

**CLIMATE VARIABILITY ADAPTATION STRATEGIES AMONG CROP FARMERS
IN LAPAI LOCAL GOVERNMENT AREA, NIGER STATE, NIGERIA**

BY

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ZARIA**

NOVEMBER, 2021

DECLARATION

I declare that the dissertationentitled “CLIMATE VARIABILITY ADAPTATION STRATEGIES AMONG CROP FARMERS IN LAPAI LOCAL GOVERNMENT AREA, NIGER STATE, NIGERIA” is a collection of my original research work and has not been presented for any other qualification elsewhere, information from other sources (published or unpublished) has been duly acknowledged.

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CERTIFICATION

This dissertation titled “CLIMATE VARIABILITY ADAPTATION STRATEGIES AMONG CROP FARMERS IN LAPAI LOCAL GOVERNMENT AREA, NIGER STATE, NIGERIA” carried out by Adeleke Adenrele (P17PSG9026) meets the regulation governing the award of the degree of Master of Philosophy in Disaster Risk and Development Studies of the Ahmadu Bello University, Zaria and it is approved for its contributions to scientific knowledge and literacy presentation.

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DEDICATION

This research work is dedicated to God whose greatness in mercy has seen me through this quest, my loving mother who has been my mentor and to my Wife FolukeAdeleke, for her love and kind support all the way.

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ABSTRACT

Climate Variability induced hazards have become serious issues and the aftermath is increasingly hampering cropping activities in Nigeria thereby affecting food security. This study examined the Climate Variability adaptation strategies among crop farmers in Lapai Local Government Area of Niger State, Nigeria. It identified the types of hazards posed by climate variability, assessed the climate variability impact on crops yield in the study area, examined the climate variability adaptation strategies employed by the crop farmers in the study area to combat the hazards of climate variability and examined most suitable adaptation strategies in the study area. Random sampling technique was adopted, 377 respondents were randomly sampled for the study. Questionnaire and Focus Group Discussion were used to gather the data. The data were analyzed using simple descriptive statistic for objective one, relative impact index for objective two, friedman's non parametric test for objective three and pairwise comparison matrix for objective four. The findings of the study revealed that 23.4% respondents from Birninmaza, 25.1% from Gulu and 51.9% from Ebbo identified flood, 21.5% from Birninmaza, 18.7% from Gulu, 12% from Ebbo also identified drought, while 43.9% from Birninmaza, 42.8% from Gulu, 24.1% from Ebbo identified increasing pest and disease infestation on crops and 11.2% respondents from Birninmaza, 13.4% from Gulu and 12% from Ebbo identified soil erosion as the climate variability induced hazards in the study area. Results also revealed that 23 % and 20.1% of the respondents had increase in pest and disease infestation and increase in soil erosion due to climate variability while 15.2%, 15%, 14.1%, 8.1%, 2.5% and 2% of the respondents had delay cropping, destruction of crops, flooding of crops, delayed crop maturity, poor

germination of seeds and reduced crop yield quantity as impact of climate variability. Climate variability adaptation strategies practiced in the study area are Planted trees for shading and change in crop varieties which (ranked 1st and 2nd respectively) as the adaptation strategies practiced to change in climate variability, mixed farming, change planting date and change from crop to livestock (ranked 3rd, 4th and 5th respectively). Other adaptation strategies to climate variability are intensive irrigation (ranked 6th), practice mixed cropping (ranked 7th), engaged in off-farming activities and practice water harvesting scheme (ranked 8th and 9th), moved from rural to urban area (ranked 10th), change from farming to other occupation (ranked 11th), good cultural practices such as mulching (ranked 12th) and farm insurance (ranked 13th). Most suitable adaptation strategies practiced by the farmers to change in climate variability are intensive irrigation system and harvest of run-off water (ranked 1st and 2nd respectively) as most adaptation strategies practiced by the farmers to change variability, planting trees for shading (ranked 3rd), change in crop varieties (ranked 4th), change in planting date (ranked 5th), good cultural practices such mulching (ranked 6th), mixed cropping (ranked 7th), mixed farming (ranked 8th) while farm insurance (ranked 9th). It was therefore recommended that Lapai Local Government Council should encourage use of supplementary irrigation systems so as to irrigate the land during the period of water deficiencies in Lapai Local Government Area. There is also need for the State and Local Government Authorities to create awareness on integrated agricultural water management interventions and train the smallholder farmers and Agricultural extension staff at Local, State and Federal Government.

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LIST OF ABBREVIATIONS

ADPC; Asian Disaster Preparedness Centre

AWM: Agricultural Water Management

CCAFS: Climate Change Agriculture and Food Security

FAO: Food and Agricultural Organization of United Nations

FGD: Focus Group Discussion

GHG: Green House Gases

HIV/AIDS: Acquire Immune Virus| Acquire Immune Deficiency Syndrome

IPCC: Intergovernmental Panel on Climate Change

NGO: None Governmental Organization

UNFCCC: United Nations Framework Convention on Climate Change

UNEP: United Nations Environmental Program

UNDP: United Nation Development Programme

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Climate change and agriculture are inextricably linked. Climate change is defined as a shift from the average weather condition of climatic elements, which persist for several decades or longer (Intergovernmental Panel on Climate Change {IPCC}, 2007). United Nations Framework Convention on Climate Change, {UNFCCC}(2008) defined climate change as "a change in the state of climate which is attributed directly or indirectly to anthropogenic activities that alter the composition of the global atmosphere, in addition to natural climatic variability observed over a comparable time period" (usually 30-50 years).

Climate change has several impacts and vulnerabilities on the environment and on socio-economic and related sectors, including water resources, agriculture and food security, human health terrestrial ecosystems and biodiversity and coastal zones. As planet warms, rainfall patterns shift, and extreme events such as drought, flood, and forest fires become more frequent Zoellick (2009), which results in poor and unpredictable yields, thereby making farmers more vulnerable, particularly in Africa (UNFCCC, 2008). Nelson (2009) identified agriculture sector as a contributor of climate change, which account for 13.5 percent of the total yearly emission of greenhouse gas, 19 percent forest land and 13.1 percent of transportation. The actualisation of the African Green Revolution and its path to food security and economic growth in sub-Saharan Africa has been endangered by climate Change. IPCC, (2007) spotlighted that the growing seasons of the African continent and high temperatures affect agricultural productivity and forecasted that rainfed crop yields in some nations would diminish by 50 percent and figured out that 50-250 million Africans will experience heightened water stress by the year 2020.

Climate change is one of the major issues that are threatening mankind globally today. This is as a result of man's various activities such as industrialization, testing of nuclear weapons, urbanization, bush burning, overgrazing, over cultivation, deforestation which subsequently results to desertification and extinction of life and causes widespread changes in the global distribution of plants and animals. Rising consumption/use of fossil fuel increases amounts of greenhouse gases into the Earth's atmosphere (Hossain and Rao. 2014). These greenhouse gases include carbon dioxide (CCh), methane (CHU) and nitrogen dioxide (NCh) and a rise in these gases has caused a rise in the amount of heat from the sun withheld in the Earth's atmosphere, heat that would normally be radiated back into space. This increase in heat has led to the greenhouse effect, resulting in climate change (Hossain and Rao. 2014). Climate change is perhaps the most serious environmental threat facing mankind worldwide (Adebayo and Oruonye, 2013). It affects agriculture in several ways, one of which is its direct impact on crop production. Climatic change, which is attributable to natural climate cycle and human activities, has adversely affected crops productivity in Africa Ziervogel (*e tal*2006).

The impact of climate change on peasant farmers could be disastrous because approximately on 6% of African croplands are irrigated (IPCC, 2007). This will further make people vulnerable to malaria and other climate-influenced diseases which have direct effects on agricultural production and food security, thereby reducing labor productivity and employment opportunities. The Food and Agriculture Organization {FAO}, (2007) stated that the components of food security in Africa are agricultural production, biophysical, political and social systems and these are expected to be placed under considerable additional stress by climate change. Dinar, Hassan, Mendelsohn and Benhin (2012) discovered that the severe impact of climate change worsens rural poverty.

It is projected that crop yield in Africa may fall by 10-20% by 2050 or even up to 50% due to climate change particularly because African agriculture is predominantly rain-fed and hence, fundamentally dependent on the vagaries of weather (Jones and Thornton, 2002). As the people of Africa strive to overcome poverty and advance economic growth, this phenomenon threatens to deepen vulnerabilities,

erode hard-won gains and seriously undermine prospects for development (Zoellick 2009). The dynamics of climate change manifest through extreme aridity, drought, dryness, excessive heat waves, and high temperatures, floods, inundation of coastal Cities, submergence of Islands, alteration of surface and shifts of ecosystems zones. However, Fischer, Shash, and Van (2002) posit that the impact of this climate change on crop farming depends on the balance of these impacts. Increase in storm surge and invasive species are also common characteristics of climate change (Vision 2020:20, Report, 2009). Nigeria is already experiencing a range of climate changes including more frequent heavy rainfall events, erratic rainfall, and unpredictable onset/retreat of rain and increasing temperature. The impacts from these changes are already threatening ecosystems and crop production.

Although crop production may be adversely affected by climate change, crops that are least able to cope will have to bear the additional adverse impacts. It has been observed that Africa is one of the most vulnerable regions to the effect of global climate change due to her low human adaptive capacity to anticipated increases in extreme events resulting from widespread poverty, heavy reliance on rain fed agriculture, limited economic and technological capacities, and educational progress (Bako, 2013). According to IPCC (2007), adaptations is defined as actions taken to help communities and ecosystem moderate, cope with, or take advantage of actual or expected changes in climatic conditions. Adaptation can also be define as ability to respond and adjust to actual or potential impacts of changing climate conditions in ways that cause moderate harm or takes advantage of any positive opportunities that the climate may afford (IUCN, USD, SEI, SDC and Interco-operation, 2004). It includes policies and measures to reduce exposure to climate variability and extremes, and the strengthening of adaptive capacity. Adaptation can be anticipatory, where systems adjust before the initial impacts take place, or it can be reactive, where change is introduced in response to the onset of impacts. They include local actions taken by the poor people themselves in response to changing crop production or environmental conditions. Such adaptation measures include; changing planting dates, planting improved varieties of

crop species, use of intercropping, using sustainable fertilizer and tillage practices, improved crop residue and weed management, better pest and disease control for crops, implementing new irrigation systems, more use of agro-forestry practices, improving forest fire management, planting of early maturing crops and temporal migration.

In Nigeria, 2/3 of the population depends on rain-fed crop farming and fishing activities for foods and livelihoods. With a population of 140 million (NPC, 2006) surviving on the physical environment through various activities within an area of 923,000 square kilometers put pressure on the physical environment (IPCC, 2007). According to Bako (2013), the awareness of climate change has spread at an unprecedented pace and it is now accepted as a major threat to human survival and sustainable development.

The impact of climate change on crops farmer's in Lapai Local Government Area was significant, (Lapai Local Government Council Annual evaluation report (2017). The report shows that there was a decline in crop yield between 2013 and 2017. The report also shows that planted crops on the irrigation sites wilted as a result of deposits from 2012 flooding. The crop farmers engaged in arable crops production such as rice, maize, sorghum, cowpea, melon, groundnuts, yams, and cassava etc.

1.2 Statement of the Research Problem

Climate change endangers agricultural production through rising temperature and rainfall variability which leads to incessant flooding and drought. Drought manifests after 15 days when surface and underground water are lacking, and it occurs between 6-12 months. Persistent and prolonged drought causes damages and harms to the economy of the study area which leads to humanitarian crisis and mass migrations (Mather, 1999).

Intergovernmental Panel on Climate Change (2007) asserted that warming of the earth's climate system is "unequivocal". The panel's conclusions were based on mounting evidence of shift in the climate and consequent effects on ecological processes and biodiversity. It also concludes that the world's less industrialized regions are particularly vulnerable to the effect of climate change.

Africa, in general, is paying a heavy price for overlooking the social realities determining the interaction between its people and climate change. In the process, in rural areas specifically, environmental change has immediate and direct effects on the health and wellbeing of millions of households that depend on natural resources for their basic livelihoods. The impact of climate change on farmers and their livelihoods could be catastrophic.

According to the report of Lapai Local Government Council (2017), over the years cropping activities in Lapai Local Government Area (LGA) of Niger State has been affected by pest and disease infestation, flood and drought. As a result of this, some arable land was washed away while some have deposit of toxic substances which are injurious to crop farming. The yield of some arable crops such as maize, yams and other vegetable crops declined. The irrigation facilities were also destroyed. The report also showed that some farmers shifted from crop farming to off-farm activities as a result of the impact of climate variability. The report further showed that 19 communities in the Area have consistently reported the incidence of flood and drought in the last five years.

In order to prevent total loss of crop production, larger farming enterprises with a range of different crop types, or even cultivars of the same crop with differing drought or pest resistance traits strategies are being implemented in Nigeria and other developing countries (International Federation of Red Cross and Red Crescent Societies, 2006).

Kurukulasurya and Mendelsohn, (2008) noted that the short-term adaptation measures for climate change by farmers include; crop insurance for risk coverage, crop/livestock diversification to increase productivity and protection against diseases, adjusting the timing of farm operations to reduce risks of crop damage, change crop intensity and adjust livestock management to new climatic conditions, food reserves and storage, as temporary relief, changing multiple cropping, permanent migration to diversify income opportunities, defining land use and tenure rights for investments. On a long term note, the authors stated the following as best adaptation options for climate change: development of crop and livestock technology adapted to climate change stress, develop market efficiency, irrigation and water storage expansion, efficient water use, promoting international trade, improving forecasting mechanisms, institutional strengthening and decision-making structures.

Adaptation is usually a long-term livelihood activity and is a continuous process where results are sustained; it uses resources efficiently and sustainably, involves planning and combining of new and old strategies and knowledge, and is focused on finding alternatives.

Ishaya and Abaje (2008) examined the indigenous people's perceptions of climate change and adaptation strategies in Jema'a Local Government Area of Kaduna State, Nigeria. The study "revealed that 60 % of the indigenous people observed some climatic changes in the environment over the years, which they attributed to diverse anthropogenic activities in which they planted different crop varieties to adapt to climate change. Again, 15 % of the respondents changed planting dates and shortened the growing season as a response; this was mainly practiced when there was less rain than normal and changes in timing of rainfall. About 30 % of the farmers adapted through maximizing water use practices. The rising temperature also leads to losses of moisture in the soil which makes 2.5 % of the farmers to use mulching and sheltering techniques to deal with this problem. Extreme changes in rainfall also made people to move from agriculture to non-farming activities in the area.

Dressa, et al (2008) in a study of the determinants of farmers' choice of adaptation methods and perceptions of climate change in the Nile Basin of Ethiopia, found that the age of the household head, wealth, and information on climate change, social capital, and agro-ecological settings were found to have significant effects on farmers' perception of climate change. The study also found out the factors that affect farmers' choice of adaptation method include use of different crop varieties, tree planting, soil conservation, early and late planting, and irrigation.

Dami, Adesina and Garba (2011) observed the various adaptation methods used by local people in coping with the harsh conditions resulting from the declining volume of water in the Lake Chad basin. A little more than one-fifth of the respondents (21.9%) engaged in rearing animals to cope with crop failure. Almost one-fifth (17.8 and 17.2%, respectively) involved in activities like buying and selling of non-agricultural products and fishing. About 1 in 20 persons (4.1%) migrated to nearby countries in search of food, while a larger proportion (24.7%) relied on the food they stored during previous good harvest. Closer to a tenth of respondents (7.5%) said that they did nothing to cope with adverse conditions, while 6.9% had other means of coping e.g. engaging in handcrafts such as weaving and mat making, hunting of wild animals, and selling of fuel wood.

The use of drought-resistant crop varieties have been tried by smallholder farmers as adaptation strategies to climate change in Nigeria, Senegal, Burkina Faso and Ghana (Ngigi, 2009). Also planting of drought resistant crops such as wheat, cassava and millet in drought prone areas, planting of drought resistant varieties like drought resistant maize (Samaz 50) were adopted by nomadic pastoralists living in the desert margins of Kenya.

Crop farmers in Lapai Local Government Area need to adopt effective agricultural adaptation strategies that will increase and maintain high crop production and ensure food security and improve the livelihood of the area hence their efforts is not effective. Therefore, the following research questions were formulated:

1. What are the types of hazards posed by climate variability to farmers in the study area?
2. What is the impact of climate variability on the farmer's output in the study area?
3. What climate variability adaptation strategies are employed by the farmers in the study area to combat the hazards posed?
4. Which adaptation strategy is the most effective in the area?

1.3 Aim and Objectives of the Study

The work assessed the climate variability adaptation strategies by crop farmers in Lapai Local Government Area, Niger State. The objectives to achieve this aim are to:

- i. identify the types of hazards posed by climate variability in the area;
- ii. assess the climate variability impact on crops yield of the study area;
- iii. examine the climate variability adaptation strategies employed by the crop farmers in the study area to combat the hazard of climate variability; and
- iv. examine the most suitable adaptation strategies in the study area.

