Study of Technological and Farming Systems Adaptation to Climate Change in Farming Communities of Enugu State, Nigeria

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Abstract

Climate change has become our new reality. It brings with it changes in weather patterns that can have serious repercussions for all of us, upsetting seasonal cycles, harming ecosystems and water supply, affecting agricultural farming systems and food production, causing sea-levels to rise. Climate change causes floods, landslides, drought and famine. Climate change has a cumulative effect on natural resources including agricultural resources and the balance of nature. Its effects are already visible in Enugu state and Nigeria in general.

In Nigeria and Enugu state in particular, varieties of food crops are produced and all are dependent on rainfall, so that where rain is abundant rain-fed crops are planted, and in drier parts of the country, crops that do not require much rain are cultivated. Based on this, the objectives of this research paper are to critically elicit the level of awareness and understanding of farmers and local communities concerning the manifestation and impacts of climate change. Furthermore, the study is to identify relationships between climate and adjustments in farming systems and management technologies in the study area. And finally, the research is to ascertain the patterns and manner of livelihood adjustments that have been implemented by the local communities and farmers in response to the climate change phenomenon.

From the research, it was found out that, individuals and communities have adapted behaviours or policies geared at restoring and conserving the environment due to climate change conditions. Increased self-reliance, avoiding unregulated forest exploitation, planting appropriate tree species, protecting watersheds, practicing agro-forestry and organic farming techniques and maintaining adequate food supplies to lessen the vulnerability of the food supply sector are some of the recent adaptive measures by different farming communities in the state. In some local communities, erecting contour bunds around farmlands as a safeguard against soil erosion and flooding; using organic manure instead of the more preferred chemical fertilizers; establishing wood lots with fast-maturing plant species that yield domestic fuel wood for community members; reducing bush-burning; using disease-resistant, quick-maturing crop and plant species; properly preserving seeds and plant seedlings to ensure healthy germination in the succeeding farming season; also helps to mitigate the effects of climate change. Furthermore, limiting access to eroded and erosion-prone areas, and initiating and stringently enforcing anti-erosion laws which act as human deterrents has been put in place in some communities.

Based on the findings from the research work, it is recommended that the most effective method of staving off the negative effects of climate change is educating the public on the menace of land erosion and the public's role in tackling the problem. Also there is need for educating Nigerians/Enugu State communities overall on how climate change will affect all human activity – especially their farming systems. Furthermore, the scientific community must be involved in studying climate change and forecasting weather, and then transmitting this information to all sectors of the society, industry and economy so that these sectors can adapt and be ready to meet a very different future than the present. The Enugu State government, especially, must adopt strategies and policies that will encourage improved farming practices and agricultural methods, and that will protect our cherished agricultural activities which is the mainstay of our economy.

List of Acronyms & Abbreviations

AfDB	African Development Bank
AIAE	African Institute for Applied Economics
AMS	American Meteorological Society
ARTES	Africa Rainfall and Temperature Evaluation System
ATPS	African Technology Policy Studies Network
BNRCC	Building Nigerian Responses to Climate Change
CEEPA	Centre for Environmental Economics and Policy in Africa
CFC	Chlorofluorocarbon
EPIC	Erosion Productivity Impact Calculation
ENSO	El Niño-Southern Oscillation
FAO	Food and Agricultural Organization
FGDs	Focus Group Discussions
GCMS	General Circulation Models
GDP	Gross Domestic Products
IPCC	Intergovernmental Panel on Climate Change
LGAs	Local Government Areas
MDGs	Millennium Development Goals
NACB	Nigerian Agricultural and Cooperative Bank
NEST	Nigerian Environmental Study Action Team
NGOs	Non-governmental Organization
NOAA	National Oceanic and Atmospheric Administration
NPC	National Population Commission
UKCIP	United Kingdom Climate Impacts Programme
UNDP	United Nation Development Programme

1. Introduction

1.1 Background information

Climate change is considered the most pressing environmental problem facing the globe today. It is affecting patterns of life and general living conditions of people around the world; the availability of water, food production, weather conditions, health, cultures, economic well-being and recreation among others. Millions of people, especially in the desert prone frontline states of the Northern Nigeria, will be confined to perpetual poverty and perilous living conditions due to food and water shortages, and extreme change in weather pattern as a result of global warning.

As reported by Ikeme (2009) Nigeria is currently experiencing increasing incidence of disease, declining agricultural productivity, increasing number of heat waves, unreliable or erratic weather patterns, flooding, declining rainfall in already desert-prone areas in the north causing increasing desertification, decreasing food production in central regions, and destruction of livelihoods by rising waters in coastal areas where people depend on fishing and farming. Climate change is making some land uninhabitable and affecting water supplies, threatening people's basic needs and triggering displacement.

In 1999 and 2000, more than 200,000 people were displaced by floods in Niger State. In1988, flooding in Kano State displaced more than 300,000 people. Meanwhile, as reported by Halliri (2010), scores of people have been killed by floods in several states of northern Nigeria where unusually heavy rains have swollen rivers and streams across the region. According to Halliri (2010), the flood overran villages in about seven states, with increasing number of deaths and loss of cattle across the region, and thousands of people displaced. Although flooding has become more or less an annual environmental disaster for the region in recent years, especially during the peak of the rainy season, year 2010 recorded some of the worst flood cases.

In some parts of northern Nigeria, especially in Sokoto, Katsina, Kano, Jigawa, Zamfara and Kebbi states, whole villages and farmlands were submerged. In the Goronyo local government of Sokoto State, thousands fled their homes, while more than 2,000 houses were destroyed in the four villages of Kagara, Boye Kai, Balla and Giyawa. Property worth millions of naira was lost and farm produce and farmlands were washed away, Halliri (2010). Over thirty houses have been destroyed by flood waters and windstorm in Shanono Local Government Area of Kano State, causing hundreds of people to take refuge in a local primary school. Furthermore, about a million people living in the low-

lying plains of the River Niger are considered to be at risk. Flooding is recorded every year in all the states along the Niger River and its tributaries, frequently causing disasters as stated by NEST (2004). In Enugu state, it is on record that flooding is of great concern to the present state government according to BNRCC (2009). Due to this flood problem in the study area which is attributable to climate change within the state, the state ministry of environment has of recent carried out listing exercise to obtain and up-date the data bank on the environmental degradation prone areas of the state. Moreover, it is reported that two-thirds of Bayelsa State and half of Delta State are inundated by devastating floods for at least a quarter of each year (Uyigue and Agho, 2007). In districts under water, schools and markets are suspended for weeks at a time.

Meanwhile environmental degradation and attendant desertification are major threats to the livelihoods of the inhabitants of the frontline states in the country. The factors responsible for this environmental and ensuing desertification include; increasing population pressure, intensive agricultural land use, overgrazing, bush burning, extraction of fuel wood and other biotic resources. In Nigeria especially in Enugu state, women and children are particularly vulnerable to impacts of climate change. Most states in the country have inadequate policy and regulatory laws for sustainable natural resources management. Forest resources and water are in particular not regulated and there are inadequate baseline data and information on ecological issues in most states of the federation.

1.2. Problem Statement

Global warning and climate change refer to an increase in average global temperature. Natural events and human activities are believed to contribute to an increase in average global temperature. This is caused primarily by increase in greenhouse gasses such as carbon dioxide which is problem to human existence. Nigeria is experiencing adverse climate conditions with negative impacts on welfare of millions of people. Persistent droughts and flooding off-season rains and dry spells have sent growing season out of orbit, on a country dependent on rain-fed agriculture. Alarm bells are ringing with lakes drying up and a reduction in river flow in the different parts of the country and even Enugu state. The result is low water supplies for use in agriculture, hydro power generation and other users. The main suspect for all this havoc is climate change. According to Odey (2009), Nigeria loses about $750 million annually to the depletion of its 350,000 hectares of forest land by direct human activities and climate change. Also Odey (2009) equally reported that the Sahara Desert in Nigeria is moving southward at a rate of 600 meters annually. Odey (2009) further added that about 100,000 farming families move southwards as a result of the desertification which is the resultant effect of climate change in the country.

Following these development in different parts of the country, there is no doubt that climate change is the greatest and biggest challenge facing mankind today. Its impact has spread beyond the environment, causing serious dislocation in world economic and social development. In Africa, Nigeria and Enugu state in particular, climate change impact poses great danger on desertification, damage to infrastructure, sea-level rise, flooding and water salinity with serious implication.

In Nigeria according to Ikeme (2009), climate change and its problems and solution strategies do not generate greater publicity effects as they are too complex for rather superficial political talks. Climate change often appears very esoteric but in Nigeria and Enugu state it is real and this call for

scientific study of this kind. We already have an increasing incidence of diseases, declining agricultural productivity, and rising number of heat waves in Enugu state. There is glaring evidence that climate change is not only happening but it's changing our lives. BNRCC (2009) reported that in Enugu state no fewer than 300 families have been rendered homeless in “Ameke Ngwo” and “Ngwo Uno” communities in Udi local council of Enugu state following the destruction of their houses and economic trees worth millions of naira by a wind storm which wrecked havoc in the area. This represents one of the resultant effects of climate change in the state.

Based on the work of IPCC (2001a), the implications of climate change for agriculture in the country and the study area can be deduced as flooding and erosion arising from higher rainfalls, rise in sea levels, coastal problems. Furthermore, there are decreases in crop yields, arising from interplay of biological and ecosystem alterations and this is consequence of climate change across the different states of the country and this call for scientific study. Despite the huge implication of climate change response measures for Nigeria's economy, it is appalling that there is no visible demonstration of the preparedness of the government to tackle this issue. The greatest call for concern is that the blueprint for Nigeria's development vision 2010 as reported by Ikeme (2009) fails to give a mere acknowledgement of the importance of climate change to Nigeria's economy, let alone stipulate the development strategy with which to tackle it. The observation above shows that the danger signals are clear which explain the need for this study. Given the above enumerated problems and others, it is clear that Nigeria and Enugu state long term development priority of poverty reduction, the Millennium Development Goals (MDGs) and both the Seven (7) points and Four (4) points agenda of the country and state respectively will be severely constrained if insufficient attention is paid to current and future climate change of the state through studies of this kind.

1.3. Research Objectives

The objectives of the research are to identify and document indigenous and emerging technologies and innovations for climate change adaptation among the farming communities. Other specific objectives include:

- To elicit the level of awareness and understanding of farmers and local communities about the manifestation and impacts of climate change;
- To identify the relationships between climate change and adjustments in farming systems and management technologies;
- To ascertain the patterns and manner of livelihood adjustments that have been implemented by local communities and farmers in response to the climate change phenomenon;
- To draw policy lessons for the state government's efforts in promoting sustainable environment and climate change mitigation and adaptation

1.4. Research Justification

Environmentally, Nigeria's climatic regime stands to be severely disrupted leaving its forests and water resources at risk. Studies show that biological productivity in Nigeria will decrease in the event of global warming (Adesina and Adejuwom, 1994) with an additional consequence of severe fuelwood shortages. Already Nigeria has experienced definite shift in the long-term rainfall mean towards more arid conditions. These climatic changes have had adverse implications for water resources availability for power generation and agriculture. Likewise, Nigeria's low-lying lagoonal

coasts stand threatened by sea-level rise, particularly because most of its major and rapidly expanding cities are on the coast. If sea level rises, inundation could occur along more than 70% of the Nigerian coastline, placing land at risk many kilometers inland (Awosika et al., 1992). In Nigeria, inundation is the primary threat for at least 96% of the land at risk (Awosika et al., 1992; French et al., 1995). Though climate change is global, its manifestations/effects are experienced by local communities in Enugu state and Nigeria in general. These communities within Enugu state have very low adaptive capacities for managing climate change. Moreover, their vulnerability is worsened by heavy reliance on renewable natural resources for livelihoods, employment and incomes. Among the most affected groups are farmers, pastoralists, foresters, fisher folks, and hunters who are faced with the increasing effects of flooding, sea level rise, desertification, drought, heat stress, pests and diseases and erratic rainfall patterns resulting from changes in the climate. The situation calls for development interventions to enhance climate risks management by local communities and individuals within the state.

