii)	Drying up of streams	77	16	7	3.7
(iii)	Overflowing streams/rivers	23	70	7	3.2

Cut off point= 50% Cut off= 3.0

Table 4: Result of test of difference between the responses of respondents in Imo and Enugu State on the extent to which climate change is contributing to changes

	Phenomena	Enugu		Imo			
		mean	S.D.	mean	S.D.	T	P-value
i.	Unusual early rains that are followed by weeks of dryness	3.19	0.98	3.94	0.97	-6.60	0.82
ii.	Erratic rainfall pattern	3.10	0.99	3.48	1.06	-3.40	0.3
iii.	Delay in the unset of rain	3.52	0.88	3.64	1.03	-1.08	0.01
iv.	Long period of dry season	3.12	1.13	3.76	1.04	-5.60	0.10
v.	Heavy and long period of rainfall	2.86	1.03	3.15	1.23	-2.20	0.05
vi.	Less rainfall	3.12	1.13	3.25	1.07	-1.04	0.33
vii.	No harmattan	2.60	1.19	2.52	1.16	0.48	0.89
viii.	Reduced harmattan	2.69	1.02	2.53	1.05	1.40	0.54
ix.	Long period of harmattan	2.97	1.23	4.02	0.94	-8.78	0.03
x.	Higher temperature	3.79	1.25	4.43	0.82	-5.00	0.00
xi.	Extreme weather events: thunderstorms	3.07	1.37	4.54	0.72	-10.45	0.00
xii.	Heavy winds	3.13	1.14	4.07	0.87	-7.34	0.00
xiii.	Floods and erosion	2.92	1.26	3.66	1.01	-5.94	0.02
xiv.	Drought	2.65	1.37	3.82	0.94	-8.61	0.00
xv.	Heat waves	3.07	1.26	3.67	0.96	-4.05	0.02
xvi.	Heavy rainfall	2.85	0.95	4.20	0.86	-13.12	0.09
xvii.	Desertification	2.92	1.25	3.42	1.39	-2.84	0.00
xviii.	Loss of forest resources	2.99	1.17	3.50	1.33	-3.10	0.00
xix.	Soil erosion	2.80	1.07	3.40	1.11	-4.77	0.25
xx.	Decrease in soil moisture	3.22	1.20	3.47	1.07	-1.99	0.61
xxi.	Increase in pest problems	3.59	1.16	3.38	1.10	1.67	0.48
xxii.	Disease incidence	3.83	1.20	3.07	1.21	5.53	0.62
xxiii.	Weed infestation	3.18	1.05	3.04	1.21	1.04	0.08
xxiv.	Decrease in soil fertility	3.53	1.09	3.58	1.12	-0.41	0.42
xxv.	Drying up of streams	3.53	1.12	3.90	1.03	-2.94	0.00
xxvi.	Overflowing of streams/rivers	3.25	1.14	3.23	1.36	0.15	0.02
xxvii.	Introduction of new crop species	2.99	1.22	1.71	1.11	9.78	0.03
xxviii.	Extinction of some crop species	3.41	1.13	2.80	1.66	3.61	0.00

Table 5: Mean response of farmers on extent of change of farm characteristics

	N	Minimum	Maximum	Mean	Std. Deviation
Extent to which soil drainage has decreased	371	1.00	5.00	3.03909	1.17195
premature ripening of crops	376	1.00	5.00	2.9681	1.22378
Reduced production cycle	368	1.00	5.00	2.8804	1.13735
Prolonged production cycle	370	1.00	5.00	2.2568	1.25438
Reduced yield	382	1.0 0	5.00	3.7068	.98434
Reduced income	380	1.00	5.00	3.9026	.92088
Reduction in storage quality of crops	376	1.00	5.00	3.2979	1.16463
Destruction of wildlife ecosystems	371	1.00	11.00	3.1860	1.59744
Streams/rivers drying up	357	1.00	5.00	3.5826	1.15488
Education in the population of fish	300	1.00	5.00	3.1700	1.34180
Loss of pastureland and vegetation	362	1.00	5.00	3.2182	1.49214
Deduction in farm size	374	1.00	5.00	3.1390	1.31476
Increased farm size	372	1.00	5.00	2.2419	1.39524

Cut off point= 3.0

Table 6: Result of test of difference between the responses of respondents on the extent to which farm characteristics have changed over ten past years in Imo state and Enugu State

s/n	Farm characteristics	Enugu		Imo			
		mean	S.D.	mean	S.D.	T	P-value
i.	Decreased soil drainage	2.06	1.11	2.87	1.09	-7.09	0.90
ii.	Premature ripening of crop	3.07	1.01	2.86	1.34	1.61	0.00
iii.	Reduced production cycle	3.15	0.93	2.59	1.27	4.85	0.00
iv.	Prolonged production cycle	2.04	1.24	2.49	1.22	-3.54	0.45
v.	Reduction in yield	3.82	0.92	3.59	1.04	2.36	0.01
vi.	Reduction in farm income	3.97	0.88	3.83	0.96	1.43	0.00
vii.	Reduction in storage quality of crops	2.92	1.20	3.70	0.97	-6.98	0.04
viii.	Destruction of wildlife ecosystems	2.49	1.69	3.91	1.09	-9.66	0.00
ix.	Streams/rivers drying up	3.52	1.22	3.65	1.07	-1.12	0.01
x.	Reduction in fish population	2.93	1.61	3.42	0.93	-3.18	0.00
xi.	Loss of pastures land/vegetation	2.38	1.50	4.08	0.86	-13.26	0.00
xii.	Reduction in farm size	2.96	1.38	3.33	1.22	-2.74	0.04
xiii.	Increased farm size	2.33	1.48	2.14	1.30	1.34	0.00

