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Technological Challenges of Climate Change Adaptation in Nigeria: Insights from Enugu State

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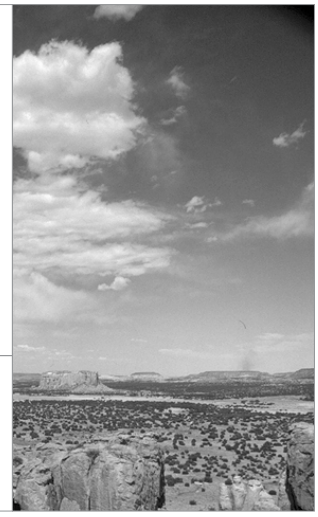

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Abstract

Climate change impacts depend on a range of the climate parameters' changes and on the country's social, cultural, geographical and economic backgrounds. The location and size of, and the characteristics relief in Nigeria especially Enugu state give rise to a variety of climates ranging from tropical rainforest climate along the coasts to the sahel climate to the northern parts of the country. Climate change is also threatening not only the sustainable development of socio-economic activities of any nation but also to the totality of human existence. Nigeria and even Enugu State begun to feel the effects of climate change as the frequency and intensity of extreme events like droughts and floods have increased.

This climate change has direct impacts on biodiversity, agriculture, water resources, forests, and coastal areas. Nigeria and Enugu State in particular 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, impacting negatively to the agricultural farming systems and triggering displacement.

In 1999 and 2000, more than 200,000 people were displaced by floods in Niger State. In 1988, flooding in Kano State displaced more than 300,000 people. 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. In Enugu no fewer than 300 families have been rendered homeless in "Ameke Ngwo" and "Ngwo Uno" communities in Udi local council of Enugu state in the year 2009 following the destruction of their houses and economic trees worth millions of naira by a wind storm which wrecked havoc in the area which is one of the resultant effects of climate change. Presently, due to climate change there are many agricultural farming systems adaptation by rural communities/farmers in Nigeria especially in Enugu state.

Farmers in the study area pointed out that the manifestations of climate change are mainly through decrease in rainfall pattern, increase in pest infestation in both crops and animals, heavy loss of pasture land/vegetation and premature ripening of crops. Also the result of the findings shows that the farming systems stopped in the last ten (10) years by the farmers in Enugu state due to climate change include sole cropping, continuous cropping, shifting cultivation and crop rotation among others.

List of Acronyms & Abbreviations

AfDB	African Development Bank
AIAE	African Institute for Applied Economics
AMS	American Meteorological Society
ATPS	African Technology Policy Studies Network
BNRCC	Building Nigerian Responses to Climate Change
CFC	Chlorofluorocarbon
FAO	Food and Agricultural Organization
FGDs	Focus Group Discussions
GDP	Gross Domestic Products
IPCC	Intergovernmental Panel on Climate Change
MDGs	Millennium Development Goals
NGOs	Non-governmental Organization
NOAA	National Oceanic and Atmospheric Administration
NPC	National Population Commission
PS	Pilot Survey
UKCIP	United Kingdom Climate Impacts Programme
UNDP	United Nation Development Programme

1. Introduction

1.1 Background information

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. As weather becomes fiercer and storms increase in frequency and intensity, serious socio-economic consequences result. Malnutrition and disease become common occurrences. 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.

A variety of food crops are produced in Nigeria and more especially in Enugu state, all dependent on rainfall, so that where rain is abundant crops dependent on rain are planted, and in drier parts of the country, crops that do not require much rain are cultivated. Food production on the whole, however, has not kept pace with Nigeria's and even Enugu state population increase. Climate change can seriously affect agricultural production, agricultural farming system and therefore, food security. Enugu State, at present, does not enjoy food security so is very vulnerable to the effects of climate change.

Land degradation reduces the quality and productivity of land. Many factors can affect it, and climate change can be one underlying cause, resulting in water and wind erosion of land at different degrees in different parts of the state, drought and the creation of deserts, acid and salt accumulation, depletion of minerals, and heavy-metal contamination. Also, in Nigeria all forms of land degradation occur in different scales and no part of the country is safe from it. The low-lying nature of Nigeria's 800 km coastline makes it prone to coastal erosion and flooding, all of which are climate change-induced forms of land degradation. In the Sahelian zone of Nigeria's north, the most pronounced climate change-related forms of land degradation are wind erosion and related sand dune formation, drought and desertification. Sheet erosion–which results in the complete removal of arable land–is Nigeria's biggest threat to agriculture, especially in the sandy soil regions of south-eastern Nigeria where Enugu state is located.

Prevailing climate is critical in controlling the ecosystem structure. Forests provide important goods and services, which include food, non-timber forest products, timber, firewood, the natural regulation of biochemical cycles, genetic resources, soil and water conservation, carbon reservoirs, recreation, cultural and spiritual values. Forests play a key role in the functioning of the biosphere and indirectly affect the provision of many other goods and services. Changes in climatic and atmospheric composition have

helped to diminish forests in Enugu state and Nigeria at-large. The upper limits of the tropical rainforest are already receding. Given the sensitive nature of the forest ecosystems, forest resources have become highly vulnerable to even slight changes in climate systems. Changes in temperature, precipitation and water cycle dynamics, therefore, can lead to remarkable forest-cover loss in Enugu State and beyond.

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.

According to Medugu (2009), scientific studies show that snows are disappearing in this part of the world and that Africa will be worst hit by the effects of climate change which Nigeria and Enugu state in particular is part of.

Following these development, 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 disease, 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 which is one of the resultant effect 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.

