AN ASSESSMENT OF FARMERS' ADAPTATION STRATEGIES TO CLIMATE CHANGE IN PARTS OF YOBE STATE, NIGERIA

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SEPTEMBER, 2016

DECLARATION

I declare that the work in this dissertation entitled AN ASSESSMENT OF THE FARMERS' ADAPTATION STRATEGIES TO CLIMATE CHANGE IN PARTS OF YOBE STATE; NIGERIA has been carried out by me in the Department of Geography, Ahmadu Bello University, Zaria. The information derived from literature has been duly acknowledged in the text and a list of references provided. No part of this dessertation was previously presented for another degree or diploma at this or any other institution.

Ahmad AUDU _____ _____

Signature Date

CERTIFICATION

This dissertation entitled AN ASSESSMENT OF FARMERS' ADAPTATION STRATEGIES TO CLIMATE CHANGE IN PARTS OF YOBE STATE; NIGERIA by Ahmad AUDU meets the regulations governing the award of a Master Degree in Geography of the Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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Signature Date

DEDICATION

This piece of work is dedicated to all my well-wishers and students of knowledge who may find it interesting in their academic life.

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ABSTRACT

This research assessed the farmers' adaptation strategies to climate change in parts of Yobe state. The objectives of the research are to analyze trends of rainfall and temperature; analyze trends on the onset; cessation and length of the rainy season; assess the effect of climate change in the study area; analyze the adaptation strategies to climate change and determine the most preferred adaptation strategy to climate change in the study area. Rainfall and temperature data for forty (40) years (1975 to 2014) were sourced from the Nigerian Meteorological Agency (NIMET) Nguru station. Means of annual rainfall and temperature for some selected months were also determined. Trends in annual rainfall and temperature were subjected to time series analysis and linear trend and trend line equations were fitted on each and the direction of change was determined. Onset and cessation dates and length of rainy season were determined as well. They were also subjected to time series analysis. In assessing the effect of climate change in the environment and farmers' adaptation strategies to these impacts, questionnaire was used to solicit information from a total of 350 respondents which were sampled from twelve sampled wards in the four LGA using purposive and systematic random sampling technique. The result revealed that there is a significant increase in annual rainfall in the study area. Rainfall trends in June, August and September showed a positive (upward) trend. The 5-year and 10-year running mean showed values below the annual long-term mean of 427mm in 1970s, 1980s and mid-1990s. Then steady and increased rainfall above the annual long term mean from early 2000s to the end of the study period. The annual maximum rainfall (712.1mm) was recorded in 2014, while the annual minimum rainfall (224.7mm) was recorded in 1983. Downward trend in annual temperature was observed with yearly fluctuations centered around the long term annual mean of 32.4^0 C. Mean monthly temperature trends for December, April and May showed a negative trend, while an upward (positive) trend in January mean temperature was recorded. Marked noises in onset and cessation dates created uncertainty in determination of planting time in the study area. The average onset date is 10^{th} July with the earliest onset date 30^{th} May in 2002 and the latest onset was 18^{th} August in 1991. Although an upward trend in cessation date was recorded, the earliest cessation date was 4^{th} August in 1984 and the latest was 17^{th} Oct. in 1976. Result from the social field survey revealed that desertification, drought, heavy rainfall, loss of biodiversity, high solar intensity, poverty, unemployment, reduction in farm yields, loss of soil fertility, hunger and starvation, high rate of disease incidence, scarcity of foodstuff, are some of the effect of climate change identified by the respondents. The farmers have therefore been able to employ some adaptation strategies as means of combating climate stress such as planting of early maturing crops, use of drought resistant varieties, intensive manure application, change in planting and harvesting dates, movement to different site, multiple cropping, use of insecticides and pesticides, irrigation practices and southward migration. Analysis from pair wise comparison matrix revealed that planting of early maturing crop is the strongest or most preferred adaptation strategy in the study area. The research concludes that the annual rainfall has increased but the frequency of the rainy events is declining in the study area. However, many adaptation strategies are recommended by this study: - The use of more resistant varieties of millet such as pearl

millet (*Pennisetum glaucum),* soil conservation practices such as mulching and crop rotation to control pest attack, subsidized new model stove, kerosene and cooking gas to reduce deforestation, should all be encouraged by government. Research centres and institutes that will update the farmers on climate change related issues should be established and monitored.