Nigeria is made up of six (6) geopolitical zones. Each zone has distinct features and peculiar climate change risks. For instance, the South-south zone is affected mainly by sea level rise and deforestation; Southwest by deforestation; Southeast where Enugu State is located by erosion, flooding and land degradation; North central by de-vegetation/overgrazing; Northeast by drought, desertification and heat stress; and Northwest by drought, desertification and heat stress. The impacts of climate change especially in Enugu state on agriculture are projected to manifest through changes in land and water regimes, specifically, changes in the frequency and intensity of droughts, flooding, water shortages, worsening soil conditions, disease and pest outbreaks on crops and livestock. The balance of risks differs across other states in the country and other geographic regions of the world. Higher altitudes will benefit from higher temperatures in the form of lengthened growing seasons. But lower altitudes will suffer shorter growing seasons and adversely affect growing conditions, since rising temperatures are likely to adversely affect soil nutrients and organic matter through microbial decomposition (Rounsevell et al, 1999).

As it is established that climate change is considered the most pressing environmental problem facing the globe today and general living conditions of people around the world and even in Enugu state, therefore there is need for this study. The rationale for this study is therefore to identify, examine and analyze the different technological and farming systems adaptation mechanisms employed by farming communities in Enugu state for coping with the impacts of climate change. The study will further be justified by finding out the coping abilities of different farming communities in Enugu state. The study will too elaborates the concept and meaning of climate change, the causes and form of climate change and the effects and implications of climate change in the livelihood of the communities in the study area.

1.5 Structure of the Report

The report is divided into six chapters. Chapter one provides the background information including problem statement, research objectives, justification and structure of the report. Literature review of the report is presented in chapter two of the report. Chapter three of the report contains the methodology. The result of the report was analyzed in chapter four of the work while as chapter five presented the summary of the findings of the work. The report ends in chapter six with conclusion and recommendations.

2. Literature Review

2.1 Concept of Climate Change Adaptation

In the views of IPCC (2007), climate change is a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and /or the variability of its properties, and that persists for an extended period typically decades longer. As reported by American Meteorological Society (AMS), climate change is any systematic change in the long-term statistics of climate elements (such as temperature, pressure or winds) sustained over several decades or longer. Climate change may be due to natural external forces, such as changes in solar emission or slow changes in the earth's orbital elements; natural internal processes of the climate system; or anthropogenic forces.

Meanwhile, Nasiru Idris Medugu (2009) refers to climate change as a change in climate that is attributable directly or indirectly to human activities, that alters the atmospheric composition of the earth which leads to global warming. Furthermore, NOAA National Weather Service (2007) sees climate change as a normal part of the earth natural variability, which is related to interactions among the atmosphere, ocean, and land, as well as changes in the amount of solar radiation reaching the earth. For example, it could show up as a change in climate normal's (expected average values for temperature and precipitation) for a given place and time of year, from one decade to the next. “Climate change" involves more than just a change in the weather; it refers to seasonal changes over a long period of time.

It is important to note that climate change is different from the generally known term like climate fluctuations or climate variability. These terms denote inherent dynamic nature of climate on various temporal scales. Such temporal scale variations could be monthly, seasonal, annual, decadal, periodic, quasi-periodic or non-periodic. With the prevalent impact of climate change, efforts have been made to discover methods of adaptation. There exist various views on the concept of adaptation to climate change.

The major scientific body associated with climatic change, the Intergovernmental Panel on Climate Change (IPCC), defines climate change adaptation as adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, public and private adaptation, and autonomous and planned

adaptation.'Climate change adaptation offered in the inter-agency report, Poverty and Climate Change (AfDB et al 2003) reported climate change adaptation as the ability to respond and adjust to actual or potential impacts of changing climate conditions in ways that moderate harm or take advantage of any positive opportunities that the climate may afford. UNDP (2005) refers to climate change adaptation as a process by which strategies to moderate, cope with and take advantage of the consequences of climatic events are enhanced, developed, and implemented. But UKCIP (2003) views the concept of climate change adaptation as the process or outcome of a process that leads to a reduction in harm or risk of harm, or realization of benefits associated with climate variability and climate change.

According to (IPCC, 2001), there are several types of climate change adaptation, which are distinguished into anticipatory or proactive climate change adaptation (which is the adaptation that take place before impacts of climate change is observed); autonomous or spontaneous climate change adaptation (which is that adaptation that does not constitute a conscious response to climatic stimuli but triggered by ecological changes in natural systems and by market or welfare changes in human systems; planned climate change adaptation is that as a result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state). Other types of climate change adaption include; private climate change adaption which is initiated and implemented by individuals, households or private companies; public climate change adaption which is initiated and implemented by governments at all levels which in Nigeria include federal, state and local government; finally is reactive climate change adaptation that takes place after impacts of climate change have been observed. Of all these named climate change types, the most associated type(s) in the study area are – private and public climate change adaptation.

2.2 Causes of Climate Change

According to Botkin and Keller (2000), the phenomenon of climate change is linked to both natural and human causes - water vapor in the atmosphere contributes the most to natural greenhouse warming. Water vapor and other "greenhouse gases" such as carbon dioxide, methane, and CFCs cause the greenhouse effect by trapping radiant heat emitted at the infrared (long) wavelengths (as opposed to shorter, solar wavelengths which can pass through the atmospheric gases) from the earth's surface and reradiating it back to the earth's surface. This trapped energy effectively creates an enclosure around the earth's atmosphere similar to a greenhouse which not only traps heat, but also restricts air circulation that would otherwise cause cooling.

The natural processes of the causes of climate change are known also as the astronomical and the extraterrestrial factors. The astronomical factors include the changes in the eccentricity of the earth's orbit, changes in the obliquity of the plane of ecliptic and changes in orbital procession while the extra-terrestrial factors are solar radiation quantity and quality among others. On the other hand, the anthropogenic factor in climate change involves human activities that either emit large amount of greenhouse gases into the atmosphere that depletes the ozone layer or activities that reduce the amount of carbons absorbed from the atmosphere. The human factors that emit large amounts of greenhouse gases include industrialization, burning of fossil fuel, gas flaring, urbanization and agriculture. Furthermore, human activities that reduce the amount of carbon sinks as reported by (IPCC, 2007 and Nzeh, 2008) are deforestation, alterations in land use, water pollution and

agricultural practices. All theses human factors have been proven to be responsible for the ongoing unequivocal climate change or global warming in Nigeria and Enugu state in particular.

2.3 Nigeria Climate and Climate Change Perspective

In the past, the descriptions of the climate of Nigeria, and indeed South East Nigeria where Enugu state is located have been rather simplistic due to paucity of data, but with the availability of data manipulation techniques, it is possible to discuss more fundamental features of the climate. Such is necessary at this point in time as recent droughts, water shortages, fauna and flora depletion have highlighted how important it is to understand weather phenomena (Oguntoyinbo, 1982) and how they affect human security. Nigeria is one of the countries in West African sub-region; it has an estimated population of over 140 million people according to (NPC, 2006) spread over a land area of 932,768sqkm. Nigeria is bound by Cameroon to the east, Chad to the northeast, Niger to the north, Benin to the west, and the Atlantic Ocean to the south.

The climate of Nigeria is tropical in nature, which is occasionally subjected to variations, depending on the rainfall. During summers, major portion of the country comes under the influence of moisture-laden tropical maritime air. Temperatures are high throughout the year, averaging from 25° to 28°C. In the higher elevations of the Jos Plateau, temperature is at an average of 22°C. Northern Nigeria experiences greater temperature extremes than the south. Rainfall varies widely over short distances from year to year.

Nigeria can be divided into the sub-equatorial south, the tropical hinterland, the tropical continental north and the high plateaux. In comparison, there is pronounced long period of wet season in the south and longer period of dry season in the North. In Nigeria there is general increase in the sunshine hours from the Atlantic coast to the interior. The amount of sunshine ranges from a minimum of 1300 hours in the Niger Delta at the coastline to over 3200 hours in the extreme North East angle. Similarly, in terms of annual totals of global radiation, the radiation level in the north of Nigeria (190kg-cal,) is almost double the level in the South (110 kg-cal,). The increase northwards is approximately parallel with the lines of latitude as reported by Oguntoyinbo, 1982.

Due to its location along the tropics of equator, Nigeria experiences high temperatures all the year round. Seasonal and latitudinal variations affect the seasonal ranges. Within Nigeria, the mean temperatures are determined by the location of a particular place in question. Observation indicates that mean maximum temperatures increase from the coast northward. The highest monthly mean of 32.2°C for the coastal region to a mean of 40.6°C in the extreme north, including the northeast axis is common. The rainfall pattern in Nigeria is a good reflection of the seasonal variations of the surface location of the Inter-Tropical Discontinuity. The basic characteristics depict a decrease both in duration and amount from the coastline to the interior except where altitudinal effects create some breaks and alterations. The coastal areas receive more than 4000mm spread over 8-10 months, while the extreme north fringes of the country receives less than 250mm, which is spread over a shorter period of time between 3-4months. The implication of variation in the overall climatic condition is differentiation in the vegetative zones in Nigeria, which are tied to a combination of amount of rainfall and temperature. According to Eboh, et al (2005), the ecology of the country varies from tropical forest in the south to dry savanna in the far north, yielding a diverse mix of plant and animal life.

About two-thirds of Nigeria lies in the watershed of the Niger River, which empties in to the Atlantic at the Niger Delta, and its major tributaries: the Benue in the northeast, the Kaduna in the west, the Sokoto in the northwest, and the Anambra in the southeast. The amount of vegetation cover on the soil decrease northwards, with the extreme north relatively bare compared to other zones. There are forests, savannah, and mountane vegetation zones. In the low-lying coastal regions, mangroves are found while swamp forest are found where the water is fresh. Farther inland, this vegetation gives way to tropical forest, with its many species of tropical hardwoods, including mahogany, iroko, and obeche. The fauna of Nigeria includes elephants, buffaloes, lions, leopards, smaller animals such as antelope, monkeys, jackals, and hyenas, which are found in abundance. Hippopotamuses and crocodiles are still common in the largest rivers. Birds, including species that migrate seasonally between Africa and Europe, are also abundant in Nigeria.

Meanwhile, climate change has been described as the greatest environmental threat in the 21st century manifesting in extremes of events such as flooding, drought, changes in rainfall intensity and pattern, sea level rise, drying up of rivers/streams among others. Nigeria has begun to feel the effects of climate change as the frequency and intensity of extreme events like droughts and floods have increased.

According to Bala-Gbogbo (2009), the humid tropical zone of southern Nigeria - including Enugu State is already too hot and too wet, and it is expected to be characterized by increase in both temperature and precipitation, especially at the peak of the rainy season. Already, temperature increases of 0.2 degree to 0.3 degree per decade have been observed in the various ecological zones of the country, particularly since 1960s."

Data from the environment watchdog according to Bala-Gbogbo (2009) reveal that for the tropically humid zones of Nigeria, precipitation increases from about 2 to 3% for each degree of global warming may be expected. By implication, it is expected that precipitation will probably increase by approximately 5 to 20% in the very humid areas of the forest regions and the southern savannah areas. Therefore, climate change will have direct impacts on biodiversity, agriculture (farming practices), water resources, forests, and coastal areas...also some areas will start receiving heavier and steadier rainfall and such areas will inevitably begin to experience increased rainfall induced erosion."