Agriculture is clearly vulnerable to the impacts of climate change in the study area. Evidence shows that farming systems and farming technologies within the state have been changing in responses to the effects of climate change. This notwithstanding, very little research is done to understand these changes and how they can be optimized to enhance farmers' livelihoods within the state.

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 Objectives of the study

The broad objective of the study is to identify and examine the technological and farming systems adaptation to climate change among farmers in communities of Enugu state, Nigeria.

The key specific objectives of the project are as follows:-

1. To elicit the level of awareness and understanding of farmers and local communities about the manifestation and impacts of climate change;
2. To identify the relationships between climate change and adjustments in farming systems and management technologies;
3. 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;
4. To draw policy lessons for the state government's efforts in promoting sustainable environment and climate change mitigation and adaptation.

2. Literature Review

2.1 Concept of climate change adaptation

According to 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 as seen by (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 Climate and climate change perspectives in Nigeria

Nigeria has been witnessing 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 Climate change, adaptation and agricultural development 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.

Available statistics as reported by Odiugo (2008) shows that except in the oil-exporting countries, agriculture is the economic mainstay in most African countries, contributing 20-30% of gross domestic product (GDP) in sub-Saharan Africa 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 artisinal 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, Angola) have low-lying lagoonal coasts that are susceptible to erosion and hence are threatened by sea-level rise, particularly because most of the countries in this area have major and rapidly expanding cities on the coast. 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.

Furthermore 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 who do not have the means to withstand shocks and changes.

2.5 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. 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.

3. Methodology

3.1 Study Design

This project is essentially an inventorisation exercise aimed at mapping out some selected communities within the three (3) agricultural zones of Enugu State that is mostly affected by the climate change. The project further built the capacity of some selected target group(s)/ individuals in selected communities within the three (3) agricultural zones of the state. Further more the stakeholders within the state thereafter participated in consultation workshop organized within the state to sensitize them more concerning change climate implications.

3.2 Sampling size criteria

It is important to emphasize that the three (3) agricultural zones of the state correspond to the three (3) different micro agro-ecological zones of the state. The choice of the communities within the three (3) agricultural zones reflects the three (3) different micro agro-ecological zones within the study area.

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 involves 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.

The third stage was the selection of respondents (i.e. farming household heads). Thirty-three (33) farming household heads each were selected from each community in both Awgu and Enugu agricultural zones. But, thirty-four (34) respondents were selected from each community in Nsukka agricultural zone, making a total number of Four hundred (400) farming household-heads. The greater number of respondents from Nsukka agricultural zone is based on NPC 2006 which reported that the population of Nsukka zone is greater than that of Awgu and Enugu zone.

3.4 Data collection and analysis

Data for this study were collected from both primary and secondary sources. The primary data were obtained by the use of structured questionnaire. Information sought include among others age of farming household heads, primary occupation of farming household heads, farming technologies employed by the farming households (e.g. tillage practices, weed control practices, planting practices and timing, harvesting practices and timing), farming systems (like cropping pattern, cropping systems soil maintenance practices) among others. Furthermore, personal contacts, oral interviews and observations were used during visitation; this aided the primary data collection techniques.

Secondary data were sourced from relevant publications which include: text-books, bulletins, periodicals, journals, annual reports, seminar papers, unpublished materials of relevance to the study, report documents from different ministries and even internet search to obtain the most recent information on the subject matter.

Meanwhile complementary qualitative data were collected by means of focus group discussion (FGD) in each of the selected communities within the three (3) agricultural zones of the study area. The FGD helped to find out the community-level indicators of climate change and climate change adaptation in the farming communities.

The project explored appropriate descriptive statistical tools for the analysis of the whole objectives after data processing.

4. Analysis & Preliminary Results

4.1 Socio-economic characteristics of farmers

Socio-economic profile of the respondents refers to their personal characteristics and conditions, which influenced the decision of the respondents toward farming activities. The socio-economic status considered in this study include sex, age, martial status, level of education, major occupation, minor occupation, types of farming activities carried out, size of farm land among others.

The female-male ration of the respondents were fairly even, with females comprising of 55% of the respondents (Figure 1). The greater number of females does not presuppose out-rightly that females outnumber the males in the study area, rather, this can be attributed to the fact that females are considered to have more access to farming activities than males in the area.

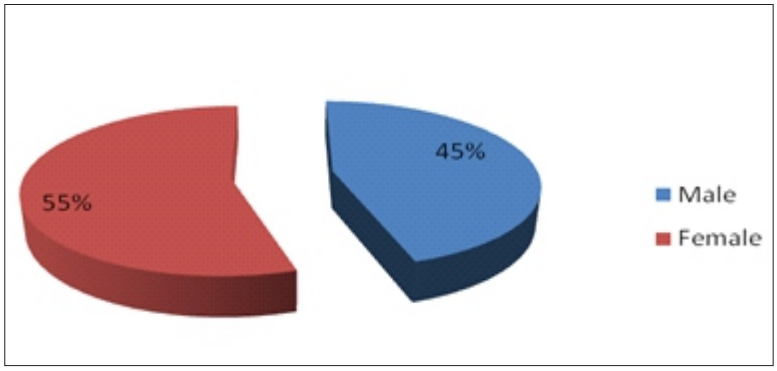

Figure 1: Distribution of respondents according to sex

The bulk of the respondents (45%) is within the 41-60 years age bracket. The old age group (61 years) comprised of 25% of the respondents, while the youth (<25 years) constituted 30% of the respondents (Figure 2). The results of the analysis show that middle-aged men and women dominate farming activities in the area. It also suggests that few youths are engaged in farming, and are likely opting for non-farm income generating economic activities.