Table 7: Mean responses of farmers on extent of practice of activities that could cause climate change

	N	Minimum	Maximum	Mean	Std. Deviation
Bush burning	381	1.00	3.00	2.0682	.70380
Continuous cropping	348	1.00	3.00	1.7126	.69012
Over grazing	323	1.00	3.00	1.1393	.40467
Extent to which Swamprice is produced	286	1.00	3.00	1.3986	.73642
Extent to which crop wastes are burnt	357	1.00	3.00	1.8235	.70289
Burning of woodfuel	389	1.00	3.00	2.6967	.54727
The use of fertilizers	389	1.00	3.00	2.1568	.76562
Use of insecticids/ pesticides	317	1.00	3.00	1.5710	.74131
The use of herbicides	316	1.00	3.00	1.5222	.74075
Deforestation	312	1.00	3.00	1.5705	.55689

Cut off mark = 2.0

Table 8: Mean and standard deviation of the responses of the respondents in Imo state and Enugu state on climate change adaptation cost*

s/n	Adaptation measures	Cost/ha		Revenue/ha		PI	
		Mean	SD	Mean	SD	Mean	SD
i.	Purchase of water for irrigation (liters)	12220.59 (17)	6014.80	35118.06 (12)	28694.81	1.86 (12)	1.26
ii.	Mulching	15116.46 (55)	31272.42	33167.28 (47)	71029.69	1.89 (39)	1.76
iii.	Use of wetlands/river valleys (e.g Fadama)	36874.8 (35)	57737.74	93539.29 (21)	100304.1	0.95 (21)	0.58
iv.	Aforestations: planting of trees	12543.01 (38)	9963.942	29001.61 (37)	15777.25	1.91 (37)	1.57
v.	Use of resistant varieties	8702.284 (44)	9654.234	22770.51 (26)	20473.11	1.77 (26)	2.43
vi.	Expansion of cultivated land area	20687.5 (18)	22296.39	55505.21 (16)	33213.96	2.64 (11)	2.41
vii.	Increased used of fertilizers	11704.36 (127)	14356.89	32700.3 (68)	34987.75	1.45 (67)	1.32
viii.	Intensive manure application	13158.66 (37)	28239.53	31285.71 (21)	46531.45	0.97 (18)	0.84
ix.	Use of chemical: herbicides, pesticides, etc.	7370.24 (65)	9426.08	17395.83(24)	15960.55	2.08 (22)	1.65
x.	Multiple/intercropping	33222.83 (50)	38004.95	118096.50 (47)	291581.50	3.01 (46)	6.86
xi.	Use of agro- forestry	8356.53 (41)	8617.53	26371.58 (39)	27284.35	2.69 (39)	2.04
xii.	Change from arable to permanent crops or vice versa	14972.31 (12)	18440.50	37405.83 (15)	37546.94	1.00 (10)	1.25

Note: Figures in parentheses are no of observations.

** Costs and revenues are calculated in Nigerian Naira (1$ =₦150)*

Table 9: OLS Regression result on factors affecting the farmers level of investment in adaptation practices

s/n	Variables	Coefficients	t
i.	Age (years)	2716.444	2.55*
ii.	Gender of household head (male=1, female=0)	-5998.05	-0.26
iii.	Level of education (years)	6453.965	2.68*
iv.	Profit from adaptation practices	-25760.96	-0.93
v.	Av. Annual income from farming	0.0418673	0.66
vi.	Farm size (ha)	3145.585	0.38
vii.	Household size	1482.901	0.27
viii.	Climate change affect agriculture (yes=1, No=0)	49687.81	2.01
ix.	Farming contributes to climate change (yes=1, No=0)	91423.52	1.72

No of observations =94; R^2 = 0.2391; F= 2.93; Prop> F= 0.0045

Table 10: Constraints to adaptation (Rotated Component Matrix)

Variables	Constraints				
	Poverty	Land and efficient input	Information and Training	Land Tenure	Labour
Limited availability of land for farming	.152	.558	.283	.384	-.010
High cost of farmland	.580	-.002	.388	.287	.105
Inherited system of land ownership	.086	.249	-.113	.786	-.178
Communal system of land ownership	-.110	.310	-.042	.775	-.139
Poor access to information sources	.353	.030	.588	-.045	-.354
Non-availability of credit facilities	.559	.378	.007	.141	-.496
High cost of irrigation facilities	.483	.244	.222	-.109	.357
Non-availability of farm inputs e.g. improved seeds	.255	.598	.329	-.002	.368
high cost of fertilizers and other inputs	.158	.761	.003	.040	.043
Inadequate knowledge of how to cope or build resilience	.050	.267	.771	-.025	.091
high cost of improved varieties	.013	.725	-.076	.203	.021
Non-availability of farm labour	.404	.413	.371	.129	.219
high cost of farm labour	.042	.201	-.150	-.075	.743
Lack of access to weather forecast technologies	.751	.146	-.267	-.200	.086
Government irresponsiveness to climate risk management	.408	-.206	.683	.006	-.131
Non-availability of storage facilities	.648	.017	.348	.311	-.150
Limited income	.782	.146	.145	.139	-.002
Non-availability of processing facilities	.668	.196	.284	-.150	-.089
High cost of processing facilities	.808	.030	.278	.109	.109
Traditional beliefs/ practices e.g. on the commencement of farming season etc	.204	-.154	.179	.663	.408

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

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Science, Technology and Innovation for African Development

ISBN: 978-9966-030-00-9