2.4 The Impacts of Climate Change in Africa

Several climate regimes characterize the African continent; the wet tropical, dry tropical, and alternating wet and dry climates are the most common. Many countries on the continent are prone to recurrent droughts, some drought episodes, particularly in southeast Africa. Deterioration in terms of trade, inappropriate policies, high population growth rates, and lack of significant investment-coupled with` a highly variable climate-have made it difficult for several countries to develop patterns of livelihood that would reduce pressure on the natural resource base. Under the assumption that access to adequate financing is not provided, Africa is the continent most vulnerable to the impacts of projected changes because widespread poverty limits adaptation capabilities.

In Africa today, tropical forests and rangelands are under threat from population pressures and

systems of land use. Generally apparent effects of these threats include loss of biodiversity, rapid deterioration in land cover, and depletion of water availability through destruction of catchments and aquifers. Changes in climate will interact with these underlying changes in the environment, adding further stresses to a deteriorating situation. A sustained increase in mean ambient temperatures beyond certain level would cause significant changes in forest and rangeland cover; species distribution, composition, and migration patterns; and biome distribution. Many organisms in the deserts already are near their tolerance limits, and some may not be able to adapt further under hotter conditions. Arid to semi-arid sub-regions and the grassland areas of eastern and southern Africa, as well as areas currently under threat from land degradation and desertification, are particularly vulnerable. Were rainfall to increase as projected by some general circulation models (GCMs) in the highlands of east Africa and equatorial central Africa, marginal lands would become more productive than they are now. These effects are likely to be negated, however, by population pressure on marginal forests and rangelands. Adaptive options include control of deforestation, improved rangeland management, expansion of protected areas, and sustainable management of forests.

Meanwhile many of the nineteen (19) water-stressed countries in the world are found in Africa, and this number is likely to increase, independent of climate change, because of increases in demand due to population growth, degradation of watersheds, and siltation of river basins. A reduction in precipitation projected by some Global Circulation Models (GCMs) for the Sahel and southern Africa, if accompanied by high inter-annual variability, could be detrimental to the hydrological balance of the continent and disrupt various water-dependent socioeconomic activities. Variable climatic conditions may render the management of water resources more difficult both within and between countries (FAO 2007). A drop in water level in dams and rivers could adversely affect the quality of water by increasing the concentrations of sewage waste and industrial effluents, thereby increasing the potential for the outbreak of diseases and reducing the quality and quantity of fresh water available for domestic use. Adaptation options include water harvesting, management of water outflow from dams, and more efficient water usage.

Available statistics as reported by Odiugo (2008) shows that apart from the oil-exporting countries, agriculture is the economic mainstay in most sub-Saharan African countries, contributing 20-30% of gross domestic product (GDP) and 55% of the total value of African exports. In most African countries, farming depends entirely on the quality of the rainy season; a situation that makes Africa particularly vulnerable to climate change. Increased droughts could seriously impact the availability of food, as in the horn of Africa and southern Africa during the 1980s and 1990s. A rise in mean winter temperatures also would be detrimental to the production of winter wheat and fruits that need the winter chill. However, in subtropical Africa, warmer winters would reduce the incidence of damaging frosts, making it possible to grow horticultural produce susceptible to frosts at higher elevations than is possible at present. Productivity of freshwater fisheries may increase, although the mix of fish species could be altered. Changes in ocean dynamics could lead to changes in the migratory patterns of fish and possibly to reduced fish landings, especially in coastal artisanal fisheries.

Furthermore, several African coastal zones, many of which already are under stress from population pressure and conflicting uses, would be adversely affected by sea-level rise associated

with climate change. The coastal nations of west and central Africa (e.g., Senegal, The Gambia, Sierra Leone, Nigeria, Cameroon, Gabon, and Angola) have low-lying lagoonal coasts that are susceptible to erosion and hence are threatened by sea-level rise, particularly because most of these countries have major and rapidly expanding coastal cities. The west coast often is buffeted by storm surges and currently is at risk from erosion, inundation, and extreme storm events. The coastal zone of east Africa also will be affected, although this area experiences calm conditions through much of the year. However, sea-level rise and climatic variation may reduce the buffer effect of coral and patch reefs along the east coast, increasing the potential for erosion. A number of studies indicate that a sizable proportion of the northern part of the Nile delta will be lost through a combination of inundation and erosion, with consequent loss of agricultural land and urban areas. Adaptation measures in African coastal zones are available but would be very costly, as a percentage of GDP, for many countries. These measures could include erection of sea walls and relocation of vulnerable human settlements and other socioeconomic facilities.

The main challenges likely to face African populations will emanate from extreme climate events such as floods (and resulting landslides in some areas), strong winds, droughts, and tidal waves. Individuals living in marginal areas may be forced to migrate to urban areas (where infrastructure already is approaching its limits as a result of population pressure) if the marginal lands become less productive under new climate conditions. Climate change could worsen current trends in depletion of biomass energy resources. Reduced stream flows would cause reductions in hydropower production, leading to negative effects on industrial productivity and costly relocation of some industrial plants. Management of pollution, sanitation, waste disposal, water supply, and public health, as well as provision of adequate infrastructure in urban areas, could become more difficult and costly under changed climate conditions. Africa is expected to be at risk primarily from increased incidences of vector-borne diseases and reduced nutritional status. A warmer environment could open up new areas for malaria; altered temperature and rainfall patterns also could increase the incidence of yellow fever, dengue fever, onchocerciasis, and trypanosomiasis. All these will result to reduction in their primary occupation which is agriculture – especially in their farming practices.

2.5 Climate Change Impact and Agricultural Development in Africa

Climate change exerts multiple stresses on the biophysical as well as the social and institutional environments that underpin agricultural production. Some of the induced changes are expected to be abrupt, while others involve gradual shifts in temperature, vegetation cover and species distributions. Climate change is expected to, and in parts of Africa 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, 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 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 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 dry land 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. A Nigerian study applied the 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.

In northwest Kenya, recurring droughts have led to increased competition for grazing resources, livestock losses and conflict. Based on temperature and precipitation readings, Michigan State University have found no discernable trend in the frequency or intensity of droughts in the region, in spite of local farmers articulating a worsening situation. There is a suggestion that higher average temperatures have stressed the regions vegetation to the extent that it takes less extreme hot and dry spells to inflict drought like conditions.

2.6 Climate change adaptation and agricultural development in Nigeria

Climate change adaptation aims to mitigate and develop appropriate coping measures to address the negative impacts of climate change on agriculture. Most agricultural systems have a measure of in-built adaptation capacity ("autonomous adaptation") but the current rapid rate of climate change will impose new and potentially overwhelming pressures on existing adaptation capacity. This is

particularly true given that the secondary changes induced by climate change are expected to undermine the ability of people and ecosystems to cope with, and recover from, extreme climate events and other natural hazards. It is for this reason that the IPCC encourages "planned adaptation", that is deliberate steps aimed at creating the capacity to cope with climate change impacts (IPCC, 2007).

Effective adaptation strategies and actions should aim to secure well-being in the face of climate variability, climate change and a wide variety of difficult to predict biophysical and social contingencies. In pursuing this aim, climate adaptation should focus on support for the decision-making and capacity building processes that shape social learning, technology transfer, innovation and development pathways. Adaptation is most relevant when it influences decisions that exist irrespective of climate change, but which have longer-term consequences (Stainforth et al., 2007).

A key component of climate adaptation involves building resilience, where resilience is the capacity of a system to tolerate disturbance without collapsing into a qualitatively different state that is controlled by a different set of processes: a resilient system can withstand shocks and rebuild itself when necessary. Over 60% of Africans remain directly dependent on agriculture and natural resources for their well-being (FAO, 2003). Agriculture is highly dependent on climate variability (Salinger et al., 2005) which is why the threat of climate change is particularly urgent in Africa (Boko et al, 2007).Despite the reliance of large proportions of the population on agriculture, agricultural development has historically not been a priority of governments, with 1% or less of the average national budgets going to agriculture (FAO, 2007). However many donors and NGOs have supported agriculture across the continent because of this reliance on agriculture and the potential to improve yields.

In spite of the documented exposure of agricultural activities to projected changes in climate, not all agricultural institutions have made use of climate science data. The current tendency is for institutions to reference climate change as a backdrop to their work as opposed integrating probabilistic future climate data into their current planning and research approaches. Accordingly it is difficult to distinguish the documented cases of climate change adaptation in Africa especially in Nigeria from general development and agricultural practice. The impacts of the East African droughts, for example, have been countered in some instances by digging and maintaining sand dams in river bottoms. The dams allow for continued cattle watering during dry periods, and have reduced cattle deaths and conflict. It is not possible, however, to establish climate change as the trigger for the construction of sand dams (or other adaptation measures), and the people constructing sand dams do not draw on climate change data.

This apparent disconnect between adaptation efforts and climate data is in spite of efforts on behalf of climate scientists to make their work more relevant to agriculture, and the equally concerted attempts by the impact community to clarify their climate information needs. It should be stated that most farming groups in Nigeria are naïve as to how difficult it is to understand, interpret and use climate information. It is equally true; however, that much of the climate modeling work remains focused on gaining greater understanding of atmospheric dynamics, and does not appreciate the type of issues confronted by farmers or the manner in which data needs to be packaged so as to make it accessible to agricultural decision makers.

Meanwhile, agricultural adaptation that has always taken, and continues to take place in Nigeria and Africa generally, is responding more to perceived climate variability than climate change. This is true of the examples unearthed in this study, as well as the season forecasting and drought early warning systems that enjoy increasing use (especially among livestock farmers) on the country. Very little has been accomplished in relating crop yield and animal productivity to climate change in the country (Nigeria) and even the study area, even though the appropriate methodology is available in contemporary literature. Whilst these systems have proven their worth for farmers, there is a danger that farmers, agricultural policy makers, crop breeders and government officials that structure their activities around short term climate variability, will be exposed by the trend of climate change and its longer-term implications.

Three problems appear to impede the wider use of climate data by farmers and agricultural decision makers in Nigeria and Enugu state. First, climate change data are not available at the spatial resolution required by farmers and as such farmers struggle to reconcile their observations of the weather with climate projections and lose confidence in the projections. Second, the timeframes (or temporal resolution) over which climate data are reported is often of little relevance to farmers. Whilst one might expect policy makers to consider the implications of a 2050 projection, farmers base their decision on more immediate issues. Third, there are very few African, Nigeria and even Enugu state scientists with the requisite training and experience to interpret and apply climate change data in the agricultural context especially in the study area.

2.7 Possible Impacts of Climate Change in Nigeria.

In Nigeria, according to Boko et al. (2007) and Ikpi (2010), some of the key expected impacts of climate change can be summarized as follows:

Food security (crop and livestock): productivity, availability and affordability:

> reduced food security; reduced availability of irrigation; increased social tension/conflicts between farmers and pastoralists;

Environmental risks:

> desertification of 50% of Guinea Savannah;
> Sahelization caused by increased unpredictable summer rains resulting in decreased agricultural productivity in northern Nigeria;
> Increased flooding, and reduced freshwater availability leading to increase in malaria and other diseases that can potentially decrease GDP;

Resource management:

> Reduced food security and fuelwood supply due to changes in forest cover (following severe dry spells) which results in poor supply of food to rural population and hamper energy supply for most rural people who depend on wood fuel for energy;

Employment and livelihoods (coastal economies, social risks, etc):

> Loss of coastal zone infrastructure, settlements and agricultural lands due to higher temperatures and higher humidity,
> Reduced hydrocarbon extraction activities in the Niger Delta and increased risks of oil spill arising from changes in the forest cover (following severe dry spells) which can lead to land

loss, food insecurity, increased social and political tensions, and deteriorating fishing industry;

Human Health:

> Negative effects on human health caused by higher temperatures, higher humidity, increased flooding, and reduced freshwater availability resulting in increased pests and breeding sites, increased exposure to vector-borne (malaria) and water-borne (cholera) diseases, increased heat stress, reduction in annual GDP growth rate by about 1.3% as a result of labour morbidity, and increased risk of malnutrition due to food insecurity, shortages and famine;

Infrastructure:

> Damaged transport routes (buckling of rail tracks and melting of road surfaces) caused by extreme weather events (floods, heat waves, etc) with impacts on trade and communications; and
> Negative effects on electricity supply and distribution caused by reduced rainfall and other extreme weather events which impacts on production of hydroelectricity, damaged energy distribution network, increased frequency of blackouts, and reduced economic activities across the nation.