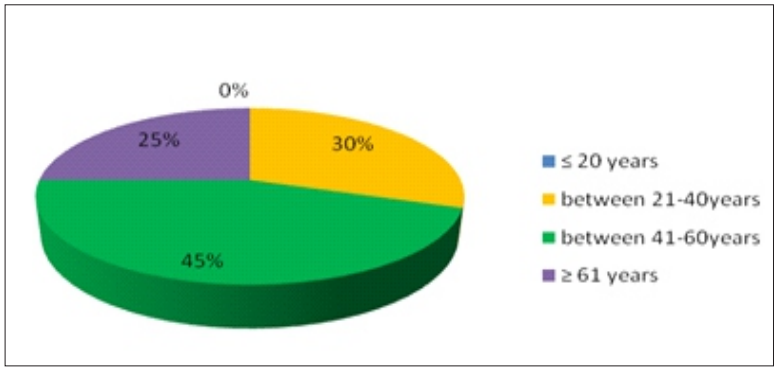

Figure 2: Distribution of respondents according to age

Generally, education is considered to broaden the horizon of human activities, operation and understanding of the environment including farming activities. Figure 3 indicates that the majority of the respondents (50%) in the area reported that they had primary education as their highest level of educational attainment. It also shows that 35% of the respondents did not have any form of formal education. Only 5% of the respondents reported that their highest level of education is secondary education, whereas only 10% of the respondents had post secondary education as their highest level of education. This scenario indicates that reduced productivity could likely be as a result of lack of adequate understanding of the best practices to farming especially now climate change is affecting farming activities

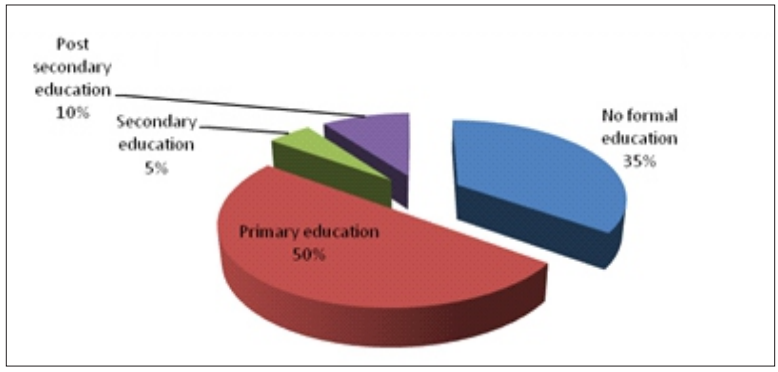

Figure 3: Distribution of respondents according to educational status

As shown in Figure 4 (below), majority (80%) of the respondents have their major occupation as farming, whereas 10% stated that civil/public service is their major occupation. Also only 5% of the respondents reported trading and wine-tapping as their major occupation respectively.

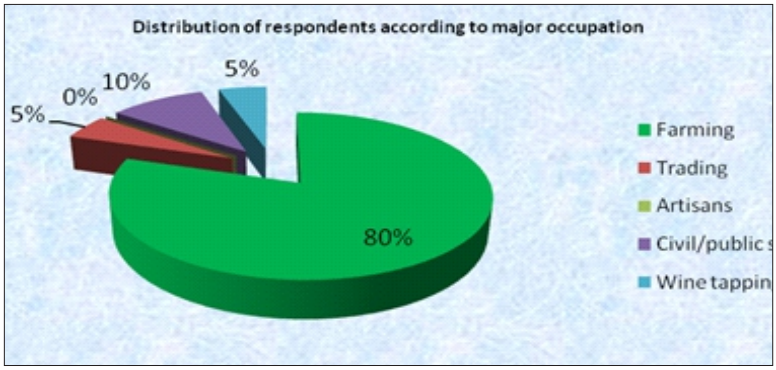

Figure 4: Distribution of respondents according to major occupation

Close to three-quarters (70%) of the respondents have access to land lesser or equal to three (3) hectares for their farming activites. Another 25% of the respondents have access to between four (4) to six (6) hectares of land for their farming activities,and only 5% reported access to between seven (7) to nine (9) hectares of land for their farming activities (Figure 5). The implication of of having a higher percentage of respondents reporting access to land ≤3 hectares for their farming activites shows the increasing pressure on land as more people depend on a fewer portion of land for farming. Our observation shows that land in these communities is also being used for other activities like building of both residence and industrial houses rather than farm activities. The landuse changes could add to the deforestation of the area which is one of the lkely causes of climate climate.

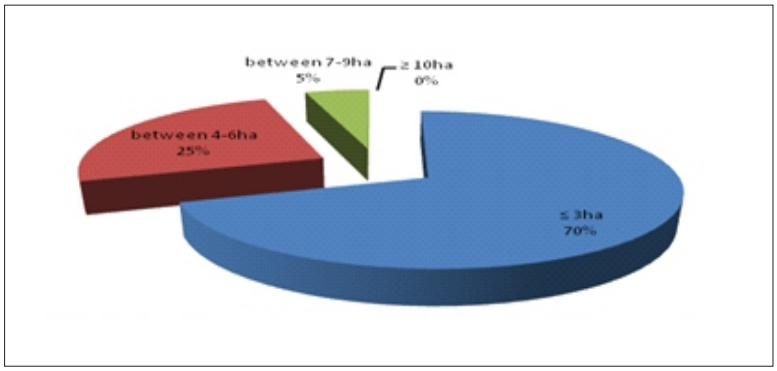

Figure 5: Distribution of respondents by farm size (ha) of land owned

4.2. Farmers perception and awareness on local manifestations of climate change

Roughly 67% of the respondents reported that the major cause(s) of climate change in the area is due to deforestation activities (Figure 6). Another 24% thought that industrial activities are the likely cause of climate change in their communities while only 9% of the respondents agreed that agricultural activities are the major cause of climate change in their area (Fogure 6).