1.4 Scope of the Study

The study is restricted to the geographical boundary of Lapai Local Government Area. The study focuses on crop farmers in the communities that have consistently reported the incidence of

climate change (flood and drought) within the period 2013-2018. Going by the report gathered from the reconnaissance survey from the Lapai LGA public relation officer; a total of 19 communities have consistently reported cases of flood, drought and climate change-related hazards like soil erosion, pest and diseases attack on crops in the LGA. Six communities from BirninMaza, nine communities from Gulu district, and four communities from Ebbo district. These communities were the areas of concentration for this study.

The study focused on climate variability induced hazards and the impact of climate variability on crop yield within the period of 2013-2018. The study also interrogated the types of adaption strategies employed by farmers as well as the most effective climate variability adaption strategies adopted by the people.

1.5 Justification of the Study

As worldwide loss of biodiversity has increased in recent decades, many farmers in Lapai Local Government area in Niger State also lose their crops, livestock, fisheries and some other farm produce due to the impact of climate change (Lapai Local Government Council, 2012). Crop farmers are the most vulnerable to climate change, and they have no alternative but to adapt their livelihood systems to changing climatic conditions, more so that they have consistently complained of impact of climate change and reduction in their yield.

Danbaba *et al.* (2013) reported that vulnerability of agriculture to climate change has made the scientific and policy communities to be doubtful of the capacity of farmers to adapt to climate change. Therefore, there is need to assess the current and available adaptation strategies among crop farmers in the study area

inorder to improve and recommend other possible options that farmers in the study area could adopt. The value of this research would also be useful to Niger State Ministry of Agriculture as well as the LGA Agricultural department.It will also be a source of reference material for other researchers and also add to the academy, hence, the justification for this study.

CHAPTER TWO

CONCEPTUAL/THEORETICAL FRAMEWORK AND LITERATURE REVIEW

2.1 Conceptual Framework

2.1.1 Concept of climate change

Climate change has been defined by IPCC (2007) as a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forces, or to persistent anthropogenic changes in the composition of the atmosphere or in land use. The United Nations Framework on Climate Change {UNFCCC} (1992), on the other hand, defined climate change as a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere, and which is an addition to natural variability that has been observed over comparable time periods. Climate, however, is only one factor within the dynamic earth system. Changes in the physical and biogeochemical environment, either caused naturally or influenced by human activities such as deforestation, fossil fuel consumption, urbanization, land reclamation, agricultural intensification, freshwater extraction, fisheries over-exploitation and waste production, contribute to global environmental change (GEC), Climate Change Agriculture and Food Security {CCAFS}(2009).

Furthermore, CCAFS report of 2009 concludes that climate change on its own represents an immediate and unprecedented threat to the food security of hundreds of millions of people who depend on small-scale agriculture for their livelihoods. Food security is achieved when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life. Changing climatic conditions are projected to affect food security from the local to global level. It is predicted that patterns of rainy season will reduce, and the frequency and intensity of severe weather events such as floods, cyclones and hurricanes will increase.

There will also be prolonged drought in some regions; and water shortages; and changes in the location and incidence of pest and disease outbreaks (FAO, 2009).

2.1.2 The impact of climate change on food production

Crop farming is extremely vulnerable to climate change. It has been predicted that climate change will impact higher temperatures, more variable rainfall and extreme climate events such as floods, cyclones, droughts and rising sea levels (Porter *et al.* 2003). Consequently, Danbaba *et al.* (2013) reported that vulnerability of agriculture to climate change has made the scientific and policy communities to be doubtful of the capacity of farmers to adapt to climate change. In the same vein, Danbaba *et al.* (2013) observed that the United Nations Framework Convention on Climate Change also identifies the threat to food production as a major worry. It is instructive to note that water scarcity is basically ascribed to factors such as climate change and population growth. Though, climatic changes manifested through weather extremes in the form of floods and droughts are likely to further increase the competition for water. However, it is population growth and the resultant increase in demand for food production that puts the greatest pressure on water availability. According to Idoma and Ismail (2014), irrigated agriculture produces approximately 40% of the world's food crops. The water use required for this crop production accounts for 70% of all water withdrawals (Idrisal, 2012). Hence, to respond to the ever growing competition for water, researchers and policy makers resolved that the role of irrigated agriculture is germane.

According to FAO by 2030, irrigated land for agriculture will expand by about 20 percent in developing countries with an associated 14% increase in water withdrawals for crop production. The greatest expansion of irrigated land will occur in South Asia, East Asia and countries located in East and North Africa (Nnadi and Akwiwu, 2008). Importantly, Falaki *et al.*, (2013) remarked that the degree of the impact of climate change on crop production will depend upon the magnitude of the climate change and

other factors. Basically, increasing temperature will directly impact crops by affecting their physiology; it will also indirectly affect crops through changes in the water regime and the increased intensity of pests and diseases. Crops are also bound to be affected by more intense rainfall and other extreme weather events occurring at different stages of production. Yet, the challenge of peasant farmers is double: coping with population growth while also facing climate change. The changes associated with global warming in temperature, carbon dioxide and rainfall are expected to impact rice production. Studies (Rahji and Omotesho; 2006; Emeka and Ugwu, 2015) have revealed that increase in temperature due to climate change adversely affect crop physiology, ultimately decreasing crop yields and grain quality. Furthermore, uncertainty related mostly to anticipate precipitation, spatial and temporal patterns caused by climate change, makes it difficult to project the full effect of intensified frequency of floods and severe droughts (Terwase and Madu, 2014).

2.1.3 Impacts of climate change on farming and livelihoods in Nigeria

Climate change is taking place at a time of increasing demand for food, feed, fiber and fuel, and has the potential to irreversibly damage the natural resource base on which agriculture depends. Changes in carbon dioxide concentrations, temperature and rainfall will have an impact on plant cover and land use which, in turn, substantially affect the behaviour of water when it falls as rain, (Muller, 2007).

Due to reduced adaptive capacity and higher climate vulnerability, smallholder and subsistence farmers in Nigeria experience reduced crop yield, reduced crop quality, reduced income, late rainfall, early cessations, short growing season, increase temperature, increase pest infestation on crops, flooding of crops, crops destruction due to water lodge, decrease soil fertility, spoilage of farm product and increase soil erosion.

2.1.4 Household asset

Livelihood strategies defined the capability and explain the constraints and strengths of the poor depends on the basic assets availability, social, recognized and unrecognized assets available to individual. Viewing from an economic concept, such livelihood resources may be seen as the ‘capital’ from which various productive means are derived and livelihoods are developed. Five assets are classified in this context (DFID, 2014).

In line with the view of Department for International Development (DFID) (2000), the divisions of sustainable livelihood framework classified capital into five which are (Social capital, Human capital, Physical capital, Financial capital and Natural capital). The success is strongly linked to livelihood selections. For example, household could venture in agricultural production or off-farm as a result of their opinion. Poor household choose their livelihood choices through diverse activities, in order to overcome risk occurrences and enable a sustainable income means over time (Samatar, 2015).

- a. Natural capital – the natural resource stocks (land, water, air, wildlife) and environmental services (hydrological cycle, environmental pollution) from which resource flows and services useful for livelihoods are derived.
- b. Economic or financial capital – the capital base (cash, credit/debt, savings, pension and other economic assets, including basic infrastructure and production equipment and technologies) which are useful for the pursuit of any livelihood strategy.
- c. Human capital – the skills, knowledge, experience, ability of labour and good health, and physical capability important for the successful pursuit of different livelihood strategies.
- d. Social capital – the social resources (networks, social claims, social relations, affiliations, sources of information, participation in government agricultural programmes, access to educational programmes, associations) upon which people draw when pursuing different livelihood strategies requiring structured actions.

- e. The physical capital refers to basic infrastructures (roads, transport, latrines, schools, land sites, meeting places, water, energy and communication) as well as the farm machineries to pursue their livelihoods.

It is essential to note that these assets exist in order to scale up the livelihood activities of rural dwellers. Utilization and sustainable management of these assets will reduce household exposure to shocks, assist them in rising out of poverty and increase their household food security level. This study examined the influence of household assets on lives of farming households in the study area (DFID, 2005; Samatar, 2015).

2.1.5 Household assets and livelihood strategy

The ability to pursue different livelihood strategies depends on the basic assets availability, social, recognized and unrecognized assets available to individual. Viewing from an economic concept, such livelihood resources may be seen as the ‘capital’ from which various productive means are derived and livelihoods are developed. Five assets are classified in this context (DFID, 2014).

Asset base is an important factor to livelihood adoption. Households choose to carry out the activities that suit into livelihood strategies and the rate employed to each activity depends on the asset base of the household. Policy changes might cause the asset base which attaches assets and affects livelihood choices. The aim for better asset is through adoption of better livelihoods activities that provide better amounts of living and sustainable growth for households limiting their exposure to risk (Yakubu, 2014).

2.1.6 Peasant (small scale) farmers

Gandure and Alam (2006) opined that peasant farmers are susceptible to alterations in climate change which cut down agricultural produce and strikes their weather-dependent sustenance system. The occurrence of drought and flood hazards in Malawi has destroyed their assets and rendered people vulnerable to such disasters which cause water and food insecurity, health disease and land degradation. Rijsberman (2006) stated that water scarcity is seen as the central issue in dry and semi-dried areas of small scale agriculture. Phiri, Saka and Alex, (2005) showed that increased droughts and floods aggravated the level of poverty, rendered numerous rural farmers pinned down in the succession of poverty and susceptibility level to lessen resources. Turner (2006) stated that change in climate and population increase lead to scarcity of water and confined its availability for irrigation and production purposes. These areas are populated by peasant farmers in pastoral and agro-pastoral societies who are capable of engaging in irrigation farming system due to their economic standard.

2.2 Theoretical Framework:Sustainable livelihoods Framework (SLF) approach

The sustainable livelihoods approach improves understanding of the livelihoods of the poor. It organizes the factors that constrain or enhance livelihoods opportunities, and shows how they relate. It can help plan development activities and assess the contribution that existing activities have made to sustaining livelihoods.

Livelihood thinking dates back to the work of Robert Chambers in the mid-1980s, in realising that conventional development concepts did not produce the desired effects, moreover, that mankind was additionally facing an enormous population pressure. Chambers developed the idea of “Sustainable Livelihoods” with the intention to enhance the efficiency of development cooperation. His concepts constitute the basics for the Sustainable Livelihoods Approach (SLA), as it was developed by the British

Department for International Development (DFID). Starting from 1997, DFID integrated the approach in its program for development cooperation.

According to Scoones (2016), the concept of rural livelihood refers to means of organizing and maintaining the basic needs of life such as water, food, housing and clothing. It is defined as a set of activities, including necessities operating either at individual level or as a group of people by managing available resources (human and material) to allow one achieve household needs on a sustainable basis. The concept of Sustainable Livelihood is an attempt to reduce poverty and live a better than present situation. These were found to be limited because focus has always been on specific areas to reveal poverty, such as limited income, and lack of attention for more important aspects of poverty such as social exemption. Attention must be paid to different conditions and processes which either hinders or enable poor people's ability to make a living in an economic, regional and social sustainable manner (Premchanda, 2016).

Sustainable livelihood concept means a more relevant and dual purpose approach to poverty. The sustainable livelihood concept was firstly revealed by the Brundtland Commission on Environment and Development, and 1992 United Nations Conference on Environment and Development which enlarged the idea stressing the achievement of sustainable livelihoods as a broad aim for poverty eradication. In social science, on the other hand, the context enlarge to capture social and cultural means, the common and individual, family or other social class has over income or means of resources that can be used or shuffled to satisfy its needs, this may also involve information, cultural experience, social link, land and other physical resources. The concept has respect for sustainability and human rights Frank, (2016).

Since livelihood entails all the ideas required for living, its progress, vulnerability and coping strategies should be of relevance. According to the United Kingdom Department for International Development

(DFID, 2016), sustainable livelihood is broad and all inclusive, it can be combined up into six main points aimed at increasing the wellbeing of the rural people. These are:

- i. Better nutrition and healthcare
- ii. More supportive and cohesive social environment
- iii. More secure access to basic and facilitating infrastructure
- iv. Better access to financial resources, and
- iv. Conducive policy and institutional environment that support multiple livelihood strategies and promote equitable competitive markets for all
- v. Improved access to high quality education, information, technologies and training

A livelihood comprises the capabilities, assets, and activities required for a means of living. It is deemed sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities, assets, and activities both now and in the future, while not undermining the natural resource base.

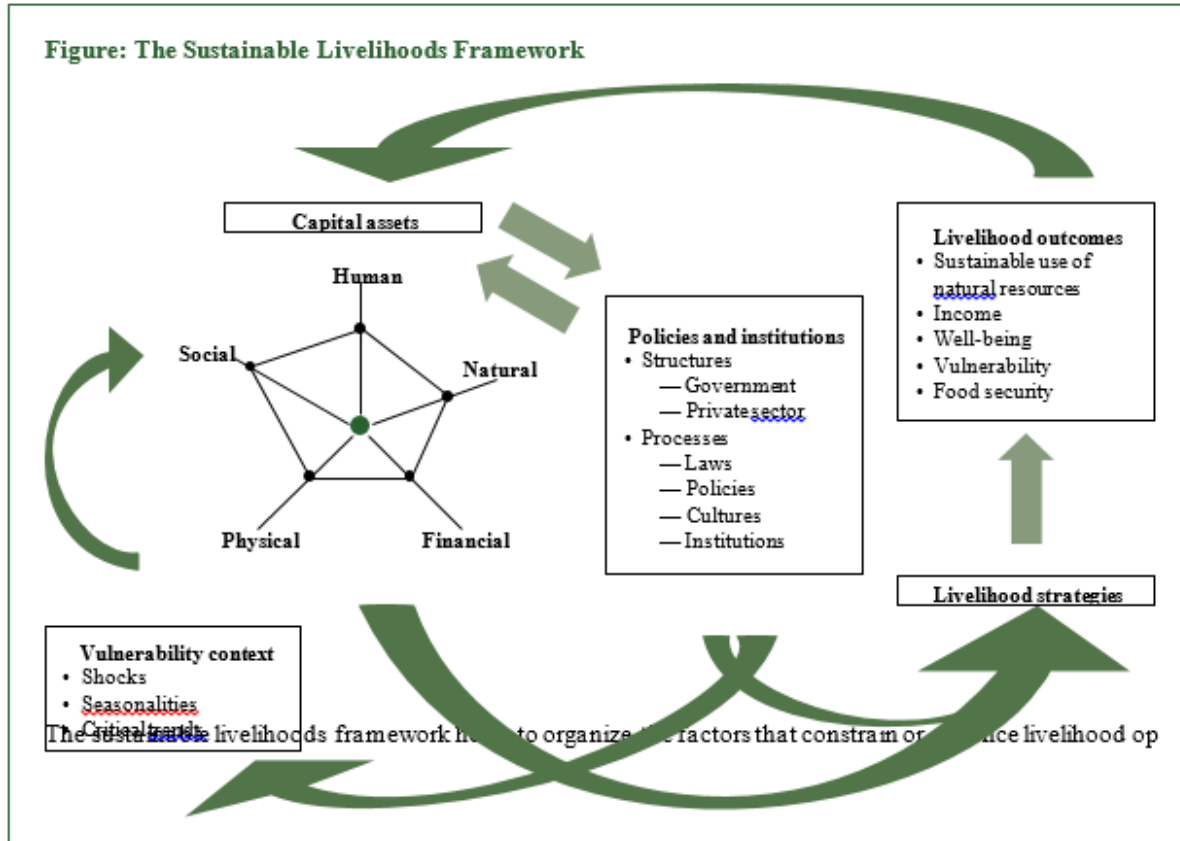
The sustainable livelihoods approach is a way of thinking about the objectives, scope, and priorities for development activities. It is based on evolving thinking about the way the poor and vulnerable live their lives and the importance of policies and institutions. It helps formulate development activities that are

- People-centered
- Responsive and participatory
- Multilevel
- Conducted in partnership with the public and private sectors
- Dynamic
- Sustainable

The sustainable livelihoods approach facilitates the identification of practical priorities for actions that are based on the views and interests of those concerned but they are not a panacea. It does not replace other tools, such as participatory development, sector-wide approaches, or integrated rural development. However, it makes the connection between people and the overall enabling environment that influences the outcomes of livelihood strategies. It brings attention to bear on the inherent potential of people in terms of their skills, social networks, access to physical and financial resources, and ability to influence core institutions.

Appreciative inquiry—originally developed as a tool for industry to avoid negative approaches to problem solving—extends this constructive outlook. Appreciative inquiry is a highly inclusive process that maximizes the positive (as opposed to minimizing the negative) in which a community takes responsibility for generating and gathering information and then forms strategies based on the most positive experiences of the past knowledge Scoones (2016).

Figure: The Sustainable Livelihoods Framework



Source: Department for International Development of the United Kingdom.

Vulnerability Context

Vulnerability is characterized as insecurity in the well-being of individuals, households, and communities in the face of changes in their external environment. People move in and out of poverty and the concept of vulnerability captures the processes of change better than poverty line measurements. Vulnerability has two facets: an external side of shocks, seasonalities, and critical trends; and an internal side of defenselessness caused by lack of ability and means to cope with these. The vulnerability context includes • shocks, e.g., conflict, illnesses, floods, storms, droughts, pests, diseases

- seasonalities, e.g., prices, and employment opportunities

- critical trends, e.g., demographic, environmental, economic, governance, and technological trends.