Adaptation to these impacts will require some policy as well as institutional imperatives. These include capacity building, policy innovations, financing incentives, risk mitigation systems, and safety nets for designing and implementing effective adaptation options.

2.8 Adaptation Options at Farm/Community/Local Level

Climate change impacts can also be organized at successive levels of the economy, including farm level, community level, sector level (e.g. agriculture, health, industry, environment, water, etc), and macro level (loss to GDP, loss of employment, increased incidence of poverty, increase in social and economic vulnerabilities). At the local household/farm/community level, Ozor et al. (2010) shows that in Nigeria (Southern Nigeria precisely) climate change impacts are observed in terms of increased weed growth, increase in pest and disease infestation, drought/reduction in moisture, uncertainty in weather conditions, reduction in soil nutrient, decrease in agricultural yield, loss of agricultural land to flood and erosion, and land degradation.

The identified adaptation/mitigation options for these impacts include cover cropping, early planting, prompt weeding, regulated/controlled herbicide use, use of weed-tolerant crop varieties, mixed cropping, use of pest- and disease-resistant crops/species, rouging, crop replacement, mulching, irrigation schemes, efficient water harvesting and storage techniques, prevention of forest losses along water bodies, use of weather forecast technologies, application of the daily weather reports from the media, prayers, flexibility in timing of farming operations, green manuring, composting, crop rotation, fallowing, use of organic fertilizers and manures, and diversification in crop and animal production. Others include value-chain addition, biotechnology and nanotechnology application, improved extension services, government support and interventions, climate change education, enterprise diversification, tree planting, improved land management techniques, biodiversity conservation, controlled grazing, construction and maintenance of drainage channels, construction of rock molls and barriers against ocean surge, planting across slope, emergency relief strategies, agro-forestry practices, forestry regulations, afforestation

programmes, and reduced tillage.

2.9 Adaptation Options at Sector Level – Agriculture

Adaptation is critical in developing countries, particularly in Africa and even in Nigeria where the vulnerability to climate change is high because the ability to adapt is low (Nzeh and Eboh, 2009). In Africa, the expected conditions resulting from climate change include elevated CO2 level, high temperature, increased droughts and increase in variability. These conditions are associated with some eco-physiological consequences in crops. For example, elevated CO2 levels can lead to potential increase in biomass C3 plants, but more neutral on C4 plants. The eco-physiological consequences of high temperature include acceleration of maturity, heat stress during flowering and reproduction, and increased pest damage. On the other hand, increased droughts can lead yield losses and potential crops failure, while increased variability can lead to instability of crop yield.

These consequences can be enhanced or mitigated by plant breeding, agronomy, and socio-economy. Conventional and molecular breeding can be undertaken to maximize yield, phonological adjustment, biotic stress, drought tolerance, and for adaptation. Some agronomic practices may include early plantings, pesticide use, and crop rotation, while crop insurance can serve as socio-economy response.

Moreover, Nigeria's MDGs Office has articulated the threats posed (in relation to the MDGs) by climate change if we continue under the business as usual. For instance, livelihoods will be threatened due to desert encroachment, agricultural productivity will fall due to soil erosion, reduced groundwater and lower rainfall, sea-level rise will threaten coastal communities and strategic industries putting at least $17.5 billion capital at risk per 1m sea-level rise, and there is likelihood of risk resource conflicts especially over water and forest/marine resources as reported by Ujah et al 2010. These threats will affect of 70% of employment which is in the climate-sensitive activities of the economy. The fiscal burden of adaption costs may exceed $85 billion in the shortest-term and can undermine the MDGs.

On the other hand, planned adaptation to climate change has benefits. Some of these as identified by the MDGs Office in Nigeria include the impetus to shift to more sustainable and productive agricultural systems, better urban planning, more employment opportunities and growth boost, increased opportunities and stability for women to invest in their families long-term wellbeing, and better livelihood opportunities in coastal/marine and forest communities.

In summary, climate change is expected to have high direct negative effects on the MDGs especially because of its negative effects on agriculture (caused by weather extremes of flood and drought), and its direct effect on water scarcity and loss of agricultural land due to sea-level rise. On the other hand, however, planned adaption strategies have the benefits of not only reducing the impacts of climate change but also provide opportunity for mitigation and sustainable development.

3. Methodology

3.1. The Study Area

The study area is Enugu State of Nigeria which was created out of the former Anambra State in 1991. According to Ukwu et al (1998) Enugu State is located in the south-eastern region of Nigeria, an irregular trapezoid territory between Latitudes $5^{0}55^{1}$ and $7^{0}10^{1}$ North and Longitudes $6^{0}50^{1}$ and $7^{0}55^{1}$ East. It is bounded in the north by Kogi and Benue States, in the east by Ebonyi and Abia States, in the south by Ebonyi, Abia and Anambra, and in the west by Anambra State. In the views of Ukwu et al (1998), the present Enugu State is a lineal descendant of the Eastern Region, one of the three original regions which since Independence has been progressively split into nine states, including Abia, Akwa-ibom, Anambra, Bayelsa, Cross River, Ebonyi, Enugu, Imo and Rivers states. Administratively the state has its Headquarters at Enugu.

Ecologically, Enugu State lies mostly in the forest-savanna mosaic of the drier northern reaches of the humid tropical zone of Southern Nigeria, with mean annual rainfall decreasing from about 200 cm at its southern extremities to about 150 cm in the north. The soils vary locally but may be grouped into three main types: the red clayey ferralitic soils of the cross River Basin, the red-yellow ferralitic soils of the plateau, and the sandy flood-plains of the Anambra Basin at the western limits. The escarpment zone is a zone of great variety and inter-digitation of soil types, as reported by Ukwu et al (1998). The State occupies an area of about 8,022.95km^{2} (Ezike, 1998) and has a population of 3,257,298 and with average annual growth rate of 3.0% according to (NPC, 2006).

Enugu State with seventeen local government areas is divided into three agricultural zones which include: Awgu zone, as Awgu, Aninri, Enugu South, Nkanu East, Nkanu West and Oji-River; Enugu zone, which are made up of Enugu East, Enugu North, Ezeagu, Igboetiti and Udi; but Nsukka zone are Igboeze North, Igboeze South, Isiuzo, Nsukka, Udenu and Uzo-Uwani.
In Enugu state farming is predominately their occupation which is done in a small-scale. Prevalent crops are cassava, yam, maize, rice, melon, groundnut, pepper and economic trees like oil palm, cashew, cocoa, oranges, kola nuts, and pears among other trees found in the state. There are forests of different density in Enugu state as reported by Nzeh (2004). Crops farm(s) are usually in small holding of about 1 to 3 hectares, but poultry production is carried out in some parts of the state but strictly on subsistence level, together with goat and sheep production (Orebiyi and Nzeh, 2002).

These small scale farmers practice bush fallowing, land rotation and mixed cropping on scattered farm land mainly inheritance land tenure arrangement and more recently on hired basis. Family labour plays very important role in labour employed. Exchange of commercial labour occasionally is carried out in small areas and hired labour constitutes another source of labour in this area.

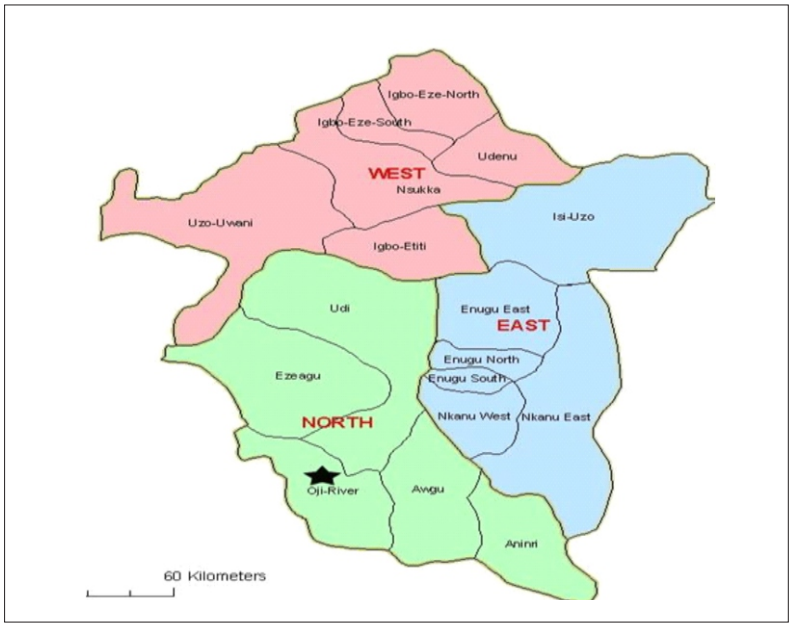


Figure 1: Map Of Enugu State, Nigeria Showing 17 Local Government Areas

3.2 Data Gathering Techniques

In the survey of the households in the study area, all the three agricultural zones of the state were visited at their community levels. The survey involved collection of detailed information on the socio-economic characteristics of the farmers, the farmer's level of awareness and manifestation of climate change in their area, farming systems and its management technologies on climate change in the study area and impacts of climate change adaptation toward faming activities etc.

There were also data gathering activities which involved both pilot survey of the two Local Government Areas to validate the data collection instrument and main survey of the entire six Local Government Areas selected from the three agricultural zones of the state.

During the survey of the households the structure of the survey instrument used includes the following:-

i. Preliminary information: This sought to collect basic data on the households including sex, age, marital status, educational attainment, occupational involvement, farming activities carried out etc.
ii. Farmers' levels of awareness and manifestation of climate change: To elicit information on level of climate change awareness, cause(s) of climate change, manifestation of climate change, and recent implication of climate change towards agriculture.

iii. Farming systems and its management technologies in climate change: This section sought information on recent farming systems stopped due to climate change, farming systems adopted toward climate change effects, changes adopted in farming systems toward climate change, kind(s) of management technologies to combat climate change effects in farms among others.
iv. Farmers' patterns and manner of adjustment to climate change: This section finds out adaptation patterns available in adjusting with climate change and impacts of climate change effects in farming activities.
v. Impacts of climate change adaptation to farming: This elicit to seek indigenous technologies in use in for climate change adaptation, modern technological climate change adaptation techniques, types of adaptation to climate change in your farming etc.

3.3. Sampling Procedure

Purposive sampling techniques were employed to select farming household respondents in each of the selected autonomous communities within the local government area of each of the three agricultural zones of the state.

In the first stage of the sampling procedure, within the three (3) agricultural zones; Awgu, Enugu and Nsukka, two (2) local government areas each were selected making total of six (6) local government areas for the study.

The second stage involved selection of communities; Two (2) communities were selected from each of the six (6) government local areas within the three (3) agricultural zones. This gave total of twelve (12) communities.

Third stage was the selection of respondents (i.e. farming household heads). Thirty-three (33) farming household heads were selected from each of the eight (8) communities in Awgu and Enugu agricultural zones, whereas thirty-four (34) farming household heads were selected from each of the four (4) communities in Nsukka agricultural zone, making a total number of four hundred (400) farming households. The number of household heads covered from Nsukka agricultural zone is higher than other zones (Awgu and Enugu agricultural) because according to NPC 2006, Nsukka agricultural zone is greater in population than Awgu and Enugu agricultural zones. See table 2 below.