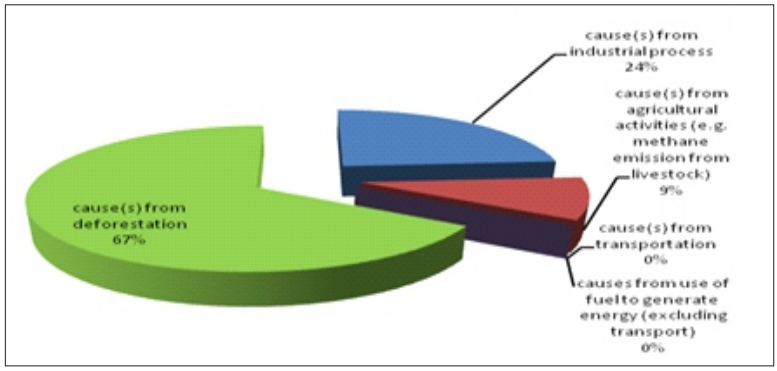

Figure 6: Distribution of respondents according to cause(s) of climate change

Fifty eight percent (58%) of the respondents stated that the manifestation of climate change in the area is highest with decrease in rainfall pattern (Figure 7). As 23% of the respondents reported that increase in pest infestation is the manifestation of climate change, 13% of the respondents said that loss of pastures land/vegetation is the manifestation of climate change in their community. Finally only 6% of the respondents confirm premature ripening of crops as the major mainfestation of climate change in the area.

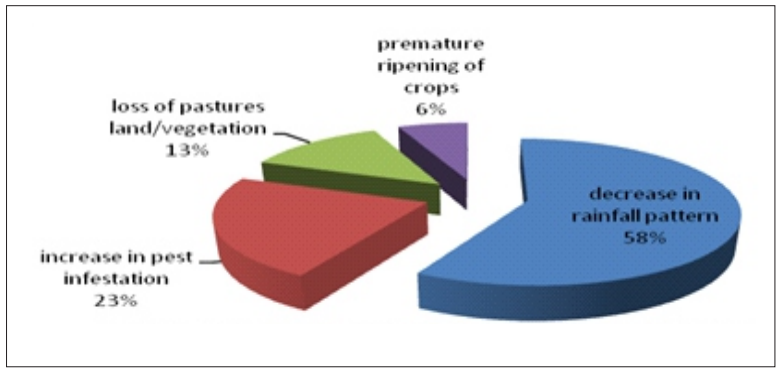

Figure 7: Distribution of respondents according to manifestation of climate change

The survey shows that 43% of the respondents (which represents 16 participants) thought that climate change phenomena was worse over the past ten years in their community in the area of changing/irregular rainfall pattern. Another 24% of the respondents (representing 9 participants) agreed that climate change phenomena was worse in their community over the past ten years in the area of increasing temperature or heat. Finally 19% (which represents 7 participants) and 14% (which represents 5 participants) of the respondents respectively stated that climate change phenomena was worse in their communities over the past ten years in the areas of harsh weather condition and pest manifestation individually (Figure 8). The higher percentage of the respondents that stated that changing/irregular rainfall pattern over the past ten years is the worse phenomena of climate change in their community confirm the views which was expressed by all the participants in the study area during the FGDs in the study area.

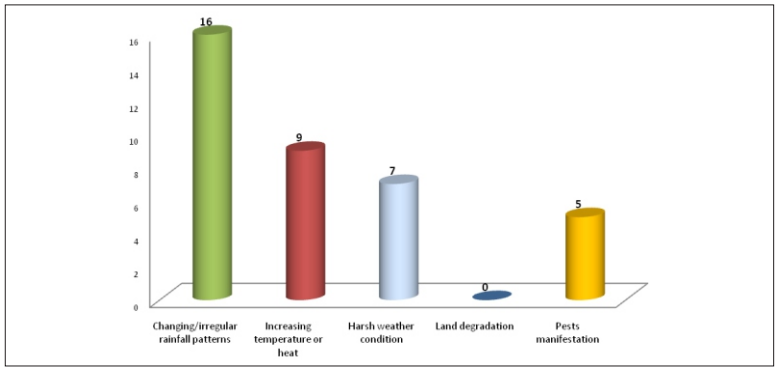

Figure 8: Distribution of respondents according to climate change phenomena over ten years ago

Figure 9 below indicated that higher number of participants 15 persons reported that increase frequency/intensity of drought is the recent implication of climate change toward agriculture activities in their community. Also 7 respondents confirmed that decrease in run-fall of rivers/water availability is the recent implication of climate change toward agriculture in their area. The increase in the frequency/intensity of drought in recent time is the indication that climate change toward agriculture 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.