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Policies and Institutions Livelihood strategies and outcomes are not just dependent on access to capital assets or constrained by the vulnerability context; they are also transformed by the environment of structures and processes. Structures are the public and private sector organizations that set and implement policy and legislation; deliver services; and purchase, trade, and perform all manner of other functions that affect livelihoods.

Processes embrace the laws, regulations, policies, operational arrangements, agreements, societal norms, and practices that, in turn, determine the way in which structures operate. Policy-determining structures cannot be effective in the absence of appropriate institutions and processes through which policies can be implemented. Processes are important to every aspect of livelihoods. They provide incentives that stimulate people to make better choices. They grant or deny access to assets. They enable people to transform one type of asset into another through markets. They have a strong influence on interpersonal relations. One of the main problems the poor and vulnerable face is that the processes which frame their

livelihoods may systematically restrict them unless the government adopts pro-poor policies that, in turn, filter down to legislation and even less formal processes.

Livelihoods are successful when they have the right structure to withstand failure and stress; are not relied upon outside plan; maintain the long term productivity of natural resources; and do not limit the livelihoods substitute open to others (DFID,1999). Sustainability can be expanded from the view of three (3) elements:

- a. Environmental sustainability is achieved when the production of main natural resources is utilized for future generations;
- b. Social sustainability is possible where social elimination is minimized and social equity is maximized; and
- c. Institutional sustainability is successful when existing structures and ways have the capacity to improve or perform their functions over the long term.

2.3 Literature Review

2.3.1 Hazards caused by climate change

Climate change might result from natural factors and processes or from anthropogenic activities. The term "climate change" is often used interchangeably with the term global warming but different from each other. Global warming refers to an average increase in the temperature of the atmosphere near the earth's surface, which can contribute to changes in global climate patterns (EPA, 2010). It is one of the most controversial 19 scientific issues of the 21st century.

According to Spore (2008), each day the sun emits rays of light onto the earth's surface. The earth absorbs part of the heat, reflects another share into the atmosphere and sends out a third share in the form of infra-red rays. The problem humanity is facing today is that there is a concentration of GHGs produced by human activity which increased significantly over time. The gases absorb the terrestrial radiations from the earth and re-radiate the heat back to earth, thereby leading to a general increase in temperature known as global warming.

The earth's climate system is driven by heat energy from the sun. Several gases in the atmosphere act to trap the energy from the sun, thus warming the earth. These gases are called greenhouse gases (GHGs) and the process is the greenhouse effect. Without this process there would be no life on earth. Human activities over the past 200 years, particularly the burning of fossil fuels (oil, coal, natural gas) and the clearing of forests, have increased the concentration of GHGs in the atmosphere (IPCC, 2007). This means more heat is being trapped, which leads to the earth's surface warming up — called the enhanced greenhouse effect. The IPCC Fourth Assessment Report (2007) stated that continued GHG emissions would induce many changes in the global climate system during the 21st century that would very likely be larger than those observed during the 20th century (Pachauri, 2009).

Human activities, principally the large-scale usage of fossil fuels, including coal, oil and gas, result in increasing emissions of GHGs into the atmosphere, including carbon dioxide (CO_2) methane and fluorocarbons (ACTSA, 2009). Coal remains the primary source of fuel for power plants and most countries are heavily dependent on fossil fuels for their energy needs. The transport sector is responsible for high carbon emissions, especially car travel, road freight, shipping and air transport, since almost all of the energy consumed is oil based. Rich industrialized countries have historically produced most of the

carbon emissions and are still the principal polluters, albeit with emerging economies catching up in the past decade (ACTSA, 2009). For instance, in 2006 China became the biggest contributor to GHG emissions globally. Today, the Group of 20 (G20) countries, those with the largest global economies, are responsible for approximately 80 percent of the world's GHG emissions (ACTSA, 2009).

Among other sources of emissions, agriculture is one of the most important contributors. According to Smith (2008) energy and chemical-intensive farming has led to increased levels of GHG emissions, primarily as a result of the overuse of fertilizers, land clearance, soil degradation, and intensive animal farming. The total global contribution of agriculture to climate change, including deforestation to create farmland and other land use changes is estimated to be equivalent to between 8.5 to 16.5 billion tonnes of carbon dioxide or between 17 to 32 percent of all human-induced GHG emissions (Smith, 2008). According to the IPCC (2007), agricultural livestock account directly for about 9 percent of the total anthropogenic GHG emission, 21 on a global scale. Livestock production and associated activities, which includes the livestock production lifecycle, burning of fossil fuel to produce mineral fertilizer used in feed production, methane release from the breakdown of the fertilizer and from animal manure, land-use changes for feed production and for grazing, and degradation, fossil fuel use in production and transport of processed and refrigerated animal products are estimated to be about 18 percent of global anthropogenic emission Gill, Smith, and Wilkinson, 2010). Gill *et al* also estimated that methane emissions accounting for 30 percent of these emissions, similar to the relative contribution of G20, while land use and land-use change, together with deforestation related to provision of grazing, account for 38 percent. These are mostly experienced in countries in Europe.

In Latin America, FAO (2010) reported that grazing occupied 26 percent of the earth's terrestrial surface which was due to the expansion of grazing land through deforestation.

Deforestation resulted in overgrazing, soil compaction and erosion attributable to livestock activity. According to Council of Australian Government (COAG), (2007) in New Zealand, enteric methane (CH₄) emissions arising from the ruminant animals constitute 30 percent of total CO₂ emissions. Enteric methane gas (CFU) emissions have increased by 9 percent since 1990. Hulme, Doherty and New (2005) discovered that ruminants contributed a significant amount of methane and nitrous oxide due to manure management and fertilizer application to the total GHG emissions in the United State of America.

Thaddeus, Nnaemeka, Chukwudumebi and Victoria (2011) further reported that human activities have tended to exacerbate climate change and its impact on agriculture and livelihoods in some communities in Nigeria. An example is the Niger Delta region of Nigeria which is reported to have over 123 gas flaring sites making Nigeria one of the highest emitters of GHGs in Africa (Akinro, Opeyemi, and Ologunagba 2008). A study by the World Bank (2008) revealed that Nigeria accounts for roughly one-sixth of worldwide gas flaring. Nigeria flares about 75 percent of its gas and all take place in the Niger delta region. At the same time, the low-lying Niger delta is particularly vulnerable to the potential effects of sea levels rising (Ugochukwu, Ertel, and Schmidt, 2008).

Deforestation is a major contributor to climate change. It causes 5.9 billion tonnes of CO₂ per year to be released into the air. This accounts for 20 per cent of the world's carbon emissions—more than the entire global transport sector produces (Canadel, Ciais, Dhakal, Dolman, Edlingstein, Gurney, and Raupach, 2010). Furthermore, deforestation illustrates the ongoing reliance of many African countries on primary extraction rather than sustainable industrial and manufacturing activities. In addition, several other human activities have led to increased atmospheric concentration of a number of GHGs, including changes in land use pattern, logging, over-grazing, bush burning, urbanization, over-cultivation and agriculture.

2.3.2 General Impact of Climate Change

The greatest challenge that confronts human beings and societies today and the generations to come is the issue of climate change. Our societies are dominated and even driven by ideas and products from science and technology (Igwe, 2003). It is very likely that its influence on our lives will continue to increase in the future. Various global problems facing us today emanated from global scientific collaborations that depend largely on the ecosphere (Sjoberg, 2002). The effects resulted in the experience of the terrible environmental problem enumerated by Udenyi (2010), such as global warming, ozone layer depletion, acid rains, extinction of wild life, extinction of various tropical plants, earthquakes/volcanic eruptions, floods disaster, rock fall, mud flow, hurricanes/hail storms, melting of ice sheet in the poles region, droughts, desertification, heatwave, windstorms, and forest fires. The impacts of climate change are mostly negative and evident in food production and agriculture, health, water resources, ecosystem, shelter, vulnerability of populations and socio-economic activities and national security.

Changes in climate could have a significant impact on food production all over the continent of Africa. Heat stress, droughts and flooding events may lead to reductions in crop yields and productivity. According to FAO (2009) countries in Africa will be the hardest hit in terms of future food security. By 2080, climate change would render Africa and certain parts of Asia the most food insecure, with 75 percent of the world's hungry desperate for food (Schulze, Warburton, and Maharaj, 2005). According to IFPRI (2009) the negative impact of climate change on crop yield is pronounced in Africa, as the agriculture sector accounts for a large share of gross domestic product, export earnings and employment. Lobell (2010) emphasized that Africa could face a 30 percent decline in maize production in the next two decades because rainfall and temperature in Africa are changing quite fast. Despite technological advances in plant breeding, fertilizers, improved varieties, genetically modified organisms, and irrigation systems, climate is a key factor in agricultural production. In the 1980s, continuing deterioration of food production

in Africa was caused in part by extended drought and soil degradation. According to Houghton (2002) the earth's average surface temperature has increased by 1°F just over the past century.

According to IPCC (2001), in Africa and Latin-America, many rain-fed crops are near their maximum temperature tolerance, so that yields are likely to fall sharply, even if the changes in climate are small. A decline in agricultural productivity of up to 30 percent over the 21st century is projected. Changes in climate induced by increasing GHGs are likely to affect crops differently from region to region. For example, according to the IPCC (2007) average crop yield is expected to drop down to 50-percent in Pakistan whereas corn production in Europe is expected to grow up to 25 percent in optimum hydrologic conditions. In a nut shell, climate change variability affects crop yield.

2.3.3 Farmers' adaptation strategies to climate change

Conservation agriculture

Application of conservation agriculture promotes the concept of optimizing yields and profits while ensuring provision of local and global environmental benefits and services. Zero tillage, along with other soil conservation practices, is the cornerstone of conservation agriculture. In Mafeteng District, NGOs together with the Ministry of Agriculture and Food Security are promoting conservation agriculture for the purposes of minimizing soil erosion and increasing crop yield (International Federation of Red Cross and Red Crescent Societies, 2006).

Agroforestry

The term agroforestry is often perceived in the narrow sense of intercropping food plants and trees. In a broader sense, it signifies any system that includes food, and/or fodder and wood production. Agroforestry systems, even if not primarily designed for carbon sequestration, present a unique opportunity to sequester carbon from the atmosphere. Carbon sequestration has been defined by the United Nations Framework Convention on Climate Change (UNFCCC), (2010) as the process of removing carbon from the atmosphere and depositing it in a reservoir. In this process atmospheric carbon dioxide is taken up by trees, grasses, and other plants through photosynthesis and stored as carbon in biomass (trunks, branches, foliage, and roots) and soils, (Center for Integrated Natural Resources and Agricultural Management and the Commonwealth Project, 2007). In essence, agroforestry core concerns include ecological and economic sustainability resilience of environment and diversity of income. It is a system that blends production (food and income security at household- and community-level) with ecosystem services, (Jama, 2005).

Crop diversification

It is well known amongst farmers that greater crop diversity and mixed farming (crops and livestock) offer considerable protection against farming risk, including climate-related risk (FAO, 2011). In order to prevent total loss of crop production larger farming enterprises with a range of different crop types, or even cultivars of the same crop with differing drought or pest resistance traits are being implemented in Nigeria and other developing countries(International Federation of Red Cross and Red Crescent Societies, 2006).

Keyhole and trench gardens

Keyhole and trench gardens are fast growing adaptation strategies to climate change (International Federation of Red Cross and Red Crescent Societies, 2006). The two systems Keyhole and trench gardens have proven an effective way to grow vegetables year round in semi-arid climate because they nourish the soil and help it retain moisture. These gardens reduce the labor required to produce food for the household (Weimer, 2008). This in turn helps households affected by chronic illnesses and HIV/AIDS, and households headed by children or the elderly, which often have limited labor capacity. This is a good example of a low-cost adaptation practice which is also supported by local government and can be up-scaled to the national level (UNDP, 2010).

Planting of drought resistant varieties of crops

Emphasis on more drought-resistant crops in drought-prone areas could help in reducing vulnerability to climate change. For example, wheat requires significantly less irrigation water compared to dry season rice. The use of drought-resistant crop varieties have been tried by smallholder farmers as adaptation methods to climate change in Nigeria, Senegal, Burkina Faso and Ghana (Ngigi, 2009). Also, strategies against drought were adopted by nomadic pastoralists living in the desert margins of Kenya.

Change in crop varieties and shift in farming system

Diversification towards high value crops is feasible in the medium to long term. Crop diversity is a high priority adaptation measure in both irrigated and non-irrigated areas. In Southern Africa for example, land use is manipulated leading to land use conversion, such as the shift from livestock farming to game farming (Ziervogel *et al.*, 2008). Crop diversification can serve as insurance against rainfall variability.

Change in cropping pattern and calendar of planting

Climate change adversely affects crop production through long-term alterations in rainfall resulting in changes in cropping pattern and calendar of operations. According to Urama and Ozor (2011), farmers in Central Africa (Cameroon, Equatorial Guinea and Central African Republic) In Tanzania, to avoid crop production risks due to rainfall variability and drought, staggered planting is very common to most farmers whereby crops are planted before rain onset (dry land) on uncultivated land. Others were planted immediately after rain, while still other plots were planted a few days after the first rains. Tilling the land commences in fields which were planted prior to cultivation on the third week after the onset of rain which also enables destroys early germinating weeds and reduces weeding. These were done purposely to distribute risk by ensuring that any rain was utilized to the maximum by the crop planted the in dry field (Liwenga, 2003).

Mixed cropping

Mixed cropping involves growing two or more crops in proximity in the same field. The system is commonly practised in Tanzania where cereals (maize, sorghum), legumes (beans) and nuts (groundnuts) are grown together. The advantages of mixing crops with varying attributes are in terms of maturity period (e.g. Maize and beans), drought tolerance (maize and sorghum), input requirements (cereals and legumes) and end users of the product (e.g. maize as food and sunflower for cash). A research conducted by Mendelsohn *et al.* (2000) on analyzing adaptations made in Africa reveals that in all countries apart from Cameroon and South Africa, the planting of different varieties of the same crop is considered to be one of the most important adaptations. Different planting dates are also considered an important adaptation in Egypt, Kenya and Senegal.

Improved irrigation efficiency

Success of climate change adaptation depends on availability of fresh water in drought-prone areas. It should be emphasized that most adaptation methods provide benefits even with the lower end of climate change scenarios, such as improved irrigation efficiency. As water becomes a limiting factor, improved irrigation efficiency will become an important adaptation tool, especially in dry season, because irrigation practices for dry area are water intensive. Climate change is expected to result in decreased fresh water availability (surface and groundwater) and reduced soil moisture during the dry season, while the crop water demand is expected to increase because of increased evapo-transpiration caused by climate change and the continuous introduction of high-yielding varieties and intensive agriculture (Selvarajuet *al.*, 2006). In Egypt, Kenya, and South Africa, significant numbers of farmers have adapted by increased use of irrigation. In Gambia, South Africa, and Sudan, farmers employ such adaptation measures as irrigation water transfer, water harvesting and storage to cushion the effects of rainfall variability (Nkomoet *al.*, 2005). As temperature increases, farmers tend to irrigate more frequently. Irrigation is clearly an adaptation strategy to warming. When precipitation increases, they tend to irrigate less often and resort to natural rainfall more often. Farms in the deserts reduce irrigation when temperature increases. Similarly, when precipitation increases, farms close to the deserts increase irrigation.

Adopting soil conservation measures that conserve soil moisture

Soil conservation techniques are increasingly practiced in Burkina Faso, Kenya, Senegal, and Niger. A study carried out by Lema and Majule (2009) in Manyoni District of Tanzania revealed that farmers in Kamenyanga and Kintinku ensure proper timing of different farming activities, burying of crop residues to replenish soil fertility, burning crop residues to enhance quick release of nutrients and allowing livestock to graze on farmlands after harvesting crops so as to improve soil organic matter.

In Tanzania, farmers used contour ridges as a strategy to minimize soil erosion to encourage better root penetration and enhance moisture conservation (Lema and Majule, 2009). In Senegal and Burkina Faso, local farmers have improved their adaptive capacity by using traditional pruning and fertilizing techniques to double tree densities in semi-arid areas. These help in holding soils together and reversing desertification.

Nyong *et al.* (2007) noted that local farmers in the Sahel conserve carbon in soils through the use of zero tilling practices in cultivation, mulching and other soil management techniques. Natural mulches moderate soil temperatures and extremes, suppress diseases and harmful pests, and conserve soil moisture. Before the advent of chemical fertilizers, local farmers largely depended on organic farming, which also is capable of reducing GHG emissions.

Planting of trees (afforestation) and agroforestry

Tree planting is the process of transplanting tree seedlings, generally for forestry, land reclamation, or landscaping purposes. It differs from the transplantation of larger trees in arboriculture, and from the lower cost but slower and less reliable distribution of tree seeds. In silviculture the activity is known as reforestation, or afforestation, depending on whether the area being planted has or has not recently been forested. It involves planting seedlings over an area of land where the forest has been harvested or damaged by fire or disease or insects. Rural farmers in most of the Africa countries have been planting trees as a way of adapting to the effect of climate change.