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CHAPTER ONE: INTRODUCTION

1.1 General Background to the Study

The global climate has changed rapidly with a global mean temperature increase of 0.7^0C within the last century (Inter-governmental Panel on Climate Change, 2007). However, the rate of change is significantly different among regions. This is primarily due to the varied types of land resources with different surface albedos, evapotranspiration and carbon cycle affecting the climate in different ways (Meissner, Weaver, Matthew and Cox, 2003; Synder, Delire and Foley, 2004). According to the Intergovernmental Panel on Climate Change (IPCC, 2007) in the fourth assessment report, climate change is a change in the state of the climate that can be identified (e.g. using statistical tests) by the changes in the mean of temperature, precipitation and wind pattern, and that persists for an extended period typically decades or longer. Climate change is therefore the statistically significant deviation or shift from the average weather conditions of climatic elements. The change could be limited to a specific region or may occur across the globe.

Climate Change is defined in the Article 1 of the United Nations Framework Convention on Climate Change (UNFCCC: 1992), 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 in addition to natural climatic variability observed over comparable time periods". Climate Change is principally caused by the emission of greenhouse gases into the atmosphere from energy production and consumption. The energy sector is responsible for 84% of global CO_2 emissions and 64% of the world's greenhouse-gas emissions (International Energy Agency, 2009). The greenhouse gases include Carbon dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Sulphur Dioxide (SO_2), Hydrofluorocarbons (HFCs), Hydrochloroflourocarbons (HCFCs), and Carbon

Monoxide (CO). Most of the outgoing heat is absorbed by these greenhouse gas molecules and re-emitted in all directions, warming the surface of the earth and the lower atmosphere causing global warming. Global warming according to De Chavez and Tauli-Corpus (2008) is the average increase in the earth's surface temperature and ocean as compared to previous centuries.

The Intergovernmental Panel on Climate Change (IPCC, 2007) fourth assessment report predicted that Africa is highly vulnerable to the various manifestations of climate change and had affirmed that reservations about climate change are inappropriate considering apparent evidences from scientific observations of increase in global average air and ocean temperatures. Ayoade, (1995); Olaniran, (2002) affirmed that the growing climatic variations and the resultant increase in temperature have plunged some localities into experiencing excessive weather conditions in the form of floods, droughts, famine and heat waves, ensuing devastating effects on human existence, agricultural productivity and food security, with many households affected by low economic status.

Adaptive capacity to climate is the ability of a system to adjust or cope with actual or expected climate stresses. Sensitivity is the degree to which a system is either adversely affected or beneficial by climate change stimuli, whereas exposure to climate vagaries is the nature and degree to which a system is exposed to climate variations (IPCC, 2001). Adaptation could be proactive also referred to as planned. This requires assessing the vulnerability of natural, man-made system as well as costs benefits of actions versus inactions, and planning alternatives accordingly. Adaptation could also be reactionary which means actions are taken to reduce the impact or take advantage of the opportunities filed up (Omolola, 2009).

The African continent spans a huge range of climate, from equatorial to tropical, desert and subtropical on both sides of the equator. Much of Africa (around 40 percent) is dryland, receiving less than 1000mm of mean annual rainfall in short rainy seasons, the remaining months being absolutely or relatively rainless (UNEP, 2006). High temperatures during the tropical rainy season cause much of the rainfall to be lost in evaporation, and the high intensity of storms may cause much of it to run off in floods. Frequent and unpredicted droughts and occasional floods cause high level of risk in farming and livestock production. In the Sahel, Africa's biggest dryland, there was a decline of up to 33% in the average rainfall between the periods 1931-1960 and 1961-1990 (Hulme, 1992).

The causes of global climate change are both natural and anthropogenic. Most often, these changes have been attributed to natural changes such as the earth's orbital cycle, ocean variability, solar radiation and other physical occurrences like earthquakes, plate tectonics, volcanic eruptions, landslides, heat waves e.t.c. (IPCC, 2001; Ayoade, 2003). Moreover, several researchers (De Weerdt, 2007; Odjugo, 2007) have recently shown that for the past few decades, anthropogenic factors like urbanization, deforestation, population explosion, industrialization and the release of greenhouse gases (i.e. carbon dioxide, chlorofluorocarbon, aerosols, methane etc.) into the atmosphere are the major contributing factors to the depletion of the ozone layer and its associated global warming and climate change.