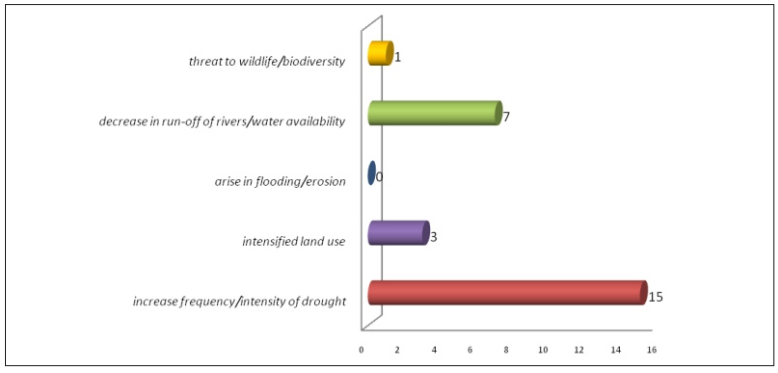

Figure 9: Distribution of respondents according to recent implication of climate change toward agriculture

4.3. Farming systems and its management technologies on climate change

Our analysis shows that 28% of the respondents have stopped using sole cropping farming system in their community due to climate change in the past ten years, and another 27% have stopped using continuous cropping farming system due to climate change in the past ten years (Figure 10). It further shows that 21% each of the respondents in the area under study have stopped the use of both crop rotation and shifting cultivation respectively as a result of climate change in their communities (Figure 10). Finally, only 3% of the respondents said they have stopped the use of intercropping due to climate change in the past ten years in their community. The high percentage (28%) of the participants that agreed that they have stopped the use of sole cropping system may likely be due to high rate of pest infestation reported in the areas (see Figure 7).

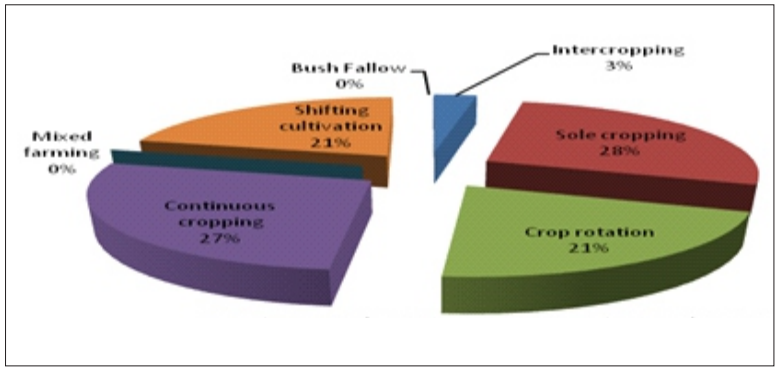

Figure 10: Distribution of respondents according to farming system(s) stopped in the past ten years due to climate change

Figure 11 depicts the distribution of respondents according to farming systems adopted in the area. It shows that more respondents (18 in number which represents 60%) reported that they adopted mixed cropping farming system in their communities toward climate change in the recent time. It also shows that while 7 respondents (which is 23%) stated that they adopted mixed farming as their own farming system in response to climate change in the recent time, only 5 respondents (representing 17%) agreed that they adopted sole cropping farming system in their communities in the recent time toward climate change. 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.

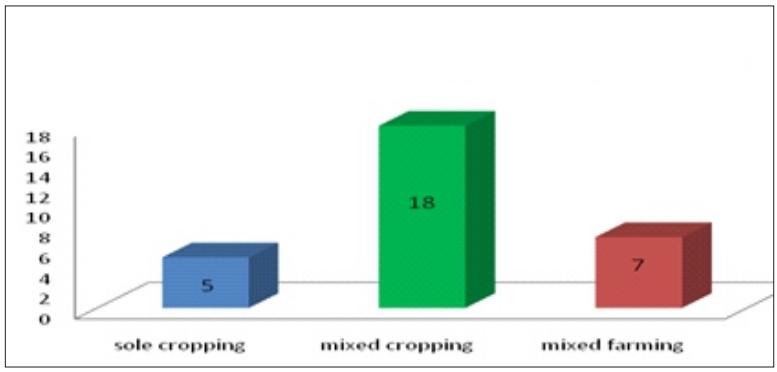

Figure 11: Distribution of respondents according to farming system(s) adopted in recent time due to climate change

From Figure 12 below, 40% of the respondents reported that the change they adopted in their faming system is changes in the planting date of crops. Another 26% and 14% of the respondents stated that the changes they adopted in farming system in their community were changes in cropping pattern and changes in the harvesting date of crop(s) respectively. Finally as 11% of the respondents reported that the changes they adopted in their farming system is changes in planting distance only 9% of the respondents agreed that changes they adopted in their farming system is changes in the storage mechanisms. The higher percentage of the respondents that reported that changes they adopted in their farming system is changes in the planting dates of crops confirmed the recent situation in the state that there is delay in rainfall in the study area hence what is mainly practiced in the study area is rain-fed agriculture.

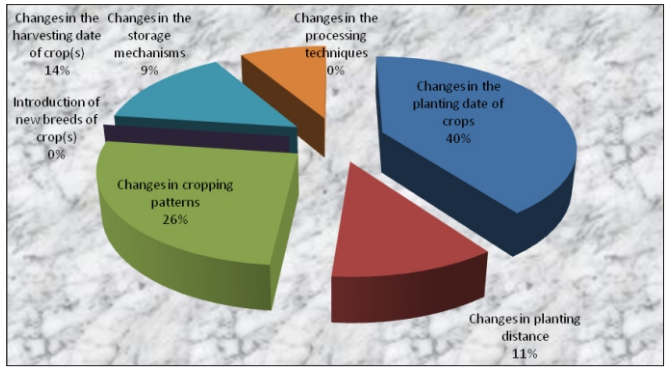

Figure 12: Distribution of respondents according to changes adopted in farming system

Figure 13 shows that 55% of the respondents stated that the kind of management technologies they use to combat change in their community is the use of fertilizer. Futhermore, 18% and 14% respectively agreed that they use pesticides and other means like crude tools for pre/post harvest activities. It also shows that only 9% of the respondents reported that they carry out tillage operation with mechanized tools as type of management technology to combat climate change, while 4% of the respondents reported that they use weedicides as the kind of management technology to combat climate change effects.