Agroforestry is a rational land-use planning system that tries to find some balance in the raising of food crops and forests. A practice similar to this has been described in a part of south western part of Nigeria to raise shade tolerant crops, such as *Dioscorea* spp, and cocoyam in essentially a permanent forest setting. In addition to the fact that agroforestry techniques can be perfected to cope with the new conditions that are anticipated under a drier condition and a higher population density, they lead to an increase in the amount of organic matter in the soil thereby improving agricultural productivity and reducing the pressure exerted on forests. In the drier parts of the Sahel, baobab (*Adansoniadigitata*) and acacia (*Acacia*) trees is usually planted by local farmers as it realized as a valuable tree, especially during the hot and dry parts of the year (Nyonget *al.*, 2007).

Livestock adaptation strategies

Livestock producers have traditionally adapted to various environmental and climatic changes by building on their in-depth knowledge of the environment in which they live. The following have been identified by several experts such as IFAD (2009), FAO (2008), Thornton *et al.*,(2006) and Sidahmed (2008) as ways to increase adaptation in the livestock sector:

Changes in livestock practices

(i) diversification, intensification and/or integration of pasture management, livestock and crop production;

(ii) altering the timing of operations;

(iii) conservation of nature and ecosystems;

(iv) modifying stock routings and distances;

(v) introducing mixed livestock farming systems, such as stall-fed systems and pasture grazing.

Adaptation strategies that are applied among pastoralists in the Sahel region of Africa include the use of emergency fodder in times of droughts, multi-species composition of herds to survive climate extremes, and culling of weak livestock for food during periods of drought. During drought periods, pastoralists and agro-pastoralists change from cattle (Bos) to sheep (Capra) and goat (Capra) husbandry as the feed requirements of the later is less than the former (Oba 1997). Pastoralists' nomadic mobility reduces the pressure on low carrying capacity grazing areas through the circular movement from the dry northern areas to the wetter southern areas of the Sahel. This system of seasonal movement represents a local type of traditional ranching management system of range resources.

Breeding strategies

Many local breeds are already adapted to harsh living conditions. However, developing countries are usually characterized by a lack of technology in livestock breeding and agricultural programmes that might otherwise help to speed adaptation. Adaptation strategies address not only the tolerance of livestock to heat, but also their ability to survive, grow and reproduce in conditions of poor nutrition, parasites and diseases (Hoffmann, 2008). Such measures could include: (i) identifying and strengthening local breeds that have adapted to local climatic stress and feed sources and (ii) improving local genetics through cross-breeding with heat and disease tolerant breeds. If climate change is faster than natural selection, the risk to the survival and adaptation of the new breed is greater (Hoffmann, 2008)

Livestock management systems

Efficient and affordable adaptation practices need to be developed for the rural poor who are unable to afford expensive adaptation technologies. These could include:

- (i) provision of shade and water to reduce heat stress from increased temperature. Given current high energy prices, providing natural (low cost) shade instead of high cost air conditioning is more suitable for rural poor producers;
- (ii) reduction of livestock numbers – a lower number of more productive animals leads to more efficient production and lower GHG emissions from livestock production (Batima, 2006);
- (iii) changes in livestock/herd composition (selection of large animals rather than small);
- (iv) improved management of water resources through the introduction of simple techniques for localized irrigation (e.g., drip and sprinkler irrigation), accompanied by infrastructure to harvest and store rainwater, such as tanks connected to the roofs of houses and small surface and underground dams.

Capacity building for livestock keepers

There is a need to improve the capacity of livestock producers and herders to understand and deal with climate change increasing their awareness of global changes. In addition, training in agro-ecological technologies and practices for the production and conservation of fodder improves the supply of animal feed and reduces malnutrition and mortality in herds.

Labour migration

Migration is a dominant mode of labor (seasonal migration), providing a critical livelihood source. The role of remittances derived from migration provides a key coping mechanism in drought and non-drought years but is one that can be dramatically affected by periods of climate shock, when adjustments to basic goods, such as food prices are impacted by food aid and other interventions (Devereux and Maxwell, 2001). Migration is (and always has been) an important mechanism to deal with climate stress. Pastoralist societies have of course habitually migrated, with their animals, from water source to grazing lands in response to drought as well as part of their normal mode of life. But it is becoming apparent that migration as a response to environmental change is not limited to nomadic societies. In western Sudan, for example, studies have shown that one adaptive response to drought is to send an older male family member to Khartoum to try and find paid labour to tide the family over until after the drought (McLeman and Smit, 2004).

Temporary migration as an adaptive response to climate stress is already apparent in many areas. But the picture is nuanced; the ability to migrate is a function of mobility and resources (both financial and social). In other words, the people most vulnerable to climate change are not necessarily the ones most likely to migrate. In the West African Sahel, recent studies have cast light on the use of temporary migration as an adaptive mechanism to climate change. The region has suffered a prolonged drought for much of the past three decades and one way that households have adapted is by sending their young men and women in search of wage labour after each harvest. But how far they travel depends, in part, on the success of the harvest (Oli, 2008).

Most effective adaptation practices used by Farmers

Adaptation is an adjustment made to a human, ecological or physical system in response to a perceived vulnerability. Specifically, IPCC (2001) described adaptation to climate change as adjustment in natural or human systems in response to actual or expected climatic stimuli and their effects which moderates harm or exploits beneficial opportunities. Adaptation is an important component of climatic change impact and vulnerability assessment and is one of the policy options in response to climatic change impacts (Smith and Lenhont, 1996). Adaptation to climatic change is therefore critical and of concern in developing countries, particularly in Africa where vulnerability is high because ability to adapt is low (Hassan and Nhemachena, 2008).

In agriculture, adaptation helps farmers achieve their food, income and livelihood security objectives in the face of changing climatic and socio-economic conditions including climatic variability, extreme weather conditions such as droughts and floods and volatile short term changes in local and large-scale markets (Kandjinkar and Risbey, 2000).

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

According to Hassan and Nkemechena (2008) the adaptation strategies farmers perceive as appropriate include crop diversification using different crop varieties, varying the planting dates; harvesting dates,

increasing the use of irrigation, increasing the use of water and soil conservation techniques, shading and shelter, shortening the length of the growing season and diversifying from farming to non-farming activities. Some strategies that serve as an important form of insurance against rainfall variability are: increasing diversification by planting crops that are drought tolerant and/or resistant to temperature stresses, taking full advantage of the available water and making efficient use of it, and growing a variety of crops-on the same plot or on different plots thus reducing the risk of complete crop failure since different crops are affected differently by climate changes (Benhin, 2006). Such farm-level adaptations aim at increasing productivity and dealing with existing climatic conditions and draw on farming knowledge and farming experience.

Brussel (2009) highlighted the possible short to medium-term adaptation practices to changes in climate by farmers to include: adjusting the timing of farm operations such as planting or sowing dates and treatments; choosing crops and varieties better adapted to the expected length of the growing season and water availability and more resistant to new conditions of temperature and Humidity; Adapting crops with the help of existing genetic diversity and new possibilities offered by biotechnology; Improving the effectiveness of pest and disease control through for instance better monitoring, diversified crop rotations, or integrated pest management methods; using water more efficiently by reducing water losses, improving irrigation practices and recycling or, storing water;/. Improving soil management by increasing water retention to conserve soil moisture and landscape management such as maintaining landscape features providing shelter to livestock Individually or the combination of these adaptation practices by farmers have-substantial potential to counter balance adverse climatic changes and to take advantage of positive ones.

CHAPTER THREE

STUDY AREA AND METHODOLOGY

3.1 The Study Area

3.1.1 Location

Lapai Local Government Area (LGA) of Niger State is the study area. Lapai town is the headquarters of the LGA. Lapai LGA lies between Latitudes $8^{\circ}10'00''\text{N}$ and $9^{\circ}30'00''\text{N}$ and Longitudes $6^{\circ}25'00''\text{E}$ and $6^{\circ}50'00''\text{E}$ (See figure 3.1)

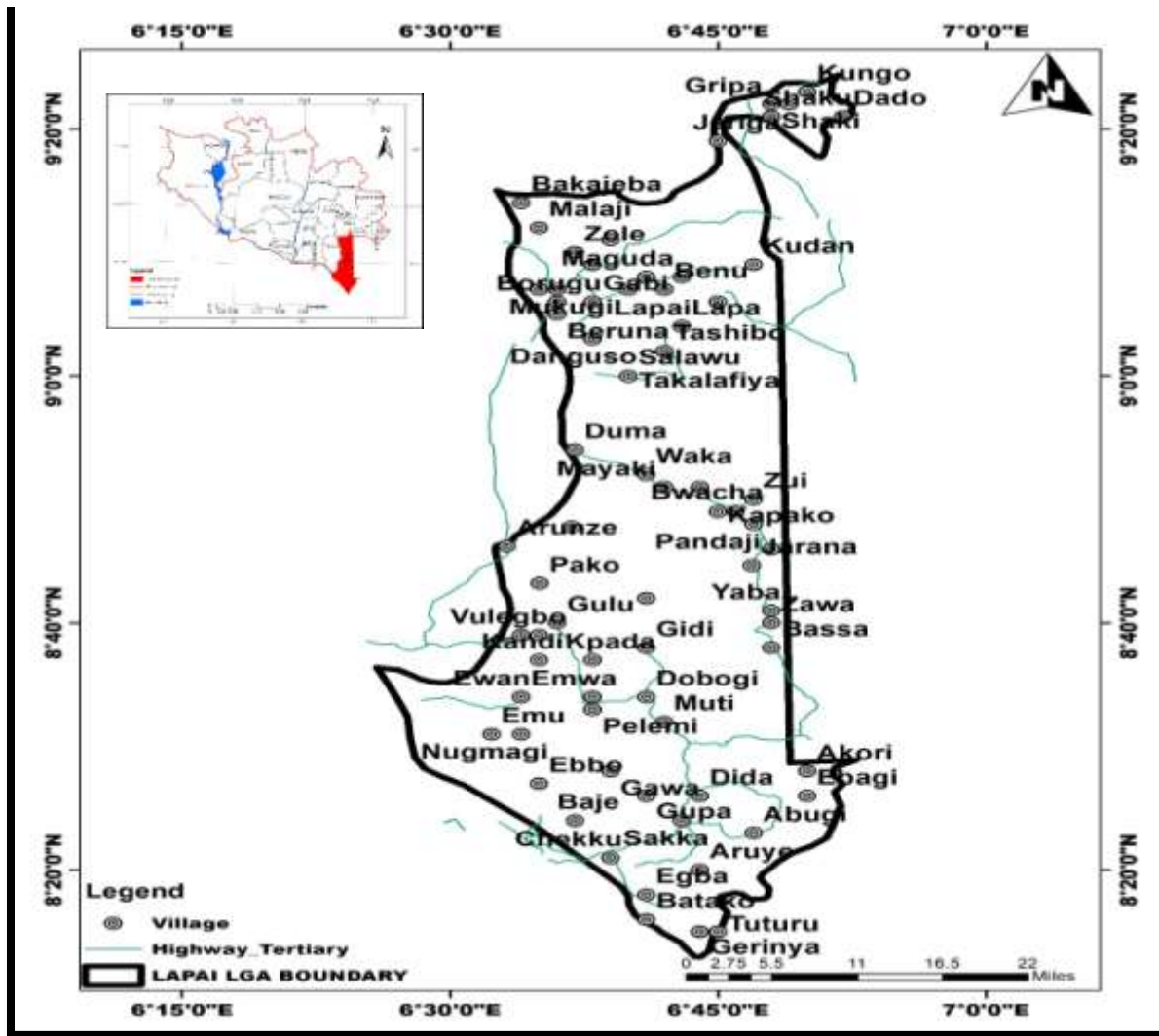


Figure 3.1: Lapai Local Government Area, Niger State

Source: Ministry of Land and Housing, 2018.

The Local Government Area is bounded to the north by Paikoro LGA, to the south by Kogi State, to the east by Federal Capital Territory and to the west is by Agaie Local government Area (See Fig 3.1).

3.1.2 Climate

Lapai LGA experiences two seasons (wet and dry) seasons. The wet season lasts from mid June to early October while the dry season commences from mid October to early June. The annual rainfall is about

1,600mm. The duration of the raining season ranges from 170 – 210 days. The mean maximum temperature remains high throughout the year hovering about 32° C particularly in March and June. However, the lowest minimum temperature occurs usually between December and January when most of the area come under the influence of the tropical continental air mass which blows from the north.

3.1.3 Drainage

The major drainage system in the area is the tributary of the River Niger that flow into Muye River to Baro River (River Niger). Lack of good drainage system leads to an ecological problem in the area, particularly flooding.

3.1.4 Soils and vegetation

Lapai LGA like other Local Governments in Niger State is covered by the sedimentary rock characterised by sandstones and alluvial deposits. It also contains the extensive flood plain of the river Niger, and this makes the area to be fertile for agriculture. It provides the best area for rice growing in Niger State. The three major soil types found in the area include the ferruginous tropical soils, hydromorphic soils and ferrosol. The most predominant soils are ferruginous tropical soils which are ideal for the cultivation of guinea corn, maize, millet and groundnut and the hydromorphic or water lodged soils largely found in the extensive flood plain of the area. The soils are poorly drained and are generally greyish or sometimes whitish in colure due to the high content of silt. Woodlands characterise the vegetation and tall grasses within the flood plains occur taller trees and a few oil palm trees. In some areas, trace of rain forest can be seen. Some common tree species found in the area include *AlbiziaZygia* (mimossoideae), *Afzahiaafricana* (caesalpinoideae), *Alstoniacongensis* (Apocynaceae), *Blighiasapida* (sapindaceae) and *Miliciaexcelsa* (Meliaceae).

3.1.5 People and population

The people of Lapai are mostly Nupe by tribe, although Lapai was one of the towns conquered by the Sokoto Caliphate. The people of the region became subject to the Hausa kingdom of Zazzau. After 1804 they came under the Fulani emirate of Zaria, part of the realm of the Emir of Gwandu. The Lapai emirate was separated from the emirates of Zaria and Agaie in 1825. The Yorubas, Igbos, and the other numerous tribes form the minority tribe in the LGA. The population of Lapai LGA according to NPC (2006) is 117,021, where males accounted for 59,974, and females 57, 047. The population is characterized by different age group as described by NPC (2006).

3.1.6 Economic activities

The economy of Lapai LGA is mostly driven by agricultural activities. The major agricultural product of the town are melon, rice and fish. The people also engage in various formal and informal activities such as trading, tailoring, welding, grinding, among others, very few are civil servant like teachers and local government council staff.

3.2 Methodology

3.2.1 Reconnaissance survey

A reconnaissance of the study area was conducted on 24th February, 2019. The three districts in the Local Government area were visited to ascertain the villages in each district and to familiarize with the terrain. The first step was to meet the District Heads who introduced other stake holders to the researcher. The second step was to design the visit schedule and the interview program.

3.2.2 Types and sources of data utilized

3.2.2.1 Primary data

The primary data required for the study include data on the socio-demographic attributes of the farmers (gender, age, marital status, education and occupation); climate variability induced hazards in the area; impacts of climate variability on crops; the implication of climate variability on food production. Other data required includes data on the adaptative strategies employed as well as the effectiveness of the adaptative strategy adopted by the farmers.

The primary data were gathered by the researcher from the field through questionnaire, while the secondary data were gathered from published document or materials.

3.2.2.2 Secondary data

The secondary data required for the study includes the administrative boundary of the study area, the number of the district in the LGA, the name and number of communities within each district of the LGA. Other relevant information on the subject matter also form some of the secondary data gathered for the study; this information were sourced from both published and unpublished document, print and electronic media.

A well-structured questionnaire was designed to elicit information on the subject matter from the respondents. The questionnaire was designed in sections: Section “A” carried questions that are related to the socio-demographic attributes of the respondents (farmer), while section “B” focused on the identification of hazards and the impact of climate change on crop yield. Section “C” was dedicated to questions on adaptation strategies employed by the farmers and the effectiveness of the adaptation strategies. The questionnaire contained both open and closed ended questions that enhanced the quality of information provided by the respondents. The questionnaire were administered with the help of three research assistants that were drawn from government agency (NAMDA) and trained by the researcher.

3.2.3 Sample size and sampling technique

The sampling frame for the study is the total population of the 19 communities with reported cases of climate variability induced hazards such as drought and flood. The population of the communities as reported by the 1991 census was 53,274 but was projected at an average growth rate of 3.2% annually using the Salland and Dillmann (1997) population projection formula as presented.

$$P_r = P_o \left(1 + \frac{r}{100}\right)^n$$

Where

Pr= Projected Population

Po= Base Population

r = growth rate

n = number of years

Table 3.1 shows that the total population of the communities in 1991 is 53, 274, while the projected population for a period of 27 years (1991-2018) is 124,700. The total projected number of household in all the communities is 20,783. Therefore the sample frame for the study is 20,783 households in the communities.