Table 1: Template showing areas of coverage and number of household heads covered by each enumerator

S/No.	ZONE	LGAs	Communities Involved	Number of Households to be Covered
1.	Awgu Agricultural Zone	Awgu	Mmaku	33
			Obeagu	33
		Oji-River	Inyi	33
			Akpugo-eze	33
2.	Enugu Agricultural Zone	Enugu East	Amaorji Nike	33
			Emene	33
		Udi	Ngwo-uno	33
			Nsude	33
3.	Nsukka Agricultural Zone	Nsukka	Obukpa	34
			Alor-uno	34
		Uzo-uwani	Adani	34
			Nkpologu	34
Grand Total				**400**

Note: *The number of household heads covered from Nsukka agricultural zone is higher than other zones (Awgu and Enugu agricultural) because according to NPC 2006, Nsukka zone is greater in population than Awgu and Enugu zones.*

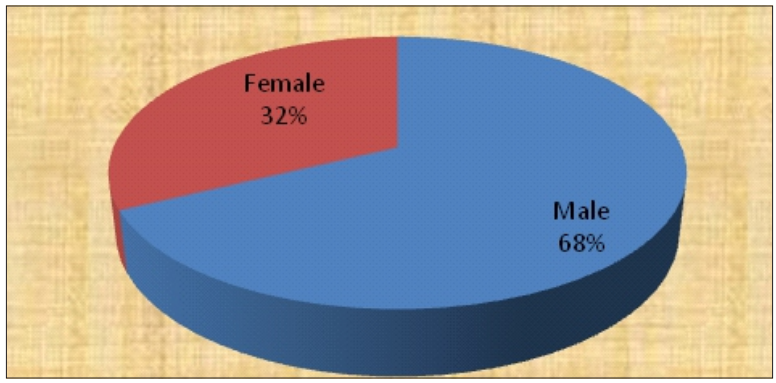
3.4 Quality Control

The ATPS research team in order to maintain standard quality control instructed the enumerators and Field Assistants in all the communities on the need for field review of completed questionnaires. This was important and helped in on-the-field errors identification. Some of the errors detected during the process include; omissions, unreasonable entries, impossible entries and double entries etc. The research team applied field monitoring and evaluation protocols to ensure that quality data were collected from the respondents. This entails occasional physical presence of the research team to the different communities to check for errors at the point of data collection. These visits were very intensive on the first week of data collection. Such early detection of errors helped eliminate further occurrence of such errors. To further ensure that there was adequate quality control, the research team also constantly made telephone calls on the enumerators during the field data collection.

4. Results & Findings

4.1. Socio-Economic Characteristics of Farmers

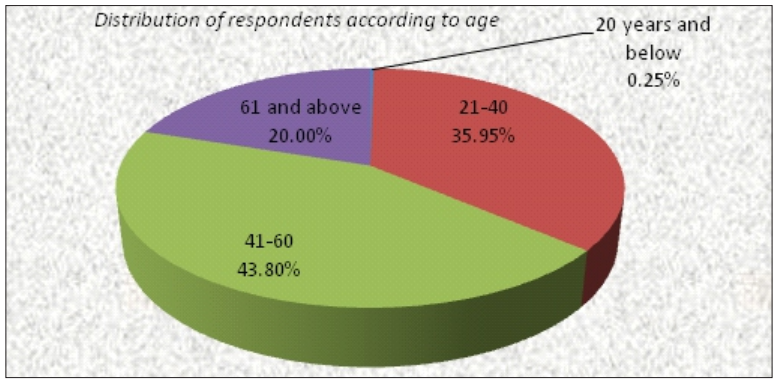
The socio-economic status considered in this study include sex, age, marital status, level of education, major occupation, minor occupation, types of farming activities carried out, size of farm land among others. Figure 2 shows that 68% of the respondents are male and 32% are female respectively. The greater number of male interacted with in the study does not mean that there are more male than female in Enugu state. According to NPC (2006) there is higher population of female than male in the study area. Meanwhile, the higher population of male interacted with here may be attributable to their more involvement in agricultural activities than females due to their ease access to land.



Source: Field survey 2010

Figure 2: Distribution of respondents according to sex

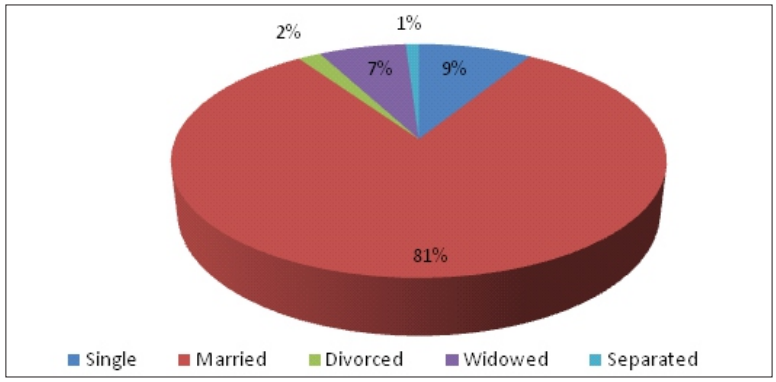
Figure 3 indicates that the more of the respondents is in the age brackets of 41-60 years of age and constitutes 43.8%. The old age group (61 years) formed 20% of the respondents while the youths constitute 35.95% of the respondents. The result of the analysis shows that middle-aged men and women dominate farming activities in the area. It also suggests that youths are massively leaving farming for other economic activities. This none involvement of youth in agricultural farming activities will lead to high cost of farming labour and even less production of agricultural goods.



Source: Field survey 2010

Figure 3: Distribution of respondents according to age.

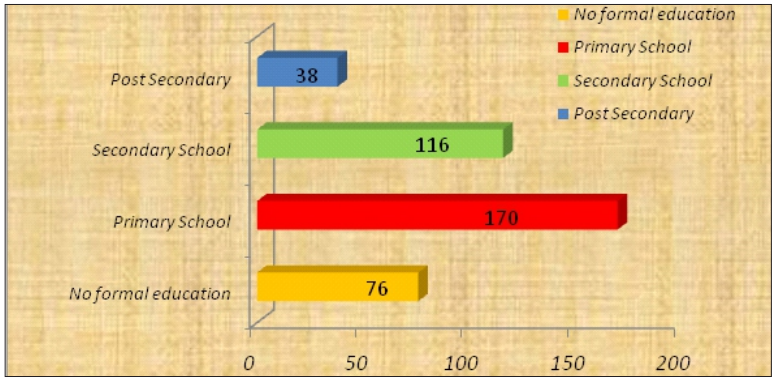
From figure 4 above, it can be seen that 81% of the respondents are married and are involved in farming activities in the study area. The same figure 4 shows 9% of the respondents are single, as 7% of the respondents are widowed. The figure finally shows that whereas 2% of the respondents reported that they are divorced only 1% of the respondents stated that are separated.



Source: Field survey 2010

Figure 4: Distribution of respondents according to martial status.

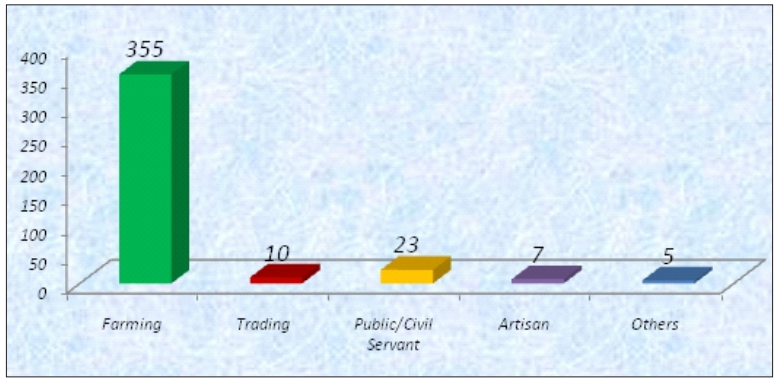
Generally, education broadens the horizon of human activities, operation and understanding of his environment including farming activities. According to figure 5 above, 42% of the respondents stated that they had their primary education. Also from the same figure 5, 29% of the respondents reported that their highest level of educational qualification is secondary education. Further critical analysis of the above figure indicated that whereas 19% of the respondents in the study area stated that they had no formal education, only 10% of the respondents agreed that their highest educational level is post secondary. The scenario above indicates that reduced agricultural productivity in the state may be as a result of lower educational levels of the respondents. This consequently affects farming activities at a higher percentage in the study area.



Source: Field survey 2010

Figure 5: Educational Level of respondents

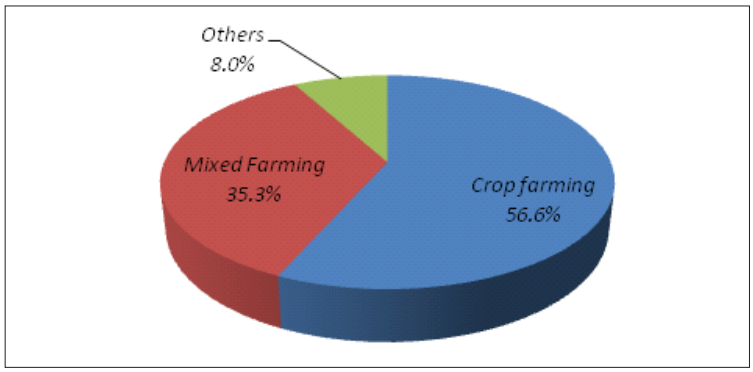
Figure 6 shows that 89% of the respondents interviewed in the study area stated that they have their major occupation as farming, whereas 6% of the respondents reported that civil/public service is their major occupation. Also from figure 6 above, it can be seen that 2% of the respondents each has trading and artisan as their major occupation. The massive respondents that agreed that farming is their major occupation simply confirmed that agricultural activities is still the mainstay of the country's economy and even that of Enugu state.



Source: Field survey 2010

Figure 6: Distribution of respondents according to major occupation.

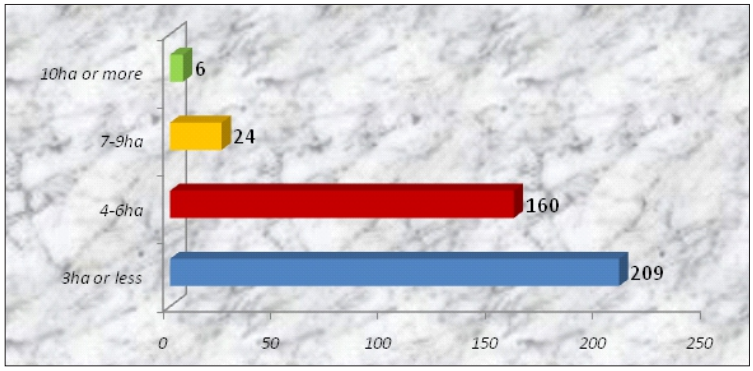
Figure 7 indicates that 56.6% of the respondents in the study area are crop farmers. Furthermore from the same figure 7, only 35.5% of the respondents agreed that they practice mixed farming. The greater percentage of the respondents that agreed that practicing crop farming is their major farming activities affirmed with the findings of Orebiyi and Nzeh 2002. In their findings they reported that crops farming is usually carried out in small holding of about 1 to 3 hectares in Enugu state and also that both poultry production, goat and sheep production are always carried out in some parts of the state but strictly on subsistence level, which is not always noticed.



Source: Field survey 2010

Figure 7: Distribution of respondents according to types of farming activities.