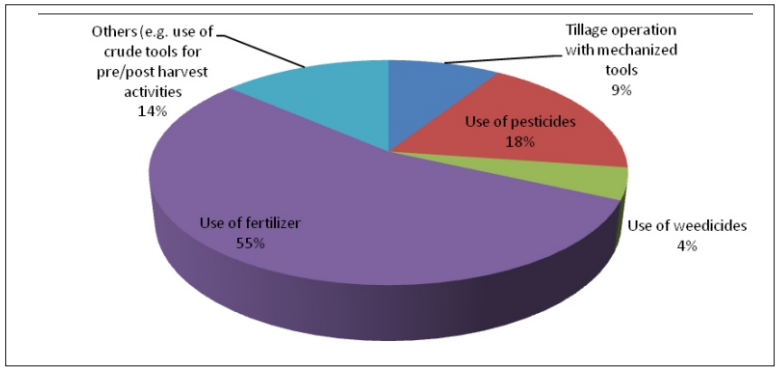

Figure 13: Distribution of respondents according to the kind(s) of management technologies use to combat climate change

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

Figure 14 above indicates that 49% of the respondents' recent adaptation patterns available in adjusting with climate change in their community is through the change in time of planting. It also shows that 12% each of the respondents reported that change in irrigation process and changes in land preparation practices(terracing, contouring, hedges, reservoirs, drainage) are the recent adaptation patterns available in adjusting with climate change in their community. Another 9% of the respondents stated that change in land and livestock management are the recent adaptation patterns available in responding to climate change in their community. Lastly, only 6% and 3% respectively reported that change in crop rotation and improve forecast mechanisms are the recent adaptation patterns available in adjusting with climate change in their community.

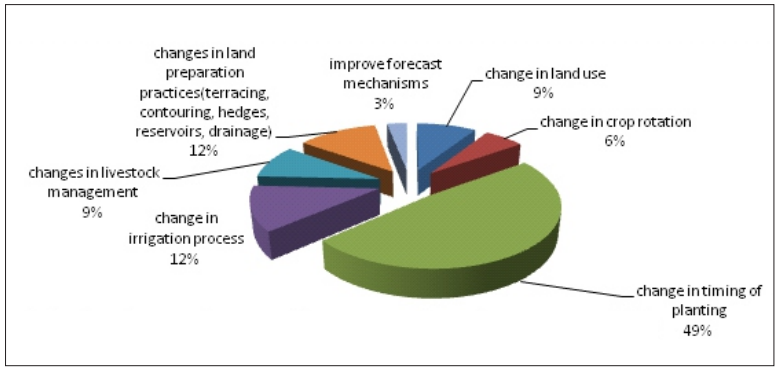

Figure 14: Distribution of respondents according to recent adaptation available

The result of the analysis reported in Figure 15 below indicates that 36% 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. Another 29% of the respondents stated that the major impact of climate change in their farming activities is in the area of increased labour (Figure 15). Whereas 22% of the respondents stated that the major impact of climate change in their farming activities is in the area of increased cost of farming, only 13% of the respondents said that increased in pest and disease manifestation is the major impact of climate change on their farming activities. This scenario whereby a higher percentage of the respondents agreed that reduced productivity is the major impact of climate change in their farming activities confirms the report of the farmers during the FGD that for years now there is reduction in the output of their farm produce due to climate change.

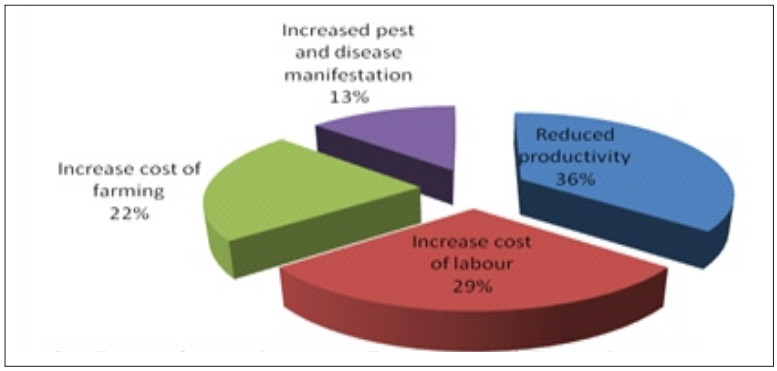

Figure 15: Distribution of respondents according to impact of climate change on farming activities

4.5 Impacts of climate change adaptation to farming communities' livelihood

As can be deciphered from Figure 16 below, only 30% 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 16, 27% of the respondents reported that the indigenous technology which are in use in their farming community is rotational bush fallow. Finally, figure 16 shows that use of flood plain farming and use of bird scaring as the indigenous technologies which are in use for climate change adaptation recorded 14% and 9% respectively.