Table 3.1: Projected Population of the Study Area

BirninMaza District	Population of 1991	Projected Population	Number of households	Sample Size
Adagba	2175	5091	849	15
Batatu	2876	6732	1122	20
Gbacidan	1897	4440	740	13
Sonfada	2283	5344	891	16
Etsugi	3925	9187	1531	28
Jimada	1913	4478	746	14
Total	15,069	35,273	5,879	107

Gulu District

Bokyo	2352	5505	918	17
Egba	2658	6222	1037	19
Gupa	3482	8150	1358	25
Kpotegi	3378	7907	1318	24
Kukwo	1738	4068	678	12
Lapaigi	2423	5672	945	17
Doba	3108	7275	1212	22
Emiworogi	3431	8031	1339	24
Hasheyimi	3902	9134	1522	28
Total	26,472	61,964	10,327	187

Ebbo District

Baka-Fifin	2357	5517	920	17
Ebbo	4594	10753	1792	33
Geku	3203	7497	1250	23
Nyanbabo	1579	3696	616	11
Total	11,733	27,464	616	83
Grand Total	53,274	124700	20783	377

To arrive at a sample size that served as a good representative of the population in the communities, Salland and Dillmann (1997) sample size formula was adopted. The formula is given as:

$$N_s = \frac{Np(p)(1-p)}{(Np-1)(B/C)2 + (p)(1-p)}$$

Where:

N_s = computed sample size needed (notation often used is n)

N_p = size of population (notation often used is N)

p = proportion expected to answer a certain way (50% or 0.5 is most conservative)

B = acceptable level of sampling error (0.05 = ±5%; 0.03 = ±3%)

C = Z statistic associate with confidence interval (1.645 = 90% confidence level; 1.960 = 95% confidence level; 2.576 = 99% confidence level)

Therefore substituting our sample frame into the formula at a 95% confidence level,

$$N_s = \frac{20783(0.5)(1 - 0.5)}{(20783 - 1)(0.05/1.96)^2 + (0.5)(1 - 0.5)}$$

$$N_s = 377$$

the sample size for the study is 377 households from the communities. The 377 households were selected from the nineteen communities based on the proportion of the population of each community to the total population of all the communities. The sample size distribution is presented in Table 3.1. Table 3.1 shows that a total of 107 respondents were administered questionnaire in BirninMaza district, 187 in Gulu District and 83 in Ebbo district.

Random sampling technique was adopted for the study. First Lapai was divided into three clusters using the district boundary. The three clusters identified are: Birninmaza, Gulu, and Ebbo district. However, since the focus of the study is on crop farmers, the study adopted the purposive sampling technique in the selection of respondents for the study (picking of respondents without bias using). This ensures the authenticity of the information provided on the subject matter as majority of the respondents experienced climate related event. This was done by interacting with the respondents on the questions designed

Focus group discussion was conducted for the study. The focused group had 12 members. The groups are three per district (Male, Female and Youths). The group discussants include farmers of varying varieties

of crops, representative of the village head, and members of the LGA in charge of agricultural promotion and development. The focus group discussion focused on the main objectives of the study in order to elicit indepth information on the subject matter (See Appendix III). Each group meet at the designated place (the village hall) as agreed during reconnaissance on Friday to the convenient of the respondents, every member where encouraged to say their view based on the question, some response where unanimous while some where arguably agreed by the group.

3.2.4 Data analysis

Objective One:Identify the types of hazards posed by climate variability in the area

The data from questionnaire was analysed using simple descriptive statistics such as frequency and percentage as well as content analysis of the response related to objective one from the FGD. The result was presented in tables, pie chart and bar chart for easy interpretation and understanding.

Objective Two:Assess the climate variability impact on crops production of the study area

Descriptive statistics was the major tool of analysis for this objective. The relative impact index (RII) was used to determine the impact of climate change on different types of crop yield. The descriptive tool includes mean, frequency and percentage. The results also were supported with content analysis of the FGD. The result was presented in tables, pie chart and bar chart for easy interpretation and understanding.

Objectives Three: Examine the climate variability adaptation strategies employed by the crop farmers in the study area to combat the hazard of climate variability

The data for objective three was analysed using Friedman's non parametric test as well as content analysis of the response related to the objective from the FGD. The result was presented in tables for easy interpretation and understanding.

The Friedman test is non-parametric alternative to the one way ANOVA with repeated measures. It is used to test differences between groups when the dependent variable being measure is ordinal. It can also be used for continuous data that has violated the assumptions necessary to run the one way ANOVA with repeated measures (e.g data that has marked deviations from normality). It can also be used to compare ranked outcomes. The data is set of adaptation strategies practice by the respondents to curb the menace of hazards posed by climate variability in the study area.

The Friedman test ranks each person's score from lowest to highest (as if respondents had been asked to rank the methods from least favourite to favourite) and bases the test on the sum of ranks for each column. The Friedman test was used the results were presented in ranks.

ObjectivesFour:Examine the most suitable adaptation strategies in the study area

The pairwise comparison matrix was used here. Pairwise comparison matrix is a method of comparing entities in pairs to judge which entity is preferred, or has a greater amount of some quantitative property, or whether or not the two entities are identical. The pairwise comparison technique has been widely used to tackle the subjective and objective judgements about qualitative and/or quantitative criteria in multi-criterial decision making (MCDM). The result of the analysis was presented in a table and pie chart.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Social-demographic Characteristics of Respondents

The personal data of the respondents under consideration include sex, age, marital status, household size, years of farming experience, level of education and so forth.

4.1.1 Sex distribution of respondents

Sex of respondents in the study area is presented in figure 4.1

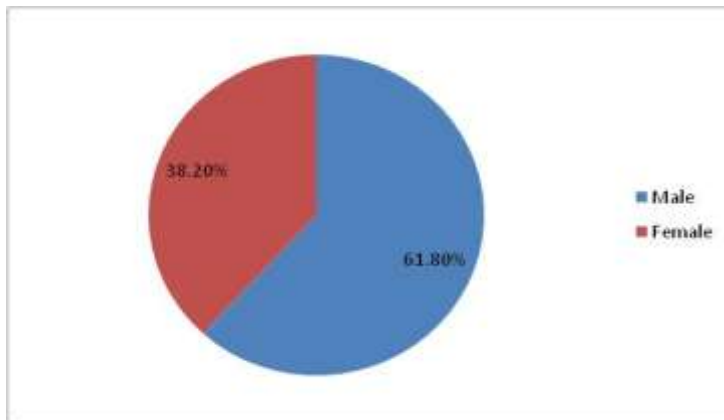


Figure 4.1: Sex of Respondents

Sources: Field survey, 2019

Figure 4.1 indicates that 61.8% of respondents in the study area were males while 38.2% were females. This implies that most of the respondents were male. This might be attributed to the fact that majority of rural men were into farming while women were always involved in post-harvest activities. This finding

agreed with Idoma *et al.* (2017), who indicated that majority of rice farmers that adopted climate change strategies in Benue State were males.

4.1.2 Age distribution of respondents

The Respondent's age is presented in Table 4.1

Table 4.1: Age Distribution of Respondents

Age	Birnin Maza		Gulu		Ebbo	
	Frequency	percentage	Frequency	Percentage	Frequency	Percentage
20-45	30	28.0	67	36.0	18	21.7
46-60	62	58.0	98	52.0	52	62.7
61-75	15	14.0	22	12.0	13	15.6
Total	107	100	187	100	83	100

Sources: Field survey, 2019

Table 4.1 shows that 58.0% of the respondents in Birnin Maza were within the age range of 46-60 years while 28.0% were within the age range of 20-45 years and 14.0% of the respondents were within the age range of 61-75 years. It also shows that 52.0% of the respondents in Gulu were within the age range of 46-60 years while 36.0% were within the age range of 20-45 years and 12.0% of the respondents were within the age range of 61-75 years, while 62.7% of the respondents in Ebbo were within the age range of

46-60 years, 21.7% were within the age range of 20-45 years and 15.6% of the respondents were within the age range of 61-75 years. This finding indicated that majority of the respondents were still within their active years of farming, this may serve as impetus in adopting strategies that would reduce the menace of climate change and also enhance their income. This finding is in consonance with Idoma *et al.* (2017), who reported that larger proportion of farmers in Agatu LGA of Benu State, Nigeria were still in their active and productive age of farming.

4.1.3 Marital status of respondents

The marital status of respondents in the study area is presented in figure 4.2

Figure 4.2 indicates that 82.2% of the respondents were married while 7.9% were divorced. Also, 6.4% were widow/widower while 3.4% were single. This implies that majority of the respondents were married, which denotes some kind of family responsibilities, which could in turn force farmers to adopt coping strategies that will reduce the menace of climatic change and also enhance their income and livelihood. Married people are also expected to adopt climate strategies and may receive assistance from their spouses in carrying out some activities on the farm. This trend seems to agree with the findings of Blessing and Goodness (2015), who reported that most of the farmers that utilized climate change strategies in Benue State (Makurdi), Nigeria were married,

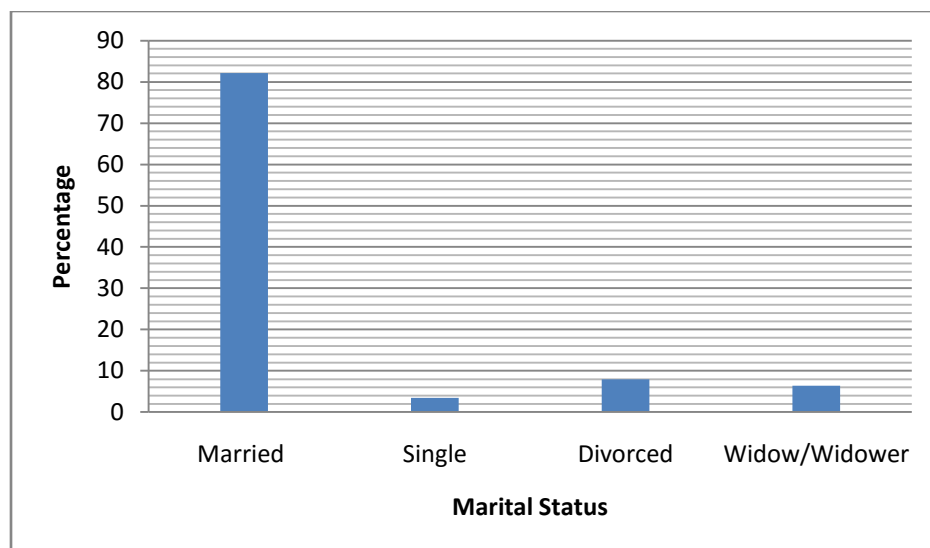


Figure 4.2: Marital Status of Respondents

Sources: Field survey, 2019

4.1.4 Educational level of respondents

Education level of the respondents is presented in Table 4.2

Table 4.2: Educational Level of Respondents

Level of Education	Birnin Maza		Gulu		Ebbo	
	Frequency	percentage	Frequency	Percentage	Frequency	Percentage
Primary	45	42.1	87	46.5	43	52.0
Quranic	30	28.0	58	31.1	17	20.4

Secondary	25	23.4	24	12.8	13	15.6
Tertiary	7	6.5	18	9.6	10	12.0
Total	107	100	187	100	83	100

Sources: Field survey, 2019

From Table 4.2, it could be observed that 42.1% of the respondents in Birnin Maza had primary education while 28.0% had Quranic education. Also, 23.4% had secondary education while 6.5% had tertiary. It could be also observed that 46.5% of respondents from Gulu had primary education while 31.1% had Quranic education. 12.8 had had secondary and 9.6% had tertiary education and 52.0% of respondents in Ebbo had primary education, 20.4% had Quranic, 15.6% had secondary while 12.0 had tertiary education. This implies that level of literacy is low among the respondents; this limit the farmers in adopting other sustainable strategies of curbing the menace of climate change in the study area. This finding agreed with Ishaya and Abaje (2008), who identified formal education as a way to increase farmers' adaptive capacity to climate change in Jama'a Local Government Area of Kaduna State. Therefore, the higher the educational qualification of farmer, the more he/she is disposed to understand necessary information on climate change in the study area.

4.1.5 Migration status of respondents

Figure 4.3 shows the migration status of the respondents in the study area

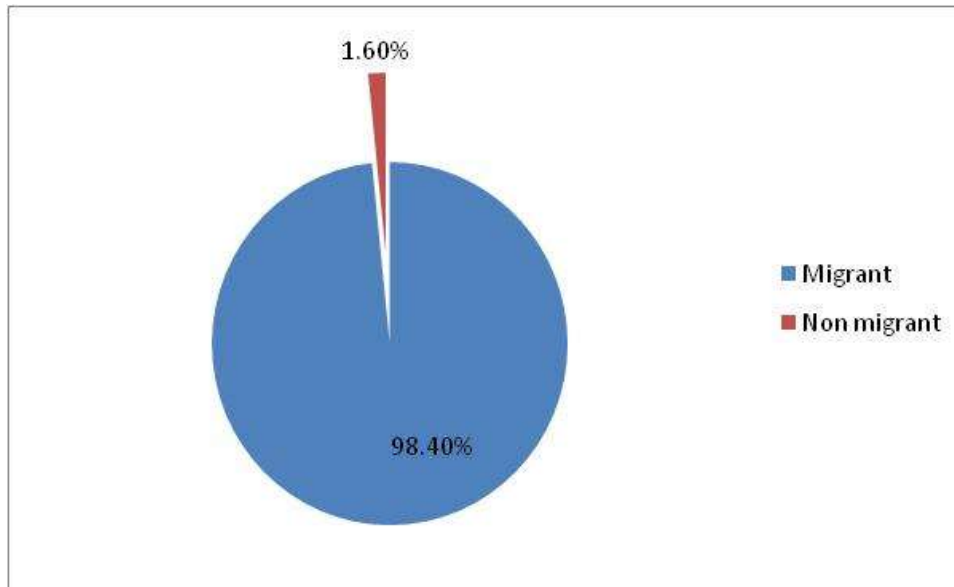


Figure 4.3: Migration Status of Respondents

Sources: Field survey, 2019

Figure 4.3 reveals that 98.4% of the respondents were migrants while 1.6% were indigenes. This implies that majority of the respondents were migrants and this affect the choice of the strategies adopted as capital intensive strategies such irrigation scheme strategies where avoided because of land dispute.

4.1.6 Major occupation of respondents

Major occupation of respondents in the study area is presented in figure 4.4

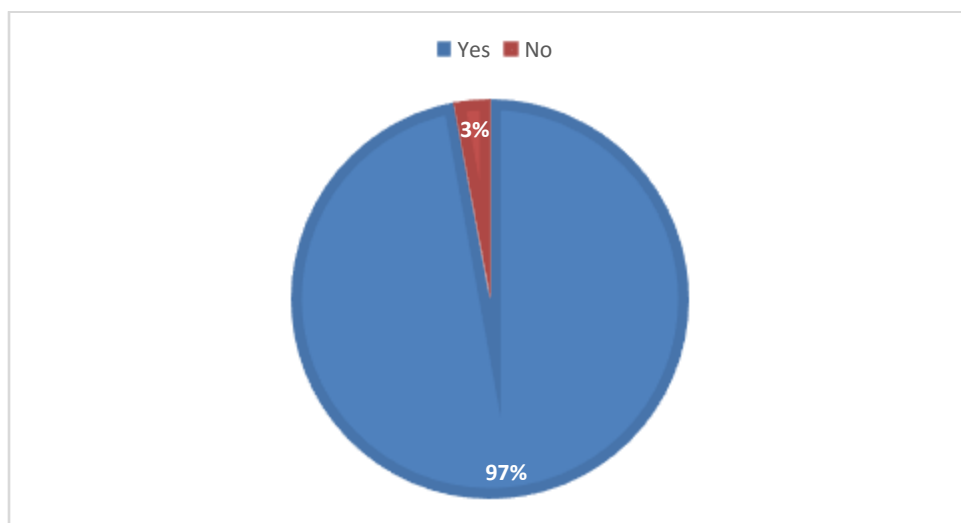


Figure 4.4: Major Occupation of Respondents

Sources: Field survey, 2019

Figure 4.4 indicates that 97.0% of the respondents were full time farmers while 3% were not. This implies that almost all the respondents were full time farmer. This is an indication that they are likely to be susceptible to the hazards to climate variability.

4.1.7 Years of farming experience of respondents

Respondent's experience in farming as occupation in the study area is presented in Table 4.3

Table 4.3: Years in Farming Experience of Respondents

Years in Farming	Birnin Maza Frequency	Birnin Maza percentage	Gulu Frequency	Gulu Percentage	Ebbo Frequency	Ebbo Percentage
1-10	133	51.4	109	10.8		
11-20	170	45.1	141	38.3	202	41.1
21-30	140	37.1	126	24.3	343	51.8
>30	54	14.3	23	23.4	113	13.3
Total	107	100	187	100	83	100

Sources: Field survey, 2019

Table 4.3: shows that 45.1% of the respondents in Birnin Maza had between 11-20 years in farming while 37.1% had between 21-30 years in farming, 14.3% of the respondents had >30 years in farming while 3.5% of the respondents had between 1-10 years in farming, while 38.3% respondents in Gulu had between 11-20 years in farming, 24.3% had 21-30 years in farming, while 23.4% had >30 years in farming and 14.0 had 1-10 years in farming and 51.8% of respondents in Ebbo had 21-30 years in farming, 24.1% had 11-20 years in farming, 13.3% had >30 years farming and 10.8% had 1-10 years in farming. This finding implies that majority of the respondents had long time experience in farming. However, long years in farming might serve as practical experience acquired over many years that will reduce the menace of climate change. This implies that the farmers have sufficient knowledge on impact of climate change on agricultural production in the study area. The result corroborates finding from Lansigan *et al.* (2000), who reported that long farming experience is an advantage for increase in farm productivity in Philippines since it encourages rapid adoption of farm innovation.