Already, climate change rate is gradually exceeding the adaptive capacity of a wide range of crops and tree population used in Nigeria ten years earlier than the prediction of the IPCC's climate model prediction of 2020 (IPCC, 2007). Food production and access to food in many dry parts of the country is becoming more expensive and in some cases scarce, severely compromised, exacerbating food security problems, malnutrition, poverty, hunger, diseases and

communal conflicts resulting from the loss of 92,000 hectares of land to drought and desertification (Commission for Sustainable Development, 2008). Researchers have linked these problems to climate change which invariably affects crop production in Sub-Saharan Africa (Odjugo and Ikhuoria, 2003; NEST, 2003; Chindu and Nyelong, 2005; Adefolalu, 2007; Ikhile, 2007).

One of the world's major ecosystems, the drylands (Yobe State inclusive) have long lived with uncertainty and the threat of unsustainability, where moisture is scarce for most parts of the year,(short duration of rainy season) and soils for the most part are infertile (Mortimore, 2009). Many dryland people have developed resilience under hardship, variability and risk that is based on historic and current adaptive knowledge and skills. Such skills are increasingly recognized, though, it is commonly claimed that such capacities employed by inhabitants of the drylands are not sufficient to cope with the speed of change, especially in the climate. Nevertheless, if better known and understood, they may contribute to development (Mortimore, 2009).

1.2 Statement of the Research Problem

In spite of man's remarkable development in science and technology, his economy and social welfare is still dependent on climate which is affected by long-term and short-term fluctuations in climate (Dey, 1982). Several studies have been carried out especially in the semi-arid regions of the world to assess the biophysical vulnerability as well as coping strategies and/or adaptation strategies to climate change. Du, Wang and Yang (2008) carried out a study on Impacts of Climate Change on Human Health and Adaptation Strategies in South China. The study revealed that the daily mean surface air temperatures above or below 26.4°C increase the death risk for the people in Guangzhou, especially the elderly ones which are more vulnerable to variations in

temperature. The risk of non-accidental deaths and respiratory disease deaths significantly rise as well. Hirsch, Johnston, Neill, Webber and Williamson (2009) undertook a study on climate change impacts and adaptation strategies for the forest sector in Canada. The study revealed that many forest species are moving to the poles or higher altitudes in response to shifts in the habitats to which the species have adapted. It also revealed fewer extreme cold days and nights, fewer forest days, more extreme warmer days and nights, decrease in annual total snowfall (southern Canada) are now being experienced. Garnet *et al*, (2013) carried a study on Climate change adaptation strategies for Australian birds. Eighteen (18) climate models were deployed all of which predicted that the rainforest avifauna of Cape York Peninsula is likely to face the strongest challenge from climate change and Kangaroo Island is most likely to lose climate space. Fire management, weed and feral animal control and, for marine taxa, controls on fishing were suggested as important actions to be taken against climate stress.

Bruce *et al*, (2013) carried out a research on Climate change vulnerability and adaptation strategies in Egypt's agricultural sector using a partial equilibrium model that simulates crop and livestock production. It revealed that climate change has damaged the Egyptian agricultural sector and the damages increase over time. Price for agricultural commodities has increased which has a negative impact on consumers.

Franklin, Gifty and Samel (2014) undertook a study on determinants of choice of climate change adaptation strategies in northern Ghana using semi-structured questionnaire. The empirical result of the binary logistic regression models revealed that farming experience, farmer's income, access to phones, mixed farming, farmer's perception on reduction in rainfall amount and access

to weather information significantly and positively affects the choice of climate adaptation strategies.

Nigeria, like many other parts of the world has witnessed many climatic anomalies with serious consequences on the environment and society. Recent studies have shown that the Sudano-Sahel zone of northern Nigeria especially has suffered decrease in rainfall in the range of 30-40% per decade since the beginning of nineteenth century (Ojo, 1985; Adejuwon, Bologun, and Adejowon, 1990). The increasing temperature and decreasing rainfall in the semi-arid region of northern Nigeria- Sokoto, Katsina, Kano, Yobe and Borno may have resulted in the increasing evapotranspiration, drought and desertification in the region (Odjugo and Ikhuoria, 2003 and Adefolalu, 2007). Gashua (1991) carried out a research on an evaluation of indigenous techniques of coping with drought in Bade Local Government Area of Yobe State. The research revealed that farming community of Bade perceives drought as its most serious ecological problem and measures for its mitigation have been evolved to reduce its effects. The emphasis here was exclusively on drought and indigenous techniques. Abubakar (2010) carried a study on farmers coping strategies to climate change in Jibya Local Government Area of Katsina State, using interview method, the researcher found that there were great loss in livestock and significant reduction in crop production due to climatic variations. In the same vein, Audu (2012) undertook a study on adaptation strategies to desertification in Yobe North, using questionnaire method. The study revealed that the most effective strategies employed by the dwellers of the environment are planting of shelter belts and southward migration. However, the study centered on desertification and never analyzed issues concerning climate change.