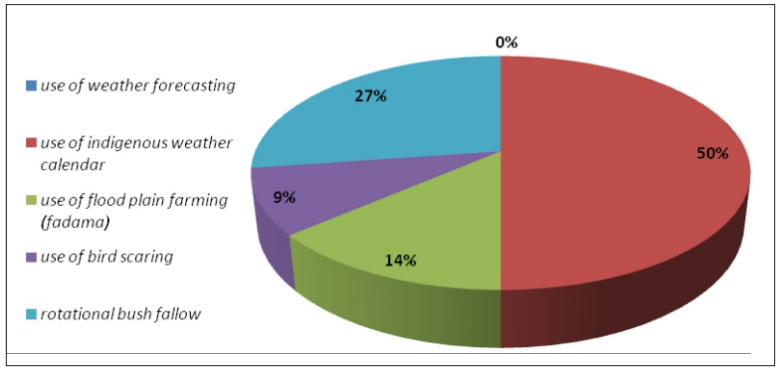

Figure 16: Distribution of respondents according to indigenous technology in use

According to figure 17 below, 45% of the respondents who confirm that they use only ≤ 20% of the indigenous technology to combat climate change in their community. Also the same figure 17 shows that 35% 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 20% of the respondents from figure 17 agreed that the percentage of climate change adaptation techniques which is attributable to indigenous technology in their farm is between 21-40%.

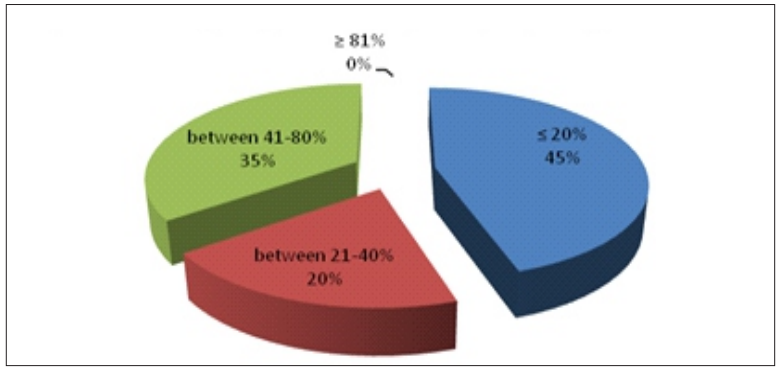

Figure 17: Distribution of respondents according to percentage of indigenous technology techniques in use

Figure 18 shows the distribution of respondents according to types of adaptation to climate change in respondents farming community. Ten (10) participants which represent 50% of the respondents stated that the type of adaptation to climate change in their farming community is shorter growing season crops. Our results also show that 5 participants each (which represents 25% each of the respondents) said that the types of adaptation to climate change in their farming community are longer growing season crops and construction of dykes respectively (Figure 18).

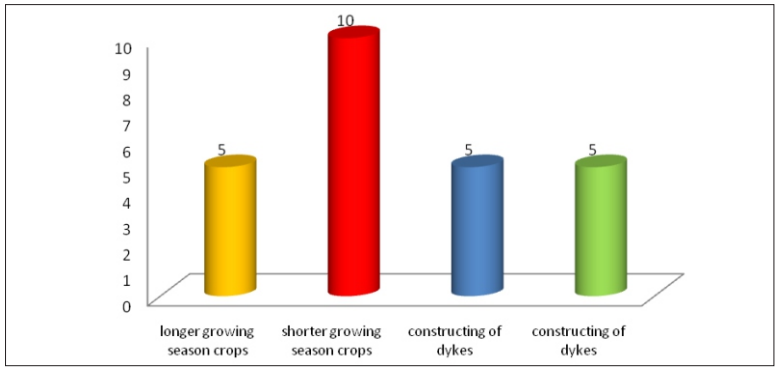

Figure 18: Distribution of respondents according to types of adaptation

Thirty six (36%) percent of the respondents reported that the modern technology used for climate change adaptation techniques in their farming community is by use of crop rotation method, and 32% stated that modern technology use for climate change adaptation techniques in their farming community is by seeking advice from government extension agents (Figure 19). Only 18% of the respondents stated that the modern technology used for climate change adaptation techniques in their farming community is by use of crop with small need for water.

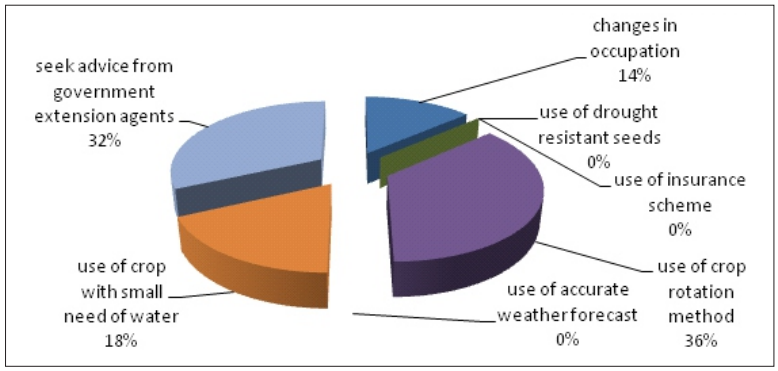

Figure 19: Distribution of respondents according to modern technologies adapted

Figure 20 shows that 35% of the respondents reported that subdivision of large field is the adaptation mechanisms (toward change in land topography to improve water intake and reduce erosion) used as climate change solution in their community. Also 30% of the respondents 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 maintainence of water ways and roughening of the land surface. Finally only 5% 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 building of wind break.