4.2 Types of Hazards caused by Climate Variability

Findings showed that flood, drought, increase pest and disease infestation are the threats to agricultural activities in the study area. The identified hazards caused by climate change are presented in table 4.4.

Table 4.4: Types of Hazards

Hazards	Birnin Maza		Gulu		Ebbo	
	Frequency	percentage	Frequency	percentage	Frequency	Percentage
Flood	25	23.44	25	14.3	51.9	
Drought	23	21.53	18.7	10	12.0	
Increase in pest and disease	47	43.98	42.8	20	24.1	
Soil erosion	12	11.22	13.4	10	12.0	
Total	107	100	187	100	83	100

Sources: Field survey, 2019

Table 4.4 revealed that in Birnin Maza 23.4% of the respondents agreed that there is increase in flood, 21.5% agreed that there is increase in drought due to low and changing pattern in rainfall while 43.9% agreed that there is increase in pest and disease infestation on crop due to increase in temperature and low rainfall, and 11.2% agreed that there is increase in soil erosion, 25.1% respondents in Gulu agreed that there is increase in flood, 18.7% agreed that there is increase in drought, 42.8% also agreed that there is increase in pest and disease and 13.4% agreed that there is increase in soil, while 51.9% of respondents from Ebbo agreed that there is increase in flood, 12% agreed there is increase in drought, and 24.1% agreed that there is increase in pest and disease, 12% also agreed that there is increase in soil erosion. Crop farming is extremely vulnerable to climate change. It has been predicted that climate variability will lead to higher temperatures, more variable rainfall and extreme climate events such as floods, cyclones, droughts and rising sea levels (Porter *et al.* 2003). Falaki *et al.*, (2013) remarked that the degree of the impact of climate change on crop production will depend upon the magnitude of the climate change and other factors. Basically, increasing temperature will directly impact crops by affecting their physiology; it will also indirectly affect crops through changes in the water regime and the increased intensity of pests and diseases. Crops are also bound to be affected by more

intense rainfall and other extreme weather events occurring at different stages of growth. The result of Focus Group Discussion (FGD) agrees with this finding. A discussant, **Mallam Sule** had this to say

“Increase in pest infestation is the number one challenge followed by flood while short time drought is another one in this our Birnin Maza,

Alhaji yawogi was of the opinion that:

The same problems are what we are experiencing here in Gulu district too,

Yaliman from Ebbo said that

We are experiencing more flooding here in Ebbo than pest attack on our crops,

According to Hajiya mamam from Ebbo: *we are experiencing short time drought in this our community,*

Usman Mohammed argue *that apart from flood pest and disease is our major problem in our farm area.”.*

4.2.1 Frequency of flood condition

Frequency of flood is expressed in figure 4.10

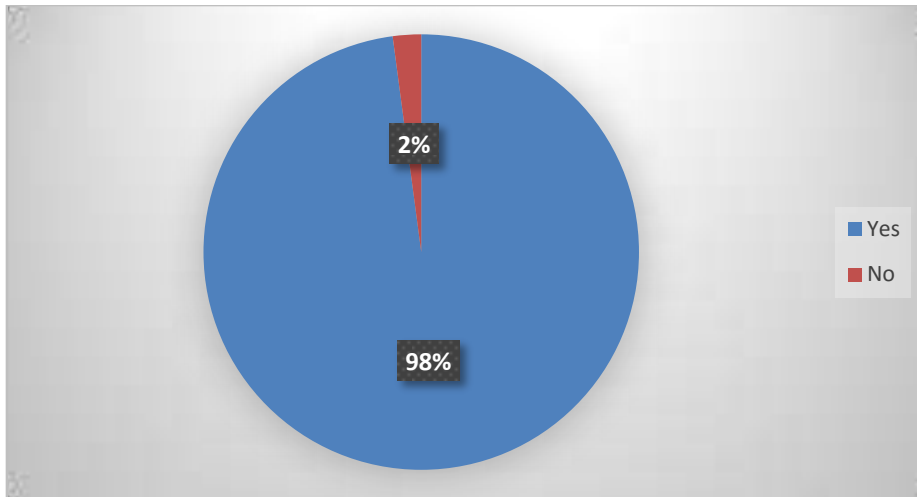


Figure 4.5: Notice of Change in Frequency of Flood

Sources: Field survey, 2019

Figure 4.5 indicates that 98% of the respondents experienced increased change in the frequency of flood condition between 2013-2018 periods. During the Focus Group Discussion, Alhaji Yawogi from Gulu claimed that

“In Gulu and generally in Lapai area we are experiencing increasing flood frequency there by making our arable land unuseful,

Alhaji Ndama Ebbocorroborated this statement that:

“It is true, flood is our general problem in our community”.

4.2.2 Change in flood condition

Change in flood condition is presented in Table 4.5

Table 4.5 Change in Flood Condition

Awareness Birnin Maza	Gulu	Ebbo
------------------------------	-------------	-------------

		Frequency	percentage	Frequency	Percentage	Frequency	Percentage
Decreasing	24	22.44	524.1	13	15.7		
Do not know	15	14.02	513.4	5	6.0		
Increasing		58	54.2	102	54.5	86	9.9
The same	10	9.4	158.0	7	8.4		
Total		107	100	187	100	83	100

Sources: Field survey, 2019

Table 4.5 shows that 22.4% respondents in Birnin Maza revealed that condition of flood has decreased over the last 20 years while 14 indicated that they cannot precisely state if the flood condition is decreasing or increasing. Also, 54.2% of respondents indicated that the condition of flood is increasing and 9.4% indicated that flood condition is the same. 24.1% respondents in Gulu revealed that condition of flood has decreased over the last 20 years, 13.4% did not know if the flood condition is decreasing or increasing, 54.5% of respondents indicated that the condition of flood is increasing while 8% indicated that flood condition is the same. Also, 15.7% respondents in Ebbo revealed that condition of flood has decreased over the last 20 years while 6% did not know if the flood condition is decreasing or increasing. Also, 69.9% of respondents indicated that the condition of flood is increasing and 8.4% indicated that flood condition is the same. Moreover, climate variability had resulted to incidence of flood in North Central Nigeria for the past 5 years, which has affected peasant crop farmers in so many ways such that some farm land in the study area are annually usually submerged, flooded and eroded (See plates 1 and 2 in Appendix I) and some had deposit of toxic substances in the farm (See plates 5, 6 and 9 in Appendix I). This agreed with Idoma *et al.* (2017), who reported that incidence of flood in Kogi, Niger and Benue States have led to loss of agricultural produce, lives and properties. During Focus Group Discussion the discussants expressed varied opinion.

Mallam Audu Gimba observed *“flood condition is increasing in this our Ebbo area due to increase in rainfall which leads to our crops been submerged in water for about 4 to 5 days,*

Hassana Aliyu was with opinion that flood condition is increasing in our village here in Gulu, this leads to increases land erosion in our area.

Mohammed Karimu said all of us in Birnin Maza are experiencing increase in flood condition, sometimes the flood deposit toxic in our farm”.

4.2.3 Change in the frequency of drought condition

Frequency of drought in the study area is shown in figure 4.6

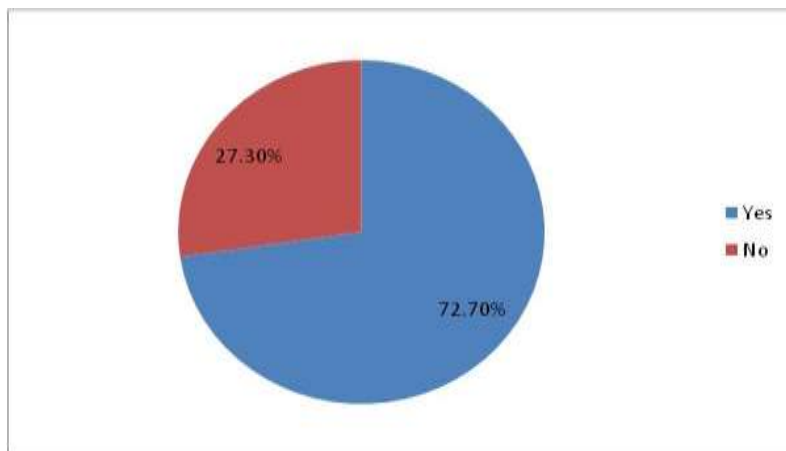


Figure 4.6: Notice of Change in Frequency of Drought

Sources: Field survey, 2019

Figure 4.6 shows that 72.7% of the respondents witnessed increase in the frequency of drought over the last twenty years while 27.3% did not notice. This implies that majority of the respondents experienced increase in drought condition as a result of climate change. According to Hughton (2002), despite technological advances in plant breeding, fertilizers, improved varieties, genetically modified organisms,

and irrigation systems, climate is a key factor in agricultural production. In the 1980s, continuing deterioration of food production in Africa was caused in part by extended drought and soil degradation. During Focus Group Discussion, a discussant Mallam Magaji Ibrahim observed that:

“There is increase in frequency of short time drought in this Birnin Maza area due to short period and unstable pattern of rainfall,

Ndayayawas with opinion that:

The drought spell in Ebbo area a short time drought between 2-3 weeks and at interval,

According to Aishatu we experience drought every year in Gulu but it is for short time in raining period”.

4.2.4 Change in drought frequency

Frequency of drought in the study area is shown in Table 4.6

Table 4.6 Change in Frequency of Drought

	Awareness Birnin Maza		Gulu		Ebbo		
	Frequency	percentage	Frequency	Percentage	Frequency	Percentage	
Decreasing	20	18.745	24.1	10	12.0		
Do not know	15	14.02	10.7	2	2.4		
Increasing		62	57.9	110	58.8	65	78.4
The same	10	9.4	126.4	6	7.2		
Total		107	100	187	100	83	100

Sources: Field survey, 2019

Table 4.6 shows that 18.7% respondents in Birnin Maza revealed that condition of flood has decreased over the last 20 years while 14% cannot precisely say if the flood condition is decreasing or increasing. Also, 57.9% of respondents indicated that the condition of flood is increasing and 9.4% indicated that flood condition is the same. 24.1% respondents in Gulu revealed that condition of flood has decreased over the last 20 years, 10.7% cannot precisely say if the flood condition is decreasing or increasing, 58.8% of respondents indicated that the condition of flood is increasing while 6.4% indicated that flood condition is the same. Also, 12% respondents in Ebbo revealed that condition of flood has decreased over the last 20 years while 2.4% cannot precisely say if the flood condition is decreasing or increasing. Also, 78.4% of respondents indicated that the condition of flood is increasing and 7.2% indicated that flood condition is the same. Moreover, climate variability had resulted to incidence of flood in North Central Nigeria for the past 5 years, which has affected peasant crop farmers in so many ways such that some farm land in the study area had been eroded (See plates 1 and 2) and some had deposit of toxic substances in the farm (See plates 5, 6 and 9). This finding agreed with Idrisal (2012), who indicated that frequent drought condition is well pronounced in Borno State, Nigeria. During Focus Group Discussion. A discussant Birnin Maza district head observed that:

“Drought condition in Birnin Maza area, is increasing due increase in temperature and fluctuating pattern of rainfall despite increase in rainfall,

Mallam Hussaini Gulu observed that:

The drought is not prolong, it happens at interval in Gulu which makes our farm land cake during that period and our crops sometimes dried reducing our crop yield”.

4.2.5 Change in Pest and Disease

Change in pest and disease in the study area is presented in figure 4.7

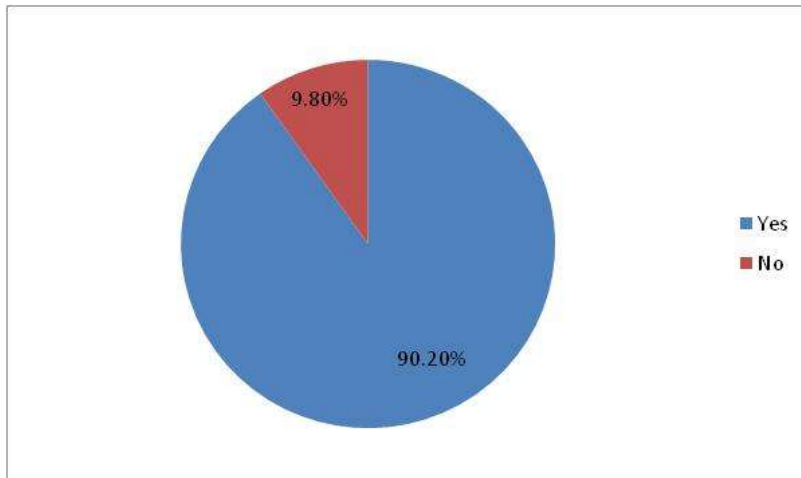


Figure 4.7: Notice of increase in Pest and Disease infestation

Sources: Field survey, 2019

From figure 4.7, it is seen that 90.2% of the respondents have noticed increase in pest and diseases infestation over the past 20 years while 9.8 did not. This implies that majority of the respondents have noticed increase in pest and disease infestation on crops due to increasing temperature (See plate 7 and 8 in Appendix D). This finding agreed with Idoma *et al.* (2017), who reported that frequent change in ambient temperature is an indication of climate variability. During Focus Group Discussion, A discussant Alhaji Audu Yawogi said that;

“We are experiencing increase in pest infestation on our crops in Gulu area, as the larvae of insect bore the stem and leave of the crops due to short period of rainfall and the increase in the temperature.

Alhaji Galadima Musa observed that:

It is the same here in Ebbo,

According to Usman Malagi, *pest infestation is more in Birnin Maza when rainfall cease and there is increase in temperature”.*

4.2.6 Frequency of Pest and Disease condition

Respondents' notice of change in frequency of Pest and Disease conditions in the study area is presented in figure 4.8

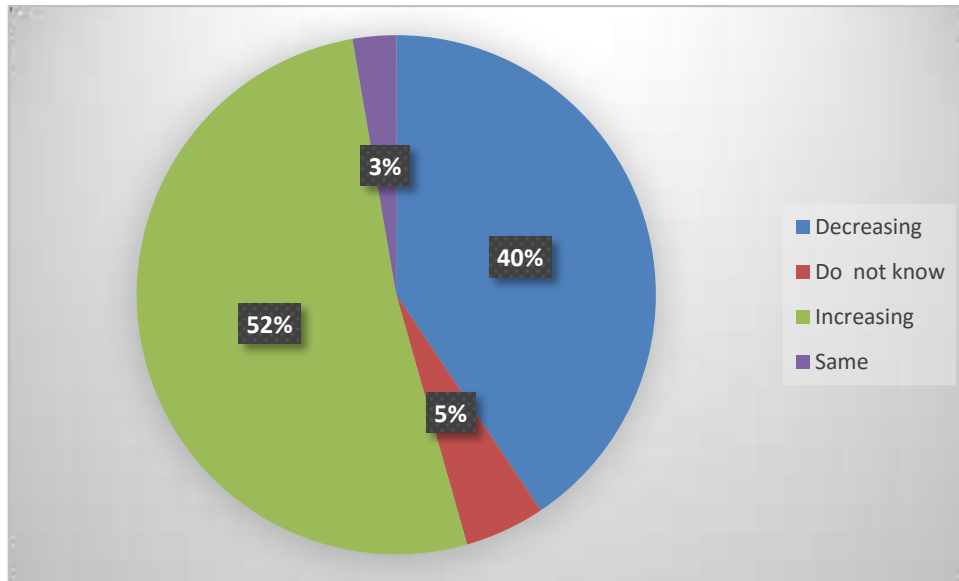


Figure 4.8: Notice of Change in Frequency of Pest and Disease Condition

Sources: Field survey, 2019

Figure 4.8 shows that 52% of the respondents revealed they experienced increasing pest and disease infestation on crops, 40% experience decrease, while 5% cannot state if there is increase or decrease in pest and disease infestation and 3% said same. Respondents also noticed increased in rainfall and pattern of rainfall in the study area. During the Focus Group Discussion, Aishatu Musa a discussant said

“In Birnin Maza and Ebbowe are experiencing increase in frequency of pest infestation on our crops due to short period of rainfall and increase in the temperature,

Mamma Issah argue that:

In Gulu we do not experience increase in pest and disease except when rain cease”.