The figure 8 shows 52% of the respondents interviwed in the study area reported that their size of farm land is three hectares or less. It also indicated that 40% of the respondents agreed that the size of land they own is between four to six hectares. Critical examination of the figure shows that whereas 6% of the respondents in the study area stated that the size of their farm land is 7 to 9 hectares only 2% of the respondents said that they have up 10 hectares of land or more. The above analysis shows that in the study area, due to method of land inhertiance farmers in the area are still owing small sized plot(s) of land for their farming operation. The negative implication of this small land ownship is that it makes modern farming activities very difficult especially as it relates to use of tractors. This subsequently results to less cultivation of land by the farmers

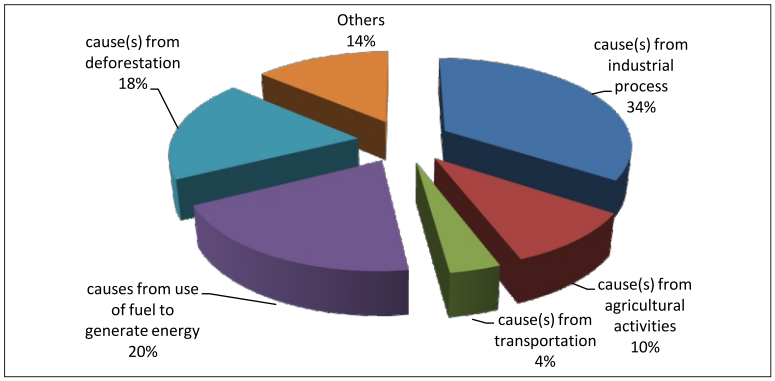


Source: Field survey 2010

Figure 8: Distribution of respondents according to size of farm land.

.4.2. Farmers level of awareness and manifestations of climate change

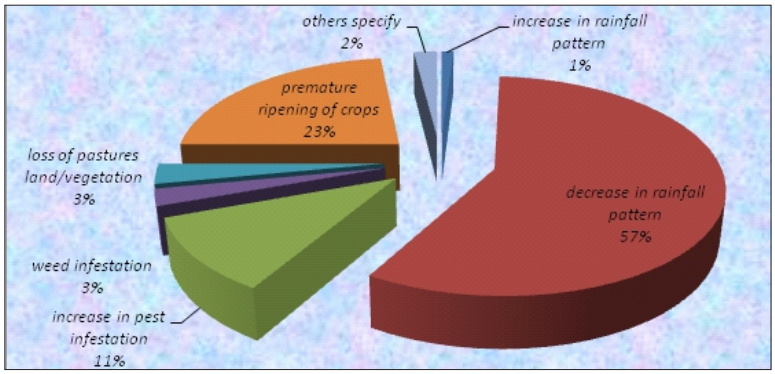
From figure 9, it can be seen that 34% of the respondents reported that the major cause(s) of climate change in the study area is stricky due to industrial process. Furthermore 20% of the respondents stated that major cause(s) of climate change in the study area is use of fuel to generate engery. Also from one can see that as 18% of the respondents said that major cause(s) of climate change in the study area is from deforestation, 4% of the respondents indicated that cause(s) of climate change in the area is from transportation. Finally, only 14% of the respondents gave other reasons as the major cause(s) of climate change in the study area.



Source: Field survey 2010

Figure 9: Distribution of respondents according to cause(s) of climate change.

Figure 10 shows that 57% of the respondents stated that the mainfestation of climate change in the study area is highest with decrease in rainfall pattern. As can be seen from the figure 10 above, 23% of the respondents reported that the mainfestation of climate change in the study area is highest with premature ripening of crops whereas only 11% of the respondents said that increase in pest infestation is highest in the mainfestation of climate change. Meanwhile, the decrease in rainfall in the study area in the recent years will directly affect the food production in the area hence most production of agricultural produce in the area is dependent purely in the rainfed agriculture. Therefore, this decrease in rainfall pattern in the recent years due to climate change may lead to food insecurity at both short, medium and long run in the state and Nigeria in general.

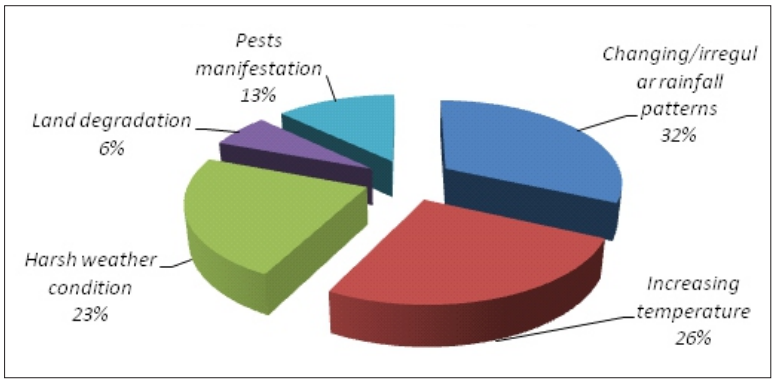


Source: Field survey 2010

Figure 10: Distribution of respondents according to climate change mainfestation.

Figure 11 below indicated 32% of the respondents reported that climate change phenomena were worse over the past ten years in the area of changing/irregular rainfall pattern in their communities. Furthermore, the same figure 11 shows that as 26% of the respondents stated that climate change phenomena was worse over the past ten year in the area of increasing temperature, 23% of the respondents equally said that harsh weather condition is the worse climate change phenomena in

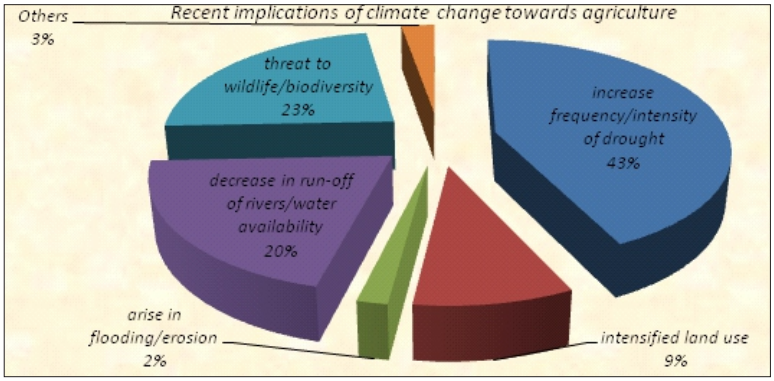
their communities over the past ten years. Critical analysis of the figure 11 above shows that only 13% and 6% of the respondents respectively reported that climate change phenomena were worse over the past ten years in their community as pests' manifestation and land degradation. The increasing temperature which recorded as the second highest problem of climate change phenomena in the study confirm the low productivity of animals in the recent times in Enugu state; hence higher temperature is not very conducive for fertility in animal because it leads to frequent abortion by the animals.



Source: Field survey 2010

Figure 11: Distribution of respondents according to climate change phenomena over ten years ago.

Figure 12 shows that higher number of respondents 43% reported that increase frequency/intensity of drought is the recent implication of climate change toward agriculture in their community. Also the same figure 12 indicated that 23% of the respondents stated that threat to wildlife/biodiversity is the recent implication of climate change toward agriculture in their area. Further analysis of the figure 12 equally shows that 20% of the respondents stated that decrease in run-off of rivers/water availability is the recent implication of climate change toward agriculture in their community. Furthermore, only 9% of the respondents reported that intensified land use is the recent implication of climate change toward agriculture in their community. But 3% and 2% of the respondents said that both other reasons and arise in flooding/erosion respectively are the recent implications of climate change toward agriculture in their community. The increase in the frequency/intensity of drought in recent time is the indication that climate has changed. This might be the reason for the massive failure of crop production especially that of cocoyam last year in the study area which was confirmed by FGD participants.

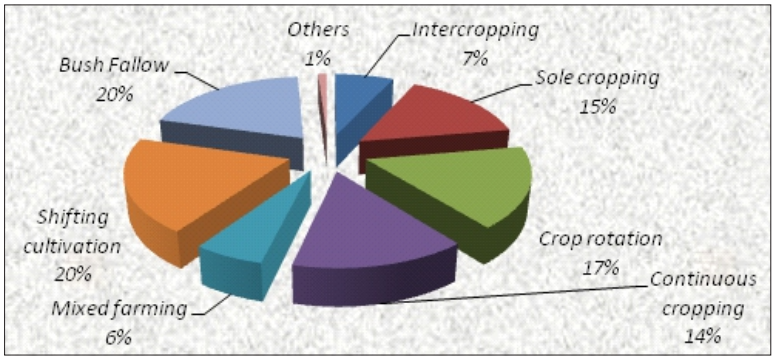


Source: Field survey 2010

Figure 12: Distribution of respondents according to recent implication of climate change toward agriculture.

4.3. Farming systems and its management technologies on climate change

The result of the analysis in figure 13 shows that 20% of the respondents in the study area reported that bush fallow and shifting cultivation are the farming system(s) they have reduced its usage in the past ten years due to change climate. The same result shows that 17% of the respondents have reduced usage of crop rotation in the past ten years due to climate change. Whereas 15% of the respondents stated that sole cropping is the farming system(s) they have reduced its usage in the past ten years due to climate change; but only 14% of the respondents agreed that continuous cropping is the farming system(s) they have reduced its usage in the past ten years due to climate change

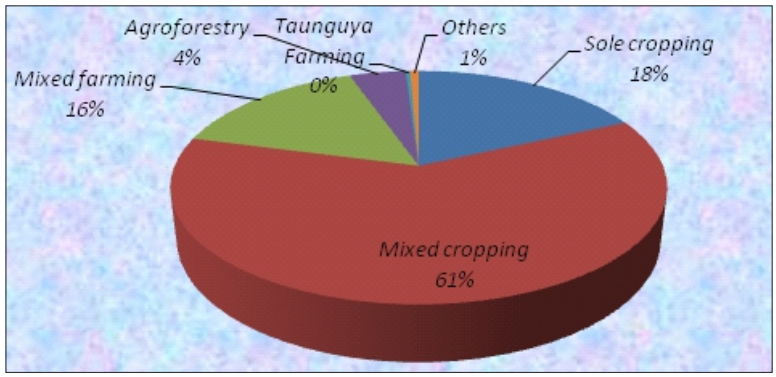


Source: Field survey 2010

Figure 13: Distribution of respondents according to farming system(s) reduce usage in the past ten years due to climate change.

Finally, from figure 13 shows that 7% of the respondents stated that intercropping is the farming system(s) they have reduced its usage in the past ten years due to climate change as only 6% of the respondents in the study area said that mixed farming is the farming system(s) they have reduced its usage in the past ten years due to climate change.

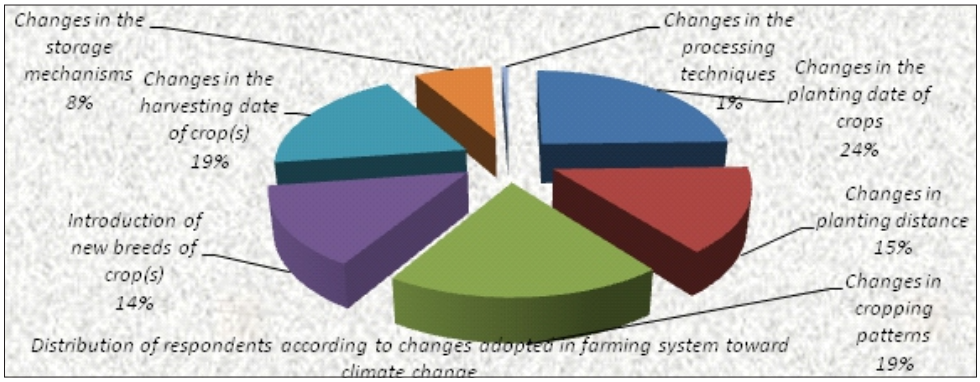
Figure 14 shows that 61% of the respondents have adopted mixed cropping as farming due to climate change effects in their community. Furthermore the same figure 14 indicated that 16% of the respondents agreed that mixed farming is the farming system they adopted due to climate change in their community and also 18% of the respondents reported that sole cropping is the farming system they adopted due to climate change effects in the study area. The implication of the higher percentage of the respondents that accepted that they adopted mixed cropping in the recent time may be to avoid total crop failures in their farm especially as it relates to pest infestation.