Similarly, Solomon (2014) carried out a study on biophysical and socioeconomic vulnerability of climate change on grain farmers and the adaptive strategies in Shinkafi Local Government Area

of Zamfara State. The research revealed that the rainfall was normally distributed at 95% confidence level and the grain farmers have adopted traditional means of combating climatic stress such as mulching and shifting cultivation. The emphasis here was on grain farmers alone. Farauta, Egbule, Idrisa and Agu. (2011) undertook a study on farmers' adaptation initiatives to the impact of climate change on agriculture in Northern Nigeria. Quantitative and qualitative approaches (Rapid Rural Appraisal, focus group discussions, and semi – structured interview schedule) were used. Their findings revealed that majority of the farmers are aware and knowledgeable of climate change and, measures adapted are; changes in planting and harvesting dates, intensive manure application, multiple cropping and shift to different places. However, Yobe State was not sampled in the study.

With reference to the available literature reviewed, (Abubakar, 2010; Audu, 2012; Bruce *et al,* 2013; Du Yao Dong *et al*, 2008; Franklin, Gifty and Samuel, 2014Garnet *et al,* 2013; Farauta *et al,* 2011; Gashua, 1991; Hirsch, Johnston, Neill, Webber and Williamson 2009, and Solomon, 2014), it can be seen clearly at a glance that there are no much studies on climate change adaptation strategies in the study area. Even Gashua (1991) did not consider the four LGAs worst hit by desertification in the extreme northern parts of Yobe. The areas are worst hit by desertification because over grazing and over exploitation of marginal lands have aggravated desertification and drought. The entire villages and major access roads have been buried under sand dunes in this extreme northern part of Yobe. Moreover, the effect of climate change is becoming more pronounced. In this area also invasion by sand inhibits many economic activities. Houses and farmlands are frequently submerged by sand. Wells are drying up. According to an indigene of the area; **Yusuf Darama**, Toshia village in Yobe State: "I am a farmer. The most serious problem we face here in Toshia is poverty. I am begging God and the government of

Yobe State to help us and our parents. And then there is the desert... it is our main worry. We don't even have roads to bring food into our village – the desert is too much." The 1991 study of Gashua can no longer represent the current situation. This study will therefore assess farmers' adaptation strategies to climate change in the four LGAs (Karasuwa, Machina, Yusufari and Yunusari) that are worst hit by desertification. Hence the research addresses the following questions:

i. What are the trends of rainfall and temperature from 1975-2014 in the study area?
ii. What are the onset, cessation and length of the rainy season in the study area?
iii. What are the effects of climate change in the study area?
iv. What are the adaptive strategies to mitigate the impacts of climate change in the Study area?
v. What is the most preferred adaptation strategy to climate change in the study area?

1.3 Aim and Objectives

1.3.1 Aim

The aim of this research is to assess the farmers' adaptation strategies to climate change in parts of Yobe State.

1.3.2 Objectives

The specific objectives are to:

i. analyze trends of rainfall and temperature from 1975 to 2014 in the study area;
ii. analyze the trends on the onset, cessation and length of the rainy season from 1975 to 2014 in the study area;

iii. assess the effects of climate change on environment, agriculture, human health and economic activities in the study area;

iv. analyze the adaptation strategies to climate change in the study area

v. determine the most preferred adaptation strategy to climate change in the study area.

1.4 Scope and Limitation of the Study

The study is restricted to four Local Governments in Yobe North (Karasuwa, Machina, Yunusari and Yusufari) that are worst hit by desertification. The scope of the study in terms of content is to assess the adaptation strategies to climate change in parts of Yobe North. The study covers the period of forty (40) years from 1975 to 2014. Due to the limited time and resources, the researcher could not cover the entire six LGA in Yobe North.

1.5 Significance of the Study

Yobe State by its geography is more vulnerable to the impacts of climate change especially northern part of the state as it is located at the fringes of the Sahara desert. The increasing intensity of climate change is further highlighted by the report of Hir (2010), where it was noted by a team of experts from Network of Nigerian Environmental Study/Action Team (NEST), one of the groups studying Nigerians' adaptation to the effects of climate change, has warned that sand dunes and the harsh arid climate in Sahel area of Toshia in Yobe State of North-Eastern Nigeria, are evidence of climate change reality. The report further noted that for the third consecutive year of the report, this area in the extreme North East recorded below normal rainfall and higher than normal temperatures during the hot season. In addition to the low rainfall,

desertification (as a result of wind erosion), is of particular concern as encroaching sand dunes threaten the few surviving oases and even houses within the settlement.