4.2.7 Change in increase of rainfall in the study area.

Figure 4.9 shows the respondents’ notice of change in increase of rainfall in the study area

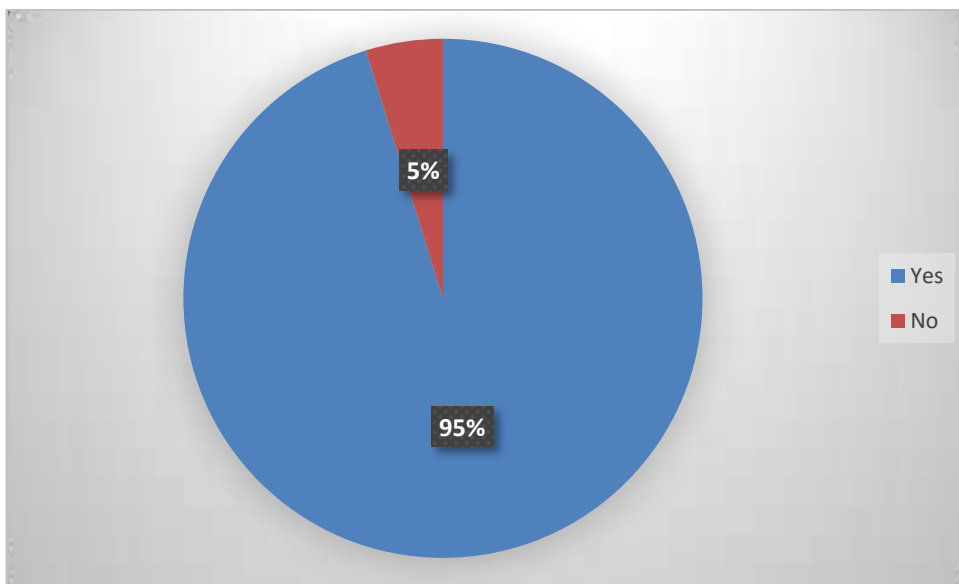


Figure 4.9: Notice Change in Increase of Rainfall

Sources: Field survey, 2019

Figure 4.9 shows that 95% of the respondents noticed an increase in rainfall in the study area over the past 20 years, while 5% do not notice any change in rainfall over the past 20 years. This implies that the majority of the respondents witnessed an increase in rainfall in the study area, which leads to crop destruction and flooding. This finding is supported by some farmers in the study area. (See plate 3 and 4 in Appendix).

corroborates Stephen (2015), who stressed that climate change often leads to uncontrollable amount of rainfall in Edo State, Nigeria. During the Focus Group Discussion. A discussant, District head of Ebbo observed that:

“In Ebbo, Gulu and Birnin Maza generally there is increase in rainfall for the past twenty years in this our three districts, the increase in rainfall leads to increase flooding and soil erosion.

Ndama Mohammed Gulu, is with the opinion that:

“There is more increase in rainfall but varies across this our area”.

4.2.8 Notice of change in condition of rainfall

Farmers’ notice of change in condition of rainfall in the study area is presented in Table 4.7

Table 4.7 Farmers’ Notice of Change in Condition of Rainfall

Awareness	Birnin Maza		Gulu		Ebbo	
	Frequency	percentage	Frequency	Percentage	Frequency	Percentage
Decreasing	10	9.315	8.0	5.6.0		
Do not know	7	6.5	52.72	2.4		
Increasing		85	79.5	162	86.6	72 86.8
The same	5	4.7	5	2.7	4	4.8
Total		107	100	187	100	83 100

Sources: Field survey, 2019

Table 4.7 indicates that 79.5% of the respondents in Birnin Maza observed increasing in rainfall in the study area while 9.3% indicated decreased of rainfall. Also, 6.5% cannot precisely state if there is increase or decrease in rainfall while 4.7% of the respondents indicated the condition of rainfall was the

same, 86.6% of the respondents in Gulu stated that there was increasing of rainfall in the study area, 8% indicated decreased of rainfall, 2.7% cannot also state if there is increase or decrease in rainfall while 2.7% of the respondents indicated the condition of rainfall was the same and 86.8% of the respondents in Ebbo revealed that there was increasing of rainfall in the study area while 6.0% indicated decreased of rainfall. Also, 4.8% of the respondents indicated the condition of rainfall was the same, while 2.4% indicated that they do not know whether the rainfall decrease or increase, This finding agreed with Idoma *et al.* (2017), who reported that frequent change in ambient temperature is an indication of climate change and that incident of flood in Kogi, Niger and Benue States have led to loss of agricultural produce, lives and properties. During Focus Group Discussion, A discussant observed that:

“In Birnin Maza district flooding is the major challenge we framers are experiencing, increase in short time drought is our second challenge and increase in pest and disease is our third major challenge.

Alhaja Jumain Jibrin is with the opinion that:

In Gulu we are experiencing in more short time drought than flooding and increase in pest and disease infestation.

Maimuna Yawogi is with a view that:

Increase in temperature leads to infestation of pest and disease on our crops in Gulu and Ebbo districts.

4.3 Impact of Climate Variability on Farming

4.3.1 Respondents' notice of specific impact of climate change on farming activities

Respondents' noticespecific effect of climate change on farming activities in the study area is revealed in Figure 4.10

Figure 4.10 reveals that23 % and 20.1% of the respondentshad increase in pest and disease infestation and increase in soil erosion due to climate change while 15.2%, 15%, 14.1%, 8.1%, 2.5% and 2% of the respondents had delay cropping, destruction of crops, flooding of crops,delayed crop maturity,poor germination of seeds and reduced crop yield quantity as a result of climate change.According to Udenyi (2010), the impacts of climate change are mostly negative and evidentin food production and agriculture, health, water resources, ecosystem, shelter, vulnerablepopulations, socio-economic activities and national security.FAO (2009), reported that changes in climate could have a significant impact on food production all over thecontinent of Africa. Heat stress, droughts and flooding events may lead to reductions in crop yields productivity. Lobell (2010) emphasized that Africa could face a 30 percent decline in maize production in the next two decades because rainfall and temperature inAfrica are changing quite fast.

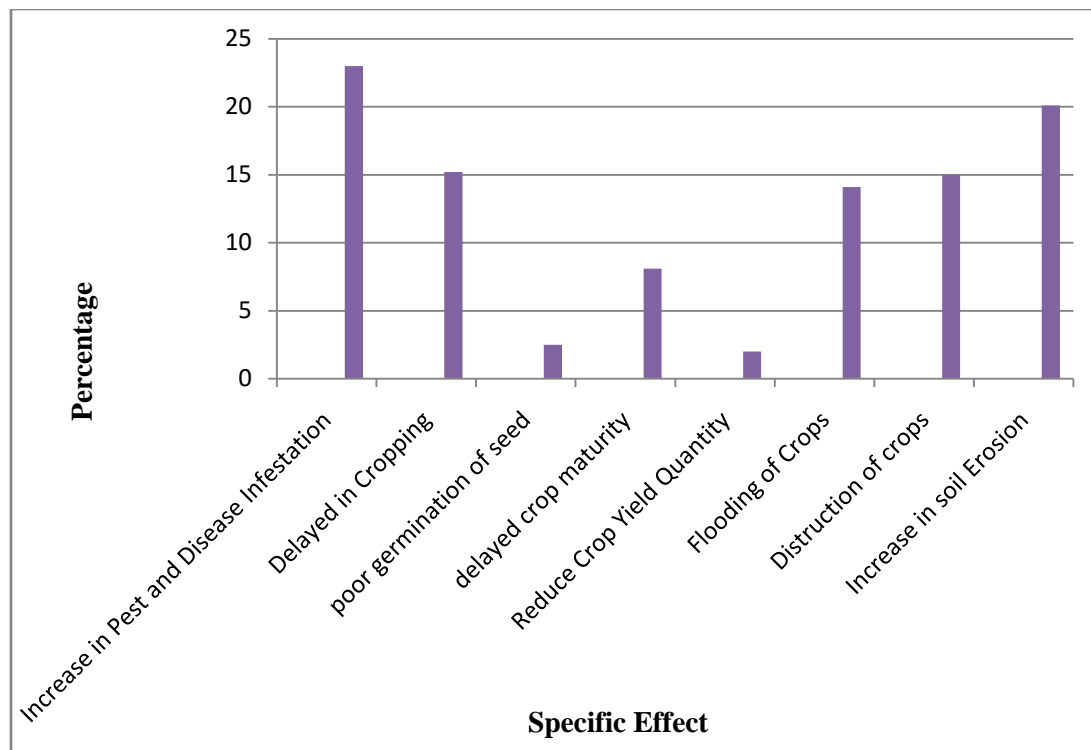


Figure 4.10: Specific Impact of Climate Change on farming activities

Sources: Field survey, 2019

A discussant from Focus Group Discussion agrees with this finding. Alhaji Liman Mohammed Gulu said

“In Gulu district we are experiencing negative impact of climate variability in our farming activities, increase in pest and disease infestation on our is more, increase in soil erosion is next, delayed in cropping is the third impact, other negatives impact of climate variability are destruction of crops, flooding of crops, delayed of crop maturity, poor germination of seeds and reduced crop yield quantity in this our area.

Usman Isah is also with opinion that:

In Ebbo we are experiencing more soil erosion as major impact, destruction of crops as second impact then increase in pest and diseases is the third impact”.

4.3.2 Respondents' change in income

Respondents' experience of low income as a result of effect of climate change on cropping activities in the study area is shown in figure 4.10

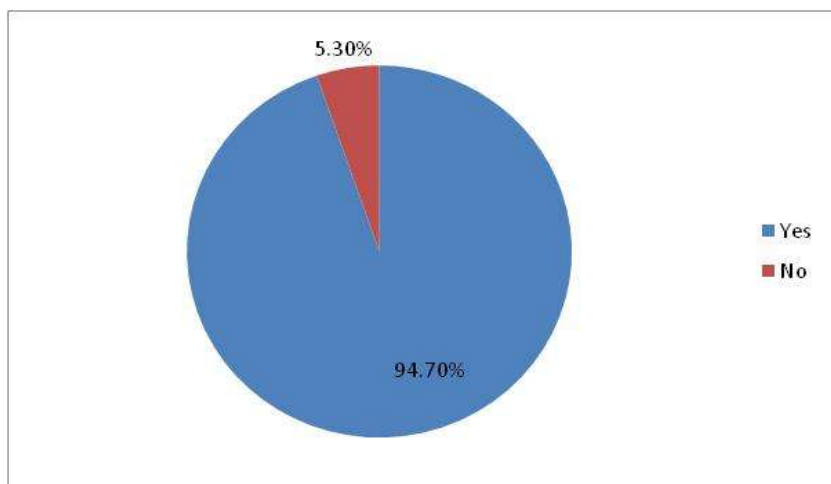


Figure 4.11: Change in Respondents' Income

Sources: Field survey, 2019

Figure 4.11 shows that 94.7% of the respondents experienced low income levels due to climate change while 5.3% did not experience change in income level due to climate change. This implies that majority of the respondents in the study area suffered from the menace of climate variability. This finding is in consonance with Stephen (2015), who posits that climate change had negative effect on farmers' income and livelihood in Nigeria. During the Focus Group Discussion, the head of Ebbo district said

“We are all experiencing reduction in our crop output due to the negative impact of climate variability on our farming activities across our three districts”.

4.4 Farmer's Adaptation Strategies to Climate Change

The Friedman's non parametric test was used to rank the adaptation strategies.

Table 4.8 shows respondents' adaptation strategies to climate variability in rank order.

Table 4.8: Adaptation Strategies employed by Respondents to climate variability in Birnin Maza District

Adaptation Strategies to Climate Change	Mean (RII)	Rank
Planting of trees for shading	8.57	1 st
Change crop varieties	8.52	2 nd
Practice mixed farming	7.10	3 rd
Change planting date	7.00	4 th
Change from crop to livestock	6.98	5 th
Practice more irrigation	6.86	6 th
Practice mixed cropping	6.71	7 th
Engaged in off-farming activities	6.58	8 th
Practice water harvesting scheme	6.58	9 th
Moved from rural to urban area	6.57	10 th
Change from farming to other occupation	6.53	11 th
Good cultural practices such as mulching	6.50	12 th
Farm insurance	2.10	13 th

Sources: Field survey, 2019

The result presented in Table 4.8 indicates that planting of trees for shading and change in crop varieties were rank 1st and 2nd respectively as adaptation strategies to long term change in climate variability. This finding agreed with Idoma *et al.* (2017), who reported that change in crop varieties and shading were the most strategies used to curb the menace of climate variability among arable crop farmers in Agatu LGA of Benue State, Nigeria.

Also, mixed farming, change planting date and change from crop to livestock were (ranked 3rd, 4th and 5th respectively). Other adaptation strategies to climate variability intensive irrigation which (ranked 6th, mixed cropping that ranked 7th), engage in off-farming activities (ranked 8th), water harvesting scheme (ranked 9th), moved from rural to urban area (ranked 10th) and change from farming to other occupation (ranked 11th), good cultural practice (ranked 12th), while farm insurance (ranked 13th).

The findings also tally with Idrisal (2012), also reported that recurrent drought in Borno State, Nigeria could be curbed with strategies such as mixed cropping, mixed farming and change in varieties of crop. The results of the Focus Group Discussion tally with this finding. An excerpt from the opinion of Idris Aliu in Batatu village, Karimu Usmanu in Jimada village and Asabe Mammudu in Sonfada village

“Planting of trees for shading is the first adopted coping strategies we employed to reduce the impact of climate variability in this our area, others are mixed farming, mixed cropping, change in crop varieties, change in planting date, change from crop to livestock, engage in off- farming activities, intensive irrigation scheme, change from farming to other occupation and moved from rural to urban area, farm insurance is the last adopted strategy due to the fact that majority of us do not insured our farms”.

Table 4.9: Adaptation Strategies employed by Respondents to climate variability in Gulu District

Adaptation Strategies to Climate Change	Mean (RII)	Rank
Planting of trees for shading	8.57	1 st
Change crop varieties	8.52	2 nd

Good cultural practices such as mulching	7.10	3 rd
Change planting date	7.00	4 th
Practice mixed cropping	6.98	5 th
Practice mixed farming	6.86	6 th
Practice more irrigation	6.71	7 th
Engaged in off-farming activities	6.58	8 th
Practice water harvesting scheme	6.58	9 th
Moved from rural to urban area	6.57	10 th
Change from farming to other occupation	6.53	11 th
Change from crop to livestock	6.50	12 th
Farm insurance	2.10	13 th

Sources: Field survey, 2019

The result presented in Table 4.9 indicates that planting of trees for shading and change in crop varieties were rank 1st and 2nd respectively as adaptation strategies to change in climate variability. The finding agreed with Oyewole (2015) which indicated that practice of mixed farming, shading, changing in plant date, practice more irrigation and engagement in off-farm activities were the most effective strategies to long change in rainfall in Nigeria.

Also, good cultural practice, change planting date and mixed cropping were (ranked 3rd, 4th and 5th respectively). Other adaptation strategies to climate variability are mixed farming (ranked 6th), intensive irrigation (ranked 7th), engage in off-farming activities (ranked 8th), water harvesting scheme (ranked 9th), moved from rural to urban area (ranked 10th) and change from farming to other occupation (ranked 11th), change from crop to livestock (ranked 12th) while farm insurance (ranked 13th).

The findings also tally with Idrisal (2012), also reported that recurrent drought in Borno State, Nigeria could be curbed with strategies such as mixed cropping, mixed farming and change in varieties of crop. The results of the Focus Group Discussion supports this finding. An excerpt from the opinion of Mamam in Kpotegi village and Ndaasabe in Emiworogi village

“Planting of trees for shading is the first coping strategies we employed to reduce the impact of climate variability in this our area, while mixed farming is next, good cultural practice, change in planting date, mixed cropping, mixed farming, intensive irrigation, engage in off-farming activities, water harvesting scheme, move from rural to urban, change from farming to other occupation, change from crop to livestock and farm insurance. Most of us did not insured our farms it is the last strategy adopted.

Table 4.10: Adaptation Strategies employed by Respondents to climate variability in Ebbo District

Adaptation Strategies to Climate Change	Mean (RII)	Rank
Planting of trees for shading	8.57	1 st
Change crop varieties	8.52	2 nd
Change planting date	7.10	3 rd
Practice mixed cropping	7.00	4 th
Good cultural practices such as mulching	6.98	5 th
Practice mixed farming	6.86	6 th
Practice more irrigation	6.71	7 th
Engaged in off-farming activities	6.58	8 th
Practice water harvesting scheme	6.58	9 th
Moved from rural to urban area	6.57	10 th
Change from farming to other occupation	6.53	11 th
Change from crop to livestock	6.50	12 th
Farm insurance	2.10	13 th

Sources: Field survey, 2019

The result presented in Table 4.10 shows that planting of trees for shading and change in crop varieties were rank 1st and 2nd respectively as adaptation strategies to change in climate variability. Also, change planting date, good cultural practices and mixed cropping were (ranked 3rd, 4th and 5th respectively). Other adaptation strategies to climate variability are mixed farming (ranked 6th), intensive irrigation (ranked 7th), engage in off-farming activities (ranked 8th), water harvesting scheme (ranked 9th), moved from rural

to urban area (ranked 10th) and change from farming to other occupation (ranked 11th), change from crop to livestock (ranked 12th) while farm insurance (ranked 13th).

The findings also tally with Idrisal (2012), also reported that recurrent drought in Borno State, Nigeria could be curbed with strategies such as mixed cropping, mixed farming and change in varieties of crop. During the Focus Group Discussion is line with this finding. Adiscussant Baba Ndagi in Baka-Fifin village said

“Planting of trees for shading is the first coping strategies we employed to reduce the impact of climate variability in this our area, while mixed farming is next, others are change in planting date, mixed cropping, good cultural practices, mixed cropping, mixed farming, intensive irrigation, engage in off-farming activities, water harvesting scheme, move from rural to urban, change from farming to other occupation, change from crop to livestock and farm insurance is the last strategy adopted as most of us did not insured our farms.