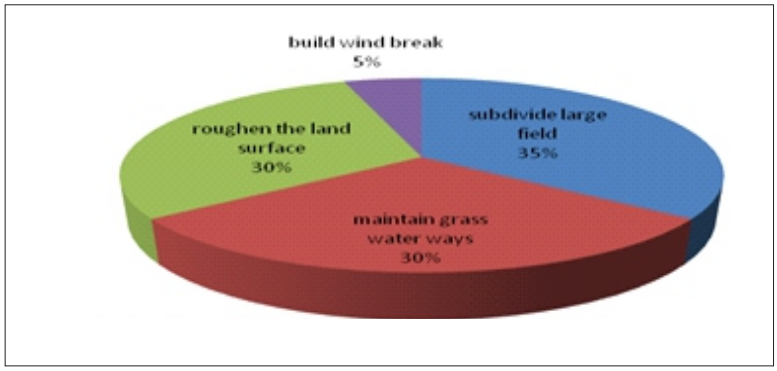

Figure 20: Distribution of respondents according to adaptation for improved water intake and reduced erosion

Our findings shows that that a higher percentage of the respondents (90%) 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 (Figure 21). Also the same figure shows that only 10% 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. The implication of higher percentage of the respondents that stated 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 is attributable to lack of improved ways of farming system in the study area.

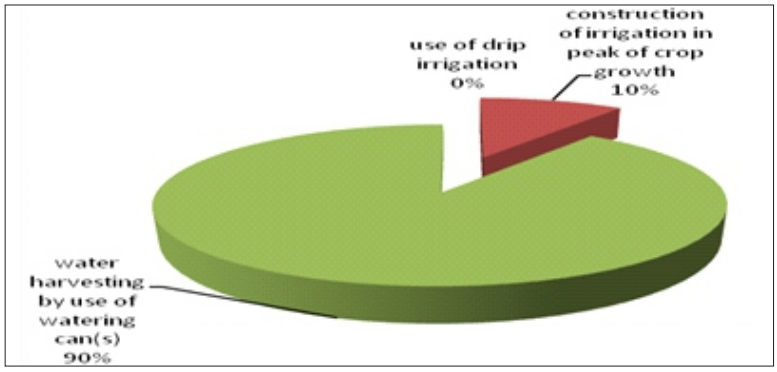

Figure 21: Distribution of respondents according to means for improved water use and availability

More than half (61%) 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 (Figure 22). Furthermore, 23% 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 as shown in Figure 22, only eihght (8%) of the respondents indicated that they use of crop rotation and lower planting densities

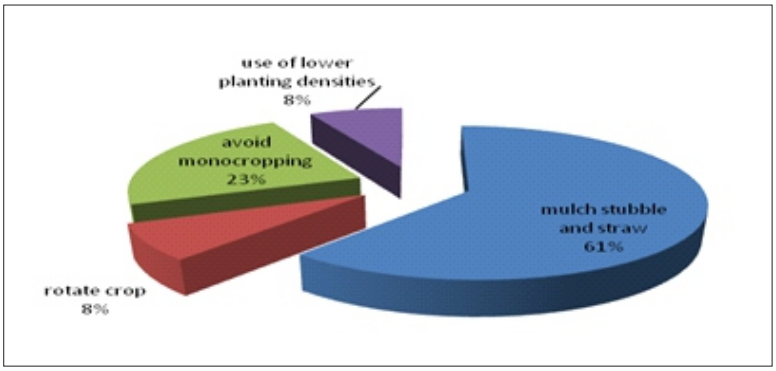

Figure 22: Distribution of respondents according to farming practices use to conserve soil moisture, nutrients and minimize run-off

5. Lessons & Implications

Agriculture is clearly vulnerable to climate change. Therefore there is need for adaptation in agricultural farming systems at all levels of government within the sub-regional level, country level like Nigeria, state and local governments' levels and finally community level.

Although farmers adopted numerous adaptation strategies to climate change affects, some of the farmers noted that some of the indigenous strategies are increasing tasking and might not stand the test of time. Historic climatic conditions, trends and variations have prospects for departures from what we use to know and observe due to climate change. This call for paradigm shift in terms of how we manage climatic risks and necessitates the need for planned adaptation strategies. It is based on this light that we make the following recommendations:

To address the climate change impacts in agricultural farming systems in Enugu state, and beyond there is need for significant improvement in agricultural research and extension system of the state. This is because agricultural research is the operational tools for deploying science and technology to improve agricultural productivity and ensure effective coping with climate change challenges. The preliminary evidence- as indicated from our findings of farmers perception of climate change impacts in Enugu - shows that in the last few years there were climate change impacts in Enugu state. These impacts, according to our interviews, were manifested through changing/irregular rainfall patterns, increasing temperature, prolonged harsh weather, higher pest manifestations, land degradation among others. Meanwhile, the recent technological responses adapted by farmers in the study area toward climate change impacts were use of weedicides, use of fertilizer, carrying out of tillage operation with mechanized tools, use of pesticides, use of crops with smaller need of water, use of drought resistant seeds, use of flood plain farming, use of rotational bush fallow etc.

There is need for Enugu state assessment framework on climate change. This will compliment both the national and global pooled climate change information and thereby generate the state specific circumstances and scenarios that will guide the choice and implementation of her policy interventions to promote adaptation options by individuals, households, communities and government institutions in general.

Finally, poor adaptive capacity and adaptation reflect the underlying structural and institutional weakness that already hold down economic growth, reinforce poverty and inequality. Therefore, adaptation impacts of

climate change can only be meaningfully and sustainably addressed within the framework of economic growth, poverty reduction and sustainable development policies of the state and the country. Climate change adaptation policies and strategies need to be considered as integral component of economic growth strategy under 4-points agenda of Enugu state.

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