Source: Field survey 2010

Figure 14: Distribution of respondents according to farming systems adopted due to climate change effects

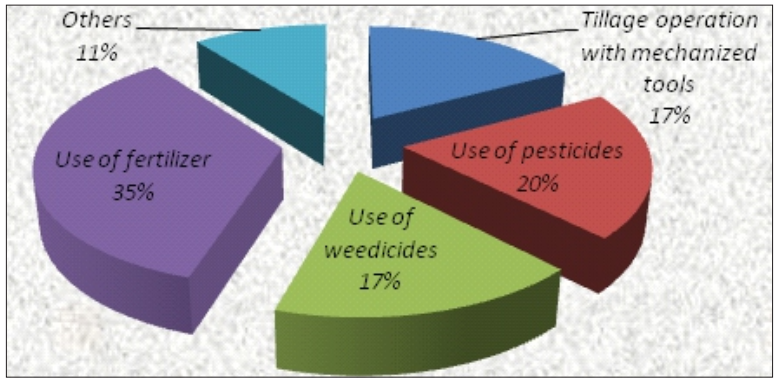
From figure 15 above, it shows that 24% of the respondents reported that changes they adopted in farming system toward climate change is changes in the planting date of crops. Meanwhile, the same figure 15 indicated that 19% of respondents respectively agreed that changes adopted in farming systems toward climate change are in the areas of changes in cropping pattern and changes in the harvesting date of crop(s). Finally, as 15% of the respondents stated that changes adopted in farming system toward climate change is changes in planting distance; 14% of the respondents said that introduction of new breeds of crop(s) are the changes they adopted in farming system toward climate change. The higher percentage of the respondents that reported that changes they adopted in their farming system is changes in the planting dates of crops may be attributable to the delay in rainfall commencement in the study area hence what is mainly practiced in the study area is rain-fed agriculture.



Source: Field survey 2010

Figure 15: Distribution of respondents according to changes adopted in farming system toward climate change.

Figure 16 above shows that 35% of the respondents in the study are reported that the kind(s) of management technologies they use to combat climate change in their community is the use of fertilizer. Furthermore, 20% of respondents agreed that use pesticides as the kind(s) of management technologies to combat climate in their community. Critical analysis of the same figure 16 shows that 17% each of the respondents stated that they use weedicides and even tillage operation with mechanized tools respectively as their own kind(s) of management technologies to combat climate change in recent time in their area. Finally only 11% of the respondents reported that the kind(s) of management technologies they use to combat climate change is other means like use of crude tools for both pre/post harvesting activities.

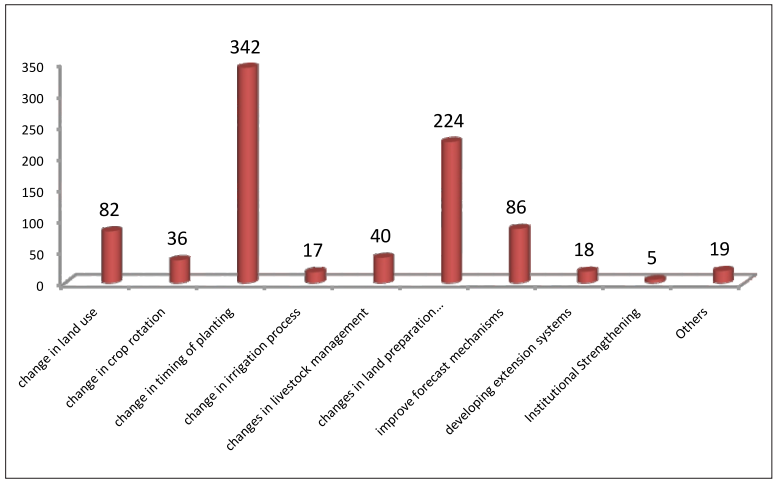


Source: Field survey 2010

Figure 16: Distribution of respondents according to the kind(s) of management technologies use to combat climate change.

4.4. Farmers' patterns and manner of adjustment to climate change

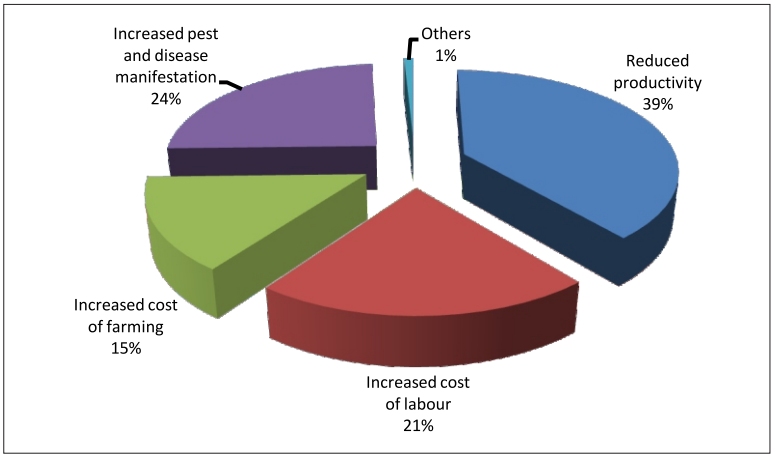
Figure 17 contains the respondents according to recent adaptation pattern(s) toward climate change in the study area. From the figure 17, 85% of the respondents stated that the recent adaptation pattern(s) toward climate change which they are using is change in timing of planting of crops. Also the same figure 17 shows that 56%of the respondents agreed that the change in land preparation practices (terracing, contouring, hedges, reservoirs, drainage) is the recent adaptation pattern(s) toward climate change they apply in their community. Furthermore, as 22% of the respondents reported that the recent adaptation pattern(s) toward climate change in the study area which they use is improve forecast mechanism, as only 21% of the respondents said that what they use as recent adaptation pattern(s) toward climate change in the study area is change in land use. Lastly, 10% of the respondents reported that the recent adaptation pattern(s) toward climate in the study area which they use is change in livestock management.



Source: Field survey 2010

Figure 17: Distribution of respondents according to recent adaptation available.

The result of the analysis in figure 18 indicates that 39% of the respondents reported that the major impact of climate change in their farming activities is in the area of reduced productivity of their farm produce. Also the same figure 18 shows that 21% of the respondents stated that the major impact of climate change in their farming activities is in the area of increased cost of labour. According to figure 18 above, whereas 24% of the respondents stated that the major impact of climate change in their farming activities is in the area of increased pest and disease manifestation, 15% of the respondents in the study area said that increased in cost of farming is the major impact of climate change on their farming activities. The scenario above which shows that higher percentage of the respondents agreed that reduced productivity is the major impact of climate change in their farming activities. This further confirms the reaction from the farmers in the study area during FGD that for many years now that there is reduction in outputs from their farm due to climate change.

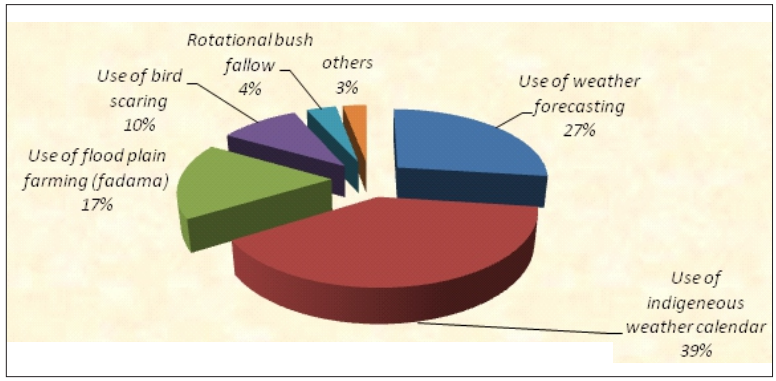


Source: Field survey 2010

Figure 18: Distribution of respondents according to impact of climate change on farming activities.

4.5. Impacts of climate change adaptation to farming communities' livelihood

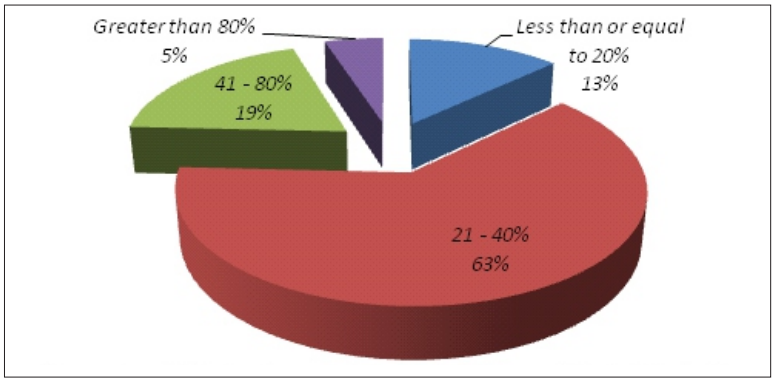
As can be deciphered from figure 19, only 39% of the respondents agreed that the indigenous technologies which are in use in their farming community for climate change adaptation is indigenous weather calendar. From the same figure 19, 27% of the respondents reported that the indigenous technologies which are in use in their farming community are weather forecasting. Furthermore, 17% of the respondents reported that the indigenous technologies which are in use in their farming community for climate change adaptation is use of flood plain farming (fadama) as 10% of the respondents confirmed that use of bird scaring is the indigenous technologies which are in use in their farming community for climate change adaptation. Finally, figure 18 shows that rotational bush fallow and use of other methodologies as the indigenous technologies for climate change adaptation recorded 4% and 3% respectively.



Source: Field survey 2010

Figure 19: Distribution of respondents according to indigenous technology in use.

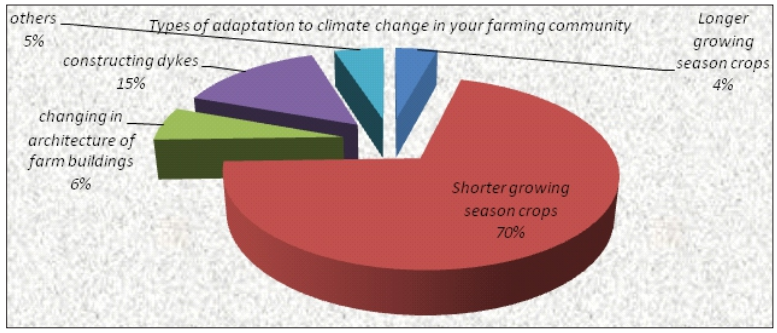
According to figure 20, 63% of the respondents confirm that they use between 21-40% of their indigenous technology to combat climate change in their community. Also the same figure 20 shows that 19% of the respondents said that the percentage of climate change adaptation techniques which is attributable to indigenous technology in their farm is between 41-80%. Lastly, only 13% of the respondents from figure 20 agreed that the percentage of climate change adaptation techniques which is attributable to indigenous technology in their farm is less than or eqully to 20%; as 5% of the repondents in the study said that they use greather than 80% of their indigenous technology to combat climate change in their community.



Source: Field survey 2010

Figure 20: Distribution of respondents according to indigenous technology in use.

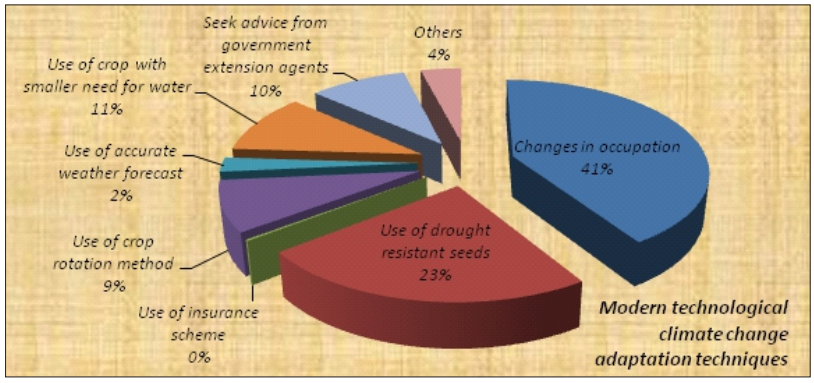
Figure 21 contains the distribution of respondents according to types of adaptation to climate change in respondents farming community. From the figure 21, 70% of the respondents stated that the type of adaptation to cliamte change in their farming community is shorter growing season crops. Also the same figure 21 shows that as 15% of the respondents said that the types of adaptation to cliamte change in their farming community is dykes construction, 6% of the respondents reported that chaning in architecture of farm buildings is the type of cliamte change adapted for their faming community in the study area. Finally only 5% of the repsondents and 4% of them in the above figure 21 accepted that other means of climate change adapattion and longer growing season crops respectively are their own ways of adaptation to climate change.