4.5 Effective Adaptation Strategies to Climate Variability

4.5.1 Effectiveness of the adaptation strategies

Effectiveness of farmers' adaptation strategies to climate variability in the study area is shown in Figure

4.12

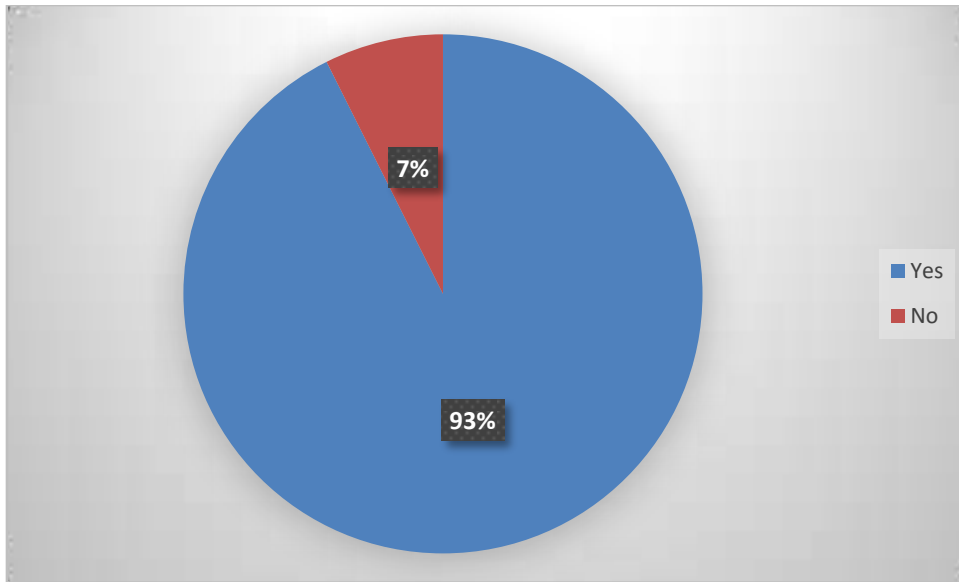


Figure 4.12: Effectiveness of Adaptation Strategies

Sources: Field survey, 2019

Figure 4.12 shows that 93% of the respondents agreed that adaptation strategies were effective to reduce impact of hazards posed by climate variability while 7% disagreed that adaptation strategies were effective to reduce the effect of hazards posed by climate variability. This implies that majority of the respondents believed that adaptation of various strategies are effective and could reduce impact of hazards in the study area. According to Kandjinkar and Risbey(2000) in agriculture, adaptation helps farmers achieve their food, income and livelihood security objectives in the face of changing climatic and socio-economic conditions including climatic variability, extreme weather conditions such as droughts and floods and volatile short term changes in local and large-scale markets. During Focus Group Discussion a discussant said

“The adopted strategies are helping us in reducing the impact of the climate related hazards in our farming activities, intensive irrigation would have been better but it involve high capital which we cannot raise”.

4.5.2 Most effective Adaptation Strategies to Climate Variability

The most effective adopted strategies to combat hazards caused by climate variability in BirninMazadi district is revealed in Table 4.11

Adaptation Strategies to Climate Variability	Mean	Rank
Practice intensive irrigation	16.97	1 th
Practice run-off water harvesting	13.72	2 nd
Planting of trees for shading	13.44	3 rd
Change crop varieties	11.20	4 th
Change planting date	10.98	5 th
Good cultural practices such as mulching	10.82	6 th
Practice mixed cropping	9.71	7 th
Practice mixed farming	9.58	8 th
Farm Insurance	3.58	9 th

Sources: Field survey, 2019

The result presented in Table 4.11 shows that intensive irrigation and collection of run-off water harvesting (ranked 1st and 2nd respectively) as the most effective adaptation strategies to climate related hazard, planting of trees for shading, change crop varieties and change planting date (ranked 3rd, 4th and 5th respectively). Other effective adaptation strategies to climate variability are good cultural practices such as mulching (ranked 6th), mixed cropping (ranked 7th), mixed farming and farm insurance (ranked 8th and 9th). The finding agreed with Oyewole (2015) which indicated that practice of mixed farming, planting of trees for shading, changing in plant date, practice more irrigation and engagement in off-farm activities were the most effective strategies to prolonged change in rainfall in Nigeria.

The results of the Focus Group Discussion concluded in Etsugi village can be summoned that:

“Various strategies we employed here positively affect our farming output as they increase our crop yield, enhance timely cropping, increase timely crop maturity, increase quality of our crop yield, enhance good cropping germination and increase our income level”.

The most effective adopted strategies to combat hazards caused by climate variability in Gulu district is revealed in Table 4.12

Adaptation Strategies to Climate Variability	Mean	Rank
Practice more irrigation	17.77	1 th
Practice run-off water harvesting	14.82	2 nd
Good cultural practices such as mulching	12.44	3 rd
Practice mixed cropping	13.30	4 th
Farm Insurance	11.98	5 th
Planting of trees for shading	9.82	6 th
Change crop varieties	9.71	7 th
Change planting date	7.58	8 th
Practice mixed farming	2.58	9 th

Sources: Field survey, 2019

The result presented in Table 4.12 showed that practice more irrigation and practice run-off water harvesting (ranked 1st and 2nd respectively) as the most effective adaptation strategies to hazards caused by climate variability, good cultural practices, practice mixed cropping and farm insurance (ranked 3rd, 4th and 5th respectively). Other effective adaptation strategies to combat hazards posed by climate variability are planting of trees for shading (ranked 6th), change crop varieties (ranked 7th), change planting date and mixed farming (ranked 8th and 9th). The finding agreed with Stephen (2015) who reported that practice of mixed cropping, change in crop varieties and change in planting date were the most successful adaptation strategies to flood in Edo State.

The results of the Focus Group Discussion concluded in Hasheyimi village can be summoned that:

“The strategies we adopted in this our area have positively affected our farming output as our crops are growing normal, they increase our crop yield, increase timely crop maturity, increase quality of our crop yield, enhance timely cropping, enhance good cropping germination and increase our income level,

Danasabe is with opinion that:

Irrigation system would have been the best for all of us to adopt but we do not have money to adopt it”.

The most effective adopted strategies to combat hazards caused by climate variability in Ebbo district is revealed in Table 4.13

Adaptation Strategies to Climate Variability	Mean	Rank
Planting of trees for shading	15.97	1 th
Good cultural practices such as mulching	14.72	2 nd
Practice more irrigation	13.44	3 rd
Practice run-off water harvesting	12.20	4 th
Change crop varieties	11.48	5 th
Change planting date	10.82	6 th
Practice mixed cropping	9.81	7 th
Practice mixed farming	9.78	8 th
Farm Insurance	1.78	9 th

Sources: Field survey, 2019

The result presented in Table 4.13 shows that planting of trees for shading, good cultural practices (ranked 1st and 2nd respectively) as the most effective adaptation strategies to climate change related hazard, intensive irrigation system, practice run-off water harvesting and change crop varieties (ranked 3rd, 4th and 5th respectively). Other effective adaptation strategies to climate variability are change planting date (ranked 6th), mixed cropping (ranked 7th), mixed farming and farm insurance (ranked 8th and 9th). The finding tally with Ngigi(2009) which indicated that the use of drought-resistant crop varieties have been tried by smallholder farmers as adaptation methods to climate change in Nigeria, Senegal, Burkina Faso and Ghana.

The results of the Focus Group Discussion concluded in Ebbo village can be summoned that:

“We in Ebbo district employed various strategies which have been positively affecting our farming output as they increase our income level increase our crop

yield, enhance timely cropping, increase timely crop maturity, increase quality of our crop yield and enhance good cropping germination,

Liman Musa observed that:

we need guide on insurance system so that we can equally adopt it as it is been done in some area like Kano”.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

The purpose of this study is to assess the climate variability adaptation strategies by crop farmers in Lapai Local Government Area, Niger State, Nigeria. Data were collected using questionnaire and Focus Group Discussion and analyzed using different statistics such as simple descriptive statistic, relative impact index (RII), Friedman's non parametric test and pairwise comparison matrix. The findings revealed that 61.8% of respondents were males while 38.2% were females. It also shows that majority of respondents are in their active age, range of between of 46-60 years. Also, majority are married across the three districts, while less no are divorced and widower. Moreover, in Birnin maza 42.2% of the respondents had primary education while 28% had Quranic education, in Gulu 46.5% of the respondents had primary education while 31.1% had Quranic education and in Ebbo 52% of the respondents had primary education while 20.4% had Quranic education. Further findings revealed that 98.4% of the respondents were migrants while 1.6% were non migrants. About 97.1% of the respondents were full time farmers while 58% of the respondents had between 46-60 years in farming in Birnin maza, 52% in Gulu and 62.7% in Ebbo, 45.1% had between 21-30 years in farming in Birnin maza, 38.3% in Gulu and 51.8% had between 21-30 years farming experience.

The identified hazards caused by climate change are increase in pest and disease, flood, drought and soil erosion. Majority (43.9%) of the respondents have noticed increase in pest and disease infestation on crops in Birnin Maza, 54.5% of the respondents in Gulu claimed to have experienced increasing in pest and disease, while 51.9% of the respondents witnessed increase in flooding.

Further findings revealed that respondents had noticed effect of change variability on their farming activities, 23% and 20.1% of the respondents noticed increase in pest and disease infestation on crops and increase in soil erosion due to climate change while 15.2%, 15%, 14.1%, 8.1%, 2.5% and 2% of the respondents had delay cropping, destruction of crops, flooding of crops, delayed crop maturity, poor germination of seeds and reduced crop yield quantity respectively as a result of climate variability.

Respondents in Birnin maza Planted trees for shading and change in crop varieties which (ranked 1st and 2nd respectively) as the adaptation strategies practiced to change in climate variability, mixed farming, change planting date and change from crop to livestock (ranked 3rd, 4th and 5th respectively). Other adaptation strategies to climate variability are intensive irrigation (ranked 6th), practice mixed cropping (ranked 7th), engaged in off-farming activities and practice water harvesting scheme (ranked 8th and 9th), moved from rural to urban area (ranked 10th), change from farming to other occupation (ranked 11th), good cultural practices such as mulching (ranked 12th) and farm insurance (ranked 13th).

Intensive irrigation system and harvest of run-off water (ranked 1st and 2nd respectively) as the most adaptation strategies practiced by the farmers to change variability in Birnin maza, planting trees for shading (ranked 3rd), change in crop varieties (ranked 4th), change in planting date (ranked 5th), good cultural practices such as mulching (ranked 6th), mixed cropping (ranked 7th), mixed farming (ranked 8th) while farm insurance (ranked 9th).

5.2 Conclusion

Increase pest and disease infestation, flooding, drought and soil erosion are the major hazards identified in Lapai LGA. Increase in pest and disease infestation on crops and increase in soil erosion were the major impact of climate variability on cropping activities in the study area. The prevalent climate variability strategies adopted in the study area are intensive irrigation, planting of trees for shading, change in crop varieties and mixed farming (ranked 1st, 2nd, 3rd and 4th respectively). The most effective adaptation strategies to climate change practiced by farmers are intensive irrigation, planting of trees for shading, change in crop varieties and practice of mixed farming.

5.3 Recommendations

Based on the findings of this study, the following recommendations were made:

1. Early warning system to create awareness about impending hazards in the communities of the study area should be encouraged by the Local and State government.
2. Findings revealed that the literacy level of farmers in the study area was low, so, farmers should be encouraged by Local Government Council to attain more formal education in order improve their capacity and to be able to assess more climate variability strategies to effectively fight against the menace of climate variability.
3. Lapai Local Government Council need to encourage use of supplementary irrigation systems so as to irrigate the land during the period of water deficiencies in Lapai Local Government Area.
4. There is need for the State and Local Government Authorities to create awareness on integrated agricultural water management interventions and train the smallholder farmers and Agricultural extension staff at Local, State and Federal Government.
5. Planting of trees for shading which ranked 1st as the most adopted strategies to change in temperature and change in rainfall and practice of mixed farming which ranked 1st as the most

adopted strategies to change in flood and change in drought should be encouraged by Local Government Council to curb deforestation in the area.

5.4 Contribution to knowledge

1. This work has contributed immensely in identification and understanding climate change induced hazards, and the possible impact of climate variability hazards on crops.
2. Prior to this, respondents were limited to their own coping strategies. They now have knowledge of other strategies and possible ways to increase their resilience in case of emergency or disaster.
3. The Government at Local and State level also have knowledge of existing climate change induced hazards, adaptation strategies and coping capacity within the study area. It also opened the existing gap of climate change impact in the study area and other part of the state.
4. This study also exposed most effective adaptation strategies such as (irrigation scheme and farm insurance) to climate variability and not sustainable in the study area which becomes a gap for further academy studies.

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APPENDIX I



Plate 1: Eroded Farm in kpotegi Community (Gulu distict)



Plate 2: Eroded Farm in Gupa Community (Gulu district)



Plate 3: Flooded Rice Farm in Nyanbabo Community (Ebbo district)



Plate 4: Flooded Rice Farm in Baka-fifin (Ebbo district)



Plate 5: Deposits in Farm Land at Doba Community (Gulu district)



Plate 6: Poorly Perform Crops due to Toxic Substances Deposited in Lapaigi Community (Gulu distict)



Plate 7: Damaged Maize Crops due to Prevalent of Pest attack as a result of increase Temperature in Emiworogi Community (Gulu district)



Plate 8: Damaged Maize Crops due to Pest Prevalent as a result of increase Temperature in Etsugi Community (BirninMaza District)



**Plate 9: Poorly Performed Crops due to Toxic Substances Deposited in Jimada Community
(BirninMaza distict)**

APPENDIX II

QUESTIONNAIRE

INTRODUCTION

I am a Master of Philosophy degree student with registration no P17PSGS9026 of Centre for Disaster Risk Management and Development Studies, Ahmadu Bello University, Zaria. Conducting a research on climate variability adaptation strategies among crop farmers in Lapai Local Government Area (LGA), Niger State, Nigeria.

This questionnaire is aimed at getting information from inhabitants at the study area. The information gathered will be used as data for all the objectives listed in this research work. The information received from the respondents will be treated as confidential and will be used only for the purpose of this research.

Instruction: Please tick (✓) where necessary; and fill in the blanks where necessary too.

SECTION A: PERSONAL DATA

1. Location.....

2. Sex: (a) Male () (b) Female ()

3. Age: (a) 20 – 45 () (b) 46 – 60 () (c) 61 – 75 ()

4. Marital status:
(a) Single () (b) Married () (c) Widow/widower ()
(d) Divorced ()

5. Education (highest attained):
(a) Primary () (b) Secondary () (c) Tertiary () (d) Qur'an ()

6. Migration (Were you born in this community?): (a) Yes () (b) No ()

7. Is farming your major occupation? (a) Yes () (b) No ()

8. How long have you been farming? Years

SECTION B: WHAT ARE THE TYPE OF HAZARDS CAUSED BY CLIMATE VARIABILITY

- 9. Have you noticed any variability change in climate over the past 5 years? (a) Yes () (b) No ()
- 10. Please state types of hazards caused by climate variability.....

SECTION C: CLIMATE VARIABILITY IMPACTS ON FARMING ACTIVITIES

- 11. Have you noticed any impact of variability in climate on your farming activities over the past 20 years? (a) Yes () (b) No ()
- 12. If yes, what specific impacts due to variability in climate on your farming activities over the past 20 years? (a) Delayed cropping () (b) Poor crop germination () (c) Delayed crop maturity () (d) Increase of pest and disease () (e) Reduced quality of yield () (f) flooding of crop () (g) Destruction of crops () (h) Increase soil erosion () Others (Specify).....
- 13. Have you noticed any change in the level of your income over the past 5 years due to any long-term Changes in climate (a) Yes () (b) No ()

SECTION D: FARMERS' ADAPTATION STRATEGIES

- 14. What specific strategies have you adopted against any climate variability over the past 5 years? (a) Plant trees for shading () (b) Practice mixed farming () (c) Change from crop to livestock production () (d) Practice more irrigation () (e) Change crop varieties () (f) practice mixed cropping () (g) Practice water harvesting scheme () (h) Change from farming to other occupation () (i) Moved from rural to urban area () (j) Engaged in off-farm income activities () (k) Change planting dates () (l) Good cultural practices such as mulching and supplying of seedlings () (m) farm insurance () other (specify).....

SECTION E: EFFECTIVENESS OF FARMERS' ADAPTATION STRATEGIES TO CLIMATE VARIABILITY

- 15. Are your adaptation strategies effective to combat hazard posed by climate variability? (a) Yes () (b) No ()
- 16. What adaptation strategies employed is most effective to combat the impact of climate variability on cropping activities? (a) Plant trees for shading () (b) Practice mixed farming () (c) Change

from crop to livestock production () (d) Practice more irrigation () (e) Change crop varieties ()
(f) practice mixed cropping () (g) Practice water harvesting scheme () (h) Change from farming
to other occupation () (i) Moved from rural to urban area () (j) Engaged in off-farm income
activities () (k) Change planting dates () (l) Good cultural practices such as mulching and
supplying of seedlings () (m) farm insurance () other
(specify).....

APPENDIX III

Focus Group Discussion (FGD) guides:

FARMERS' CLIMATE VARIABILITY IMPACT ON CROPPING ACTIVITIES

1. What types of hazard do you experience? (Specify)
2. What are the impacts of the hazards noticed on cropping activities? (Specify)
.....
3. What are the coping strategies employed to reduce the impact of the hazards on cropping activities? (Specify)
4. What are the most effective strategies adopted to reduce the impact of climate change on cropping activities?(Specify).....