Source: Field survey 2010

Figure 21: Distribution of respondents according to types of adaptation.

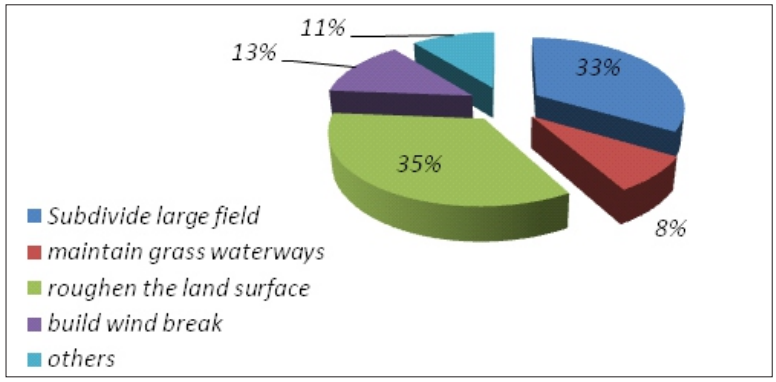
Figure 22 shows that 41% of the respondents reported that the modern technology used for climate change adaptation techniques in their farming community is by changes in their occupational system. Futhermore, 23% of the respondents stated that the modern technology use for climate change adaptation techniques in their farming community is by use of drought resistant seeds. In the same figure 22 above, as 11% of the respondents stated that the modern technology used for climate change adaptation techniques in their farming community is by use of crops with smaller need for water; 10% of the repsondents reported that the modern technology used for climate change adaptation techniques in their farming community is by seek of advice from government extension agents. Crtitical analysis of the figure 22 above shows that only 9% of the respondents agreed that the modern technology used for climate change adaptation techniques in their farming community is by use of crop rotational methods. The higher percentages of respondents that said that the modern technology used for climate change adaptation techniques is by changes in occupational system confirm the high cost of farming labour in the study area hence so many able bodied men and women recently are involved in other means of livelihood other than farming due to change in climate.



Source: Field survey 2010

Figure 22: Distribution of respondents according to modern technologies adapted.

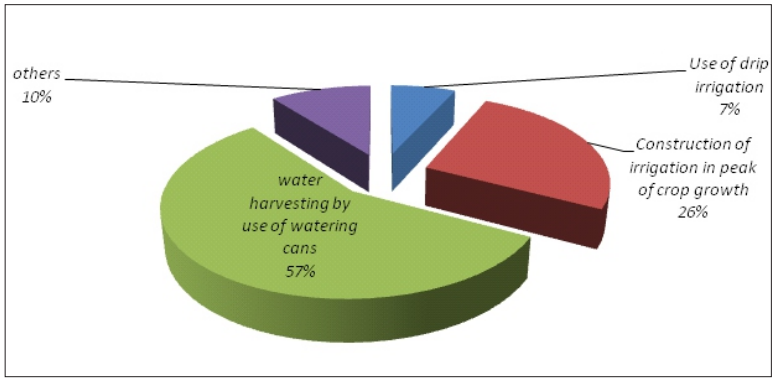
Figure 23 shows that 35% of the respondents reported that roughening of the land surface is the adaptation mechanisms (toward change in land topography to improve water intake and reduce erosion) used as climate change solution in study area. Also the same figure 23 above indicated that 33% of the respondents in Enugu state agreed that the adaptation mechanisms toward change in land topography to improve water intake and reduce wind erosion (as climate change solution used in their community) are subdvision of large field. Furthermore, as 13% of the respondents stated that building of wind break is the adaptation mechanisms (toward change in land topography to improve water intake and reduce erosion) used as climate change solution in study area; 11% of the respondents reported that other means adaptation mechanism toward change in land topography to improve water intake and reduce wind erosion are in use by them in the stsudy area. Finally, only 8% of the respondents stated that the adaptation mechanism toward change in land topography to improve water intake and reduce wind erosion (as climate change solution used in their community) is by maintenance of grass waterways.



Source: Field survey 2010

Figure 23: Respondents distributions on adaptation mechanisms for improve water intake and wind erosion reduction.

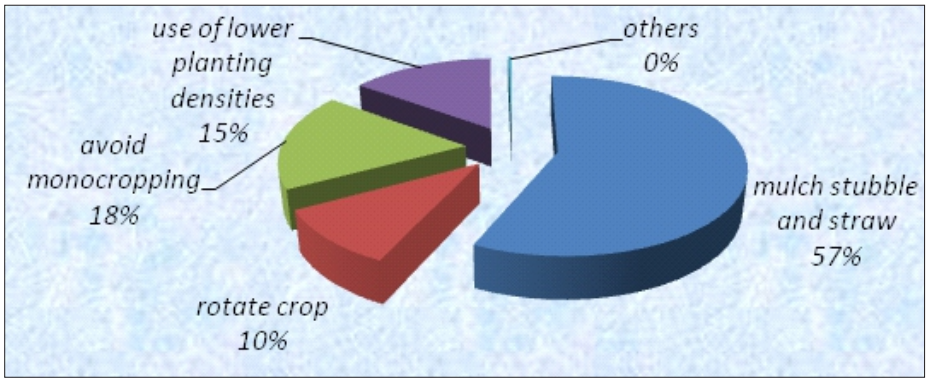
Figure 24 indicate that higher percentage of the respondents in the study area (57%) reported that water harvesting by the use of watering can(s) is the means they use in their community to improve water use and availability in their farming system. Also the same figure shows that only 26% of the respondents stated that they use construction of irrigation in peak crop growth as their means to improve water use and availability in their farming system. Critical analysis of the figure 24 shows that 7% of the respondents stated that they use drip irrigation as the method(s) to improve water use and availability in the study area. The implication of the higher percentage of those respondents that agreed that they use watering can(s) means that there is lack of improved modern ways of water application in farming system in the study area.



Source: Field survey 2010

Figure 24: Distribution of respondents according to means used to improve water use and availability.

Figure 25 above shows that 57% of the respondents stated that the use of mulch and straw are the means they use to conserve soil mositure, nutrients and reduce run-off due to consequence of climate change in their farming community. Furthermore, 18% of the respondents reported that the mean they use to conserve soil mositure, nutrients and reduce run-off due to consequence of climate change in their farming community is by avoidance of monocropping. But figure 25 also shows that the use of crop rotation recorded 10% respondents; as the use of lower planting densities recorded 15% in the same figure 25 above.



Source: Field survey 2010

Figure 25: Distribution of respondents according to farming practices uses to conserve soil moisture, nutrients and minimize run-off

5. Summary of Findings

Major findings from the research study indicate that recent reduction in agricultural productivity in Enugu state is as a result of lack of adequate understanding of best farming practices. This may be attributable to lower educational of respondents in the study area. Similarly, the research find out that higher percentage of the farmers are engaged in crop farming than livestock farming although in small holding of 1 to 3 hectares. Most farmers were aware of cause(s) of climate change in Enugu state, Nigeria. This awareness in their views are mainly through industrial process pollution, use of fuel to generate energy, deforestation activities, use of various means of transportation and even other causes from different means of agricultural activities. Farmers in the study area pointed out that the manifestations of climate change are mainly through decrease in rainfall pattern, premature ripening of crops, and increase in pest infestation in both crops and animals. Also there is increase in weed infestation, heavy loss of pasture land/vegetation, and occasional increase in rainfall pattern which result to heavy flooding. They have variously described climate change phenomena over the past ten years as changing/irregular rainfall patterns, increasing temperature, prolonged harsh weather, higher pests' manifestation and recent land degradation.

Most farmers believe that climate change affect agriculture. This is because farmers in the area depend on rain-fed agriculture which is now being thwarted by climate change catastrophes. The farmers opted that the implications of climate change toward agriculture include; increase/intensity of drought, threat to wildlife/biodiversity, decrease in runoff of river/water availability, intensity in land usage and even rise in flooding/erosion. The notable activities stopped by farmers in the area due to climate change effects include; bush fallow, shifting cultivation, sole cropping, and even continuous cropping. Meanwhile, the research find out that the farming system adopted by the famers in the area due to climate change were both mixed farming/cropping, agro-forestry, and lastly tunguya farming. The most extensive commonly used indigenous farming system toward climate change adaptation in the area are; change in planting date, change in cropping patterns, change in harvesting date of crops, change in planting distance, introduction of new breeds of crop(s), changes in the storage mechanism and change in the processing techniques. From the research, it was noticed that major kinds of management technologies use to combat climate change in the area were use of pesticides, use of weedicides, use of fertilizers and carrying out tillage operation with mechanized tools. It was further find out that impacts of climate change in farming activities in Enugu state are in the area of reduced productivity, increased in pest and disease manifestation, and finally increase in the costs of farming and labour.

6. Conclusion & Recommendations

The research has shown that most farmers in Enugu state, Nigeria are aware that weather patterns are changing as manifested in increasing flooding and changes in rainfall patterns, increase in temperature, high incidence of pests, diseases and weeds, and even decrease in crop yields etc. But, their understanding of the concept of global climate change with regard to green house emissions, ozone layer depletion is limited. Although farmers adopted numerous adaptation strategies to climate change effects, they noted that most of the strategies are increasing tasking and might not stand the test of time especially with the increasing negative impacts of climate change in the recent time.

The major challenges to the farmers were lack of climate change information and extension services, poor infrastructural development, and lack/high cost of factors of production like labour, land and even capital. Notwithstanding that some farmers were aware of some government policies aimed at environmental protection such as ban on indiscriminate deforestation and bush burning, they confirmed that these policies are not being effectively implemented in the state.

Based on the above key findings from this research study, the following recommendations are proffered:

There is need for increase in the awareness level of farmers and general public on climate change issues. The people's ability to respond toward climate change challenges is determined by the quality of the information available to them and how easily they can be accessed. It is based on the information the people have that they can make informed decisions for climate change adaptation. Therefore the role of awareness creation is that of everybody in Enugu state, but a responsive government should take the first step.

There is need for a systematic collaborative approach involving all the stakeholders – science experts and researchers, policy makers and governments at all levels, private sectors; non-governmental and civil society organizations; farmers associations, youths and women groups to work together in turning the critical challenges posed by climate change into opportunities. The systems will lead to development of effective climate change resilient capacity, knowing that systems thinking espouse the principles of collaboration which breeds innovation.

Basically the indigenous technologies adopted by farmers in the area over the years have helped them cope with the changing climate. It is vital to apply the most recent modern technologies and practices for effective adaptation to take place. This is because, with time, some of the indigenous methods and practices for adaptation will not be effective any long.

There is also need for climate policy at national, state, local government levels and even community levels in this country. Such policies will streamline roles and responsibilities, strategies for climate change adaptation, vulnerability scenarios, and stakeholder's involvements in a more systematic manner. There is equally need for regular workshops, conferences, debates at all levels of governments in the state to provide updated information on climate change activities.

Finally, the Enugu State government must adopt strategies and policies that will encourage improved farming practices and agricultural methods, and that will protect our cherished agricultural activities which is the mainstay of our economy. Furthermore, there is need for constant use of both electronic and print media in strengthening climate change awareness and in communicating effective response strategies.

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