Hence, study that addresses climatic trends and how the environment is adapting to the impacts of climate change in the study area is justifiable. The findings and recommendations of this research will go a long way to assist the people especially farmers in understanding fully how to respond to climate change scenario. It will also bring out the extend of vulnerability of the area to climate change and trends of climatic parameters especially rainfall and temperature. The research will equip the farmers with better climate change adaptation strategies. The research will also constitute a valuable source of data for future references

CHAPTER TWO: CONCEPTUAL FRAME WORK AND REVIEW OF RELATED LITERATURE

2.1 INTRODUCTION

This chapter reviews the literature that is considered relevant for this study. The review gave the researcher the opportunity to appraise previous works done on rainfall and temperature variability and trends especially in the sudano-sahelian region of Nigeria as well as climate change vulnerability and adaptation strategies employed by farmers in addressing climate change. Hence, this chapter is organized under the followings sub-headings:

2.2 CONCEPTUALIZATION OF CLIMATE CHANGE

The knowledge of climate variability over a period of instrumental records and beyond on different temporal and spatial scale is important to understand the nature of different climate systems and their impact on environment and society (Oguntunde, Abiodun and Gunnar, 2012). Climate today as we know is the synthesis of weather of a place over a long period of time (30years- 35years). By synthesis, we mean average conditions (smoothening the variations) over a long period. Therefore statistics such as mean and standard deviation are the most initial point of analysis and the longer the length of statistics, the better the results. The World Meteorological organization (WMO) recommended the use of 30 years to derive the climate of a place because it is believed that a period of 30years is sufficient for calculating climate normal, whether of temperature or rainfall (Ayoade, 2003).

However, because climatic variations occur in both time and space, various terms have been used to describe the variations in climate on the basis of climate trends: The term **trend** is used when the change is discernable whether upward or downward in the values of the climatic element concerned. When these variations become periodical or cyclical, it becomes a **climatic cycle**.

When fluctuations or variations occur, in such a manner that a change in the prevailing climate of a place occurs, then we have a **climate change**.

2.2.1 Vulnerability to Climate Change

In order to effectively address the adaptation to climate change, it is essential to have a clear perception of vulnerabilities of ecological, economic and social system within a country. This will provide some guides as to the type of interventions each part of the country require and the financial resources needed (Francis and Theophilus, 2011).Vulnerability to climate change refers to the propensity of human and ecological systems to suffer harm and their ability to respond to stresses imposed as a result of climate change effects. The vulnerability of a society is influenced by its development path, physical exposures, and the distribution of resources, prior stresses and social and government institutions (Kelly and Adger, 2000; Jones, 2001; Yohe and Tol, 2002; O'Brien, Sygna and Haugen, 2004; Smit and Wandel, 2006).

However, the most authoritative definition of the term "vulnerability" in the context of climate change has been put forth by the Working Group II of the IPCC (2007): Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability therefore, is a function of the character, magnitude and rate of climate change and its variation to which a system is exposed, its sensitivity, and its adaptive capacity (Anna and Somya, 2014). Vulnerability to climate change is also defined by Klein and Smith (2006) as the degree to which geophysical, biological and socio-economic systems are susceptible to, and unable to cope with, adverse impacts of climate change. Three main elements which are more or less mutually exclusive are involved in any assessment of vulnerability. They include the;

i. Exposure of a system to climate variations,

ii. Its sensitivity and

iii. Adaptive capacity

2.2.1.1 *Exposure to Climate Change*

Exposure is the degree of climate stress to which a particular unit or system is exposed. The stress could be changes in climate conditions or variability in climatic behaviour including the magnitude and frequency of extreme events (O'Brien, Sygna and Haugen, 2004). Using agriculture as an illustration, the less dependent an agriculture system is to climate the less exposed it is. In this respect a well irrigated faming system will be less exposed to drought than a rain-fed system since its immediate source of water is not necessarily rainfall. It should be noted that the efficiency of the irrigation method in use will influence the vulnerability of the irrigation system itself. A system where the surface method of irrigation is dominant is more exposed than one with the drip method (Francis and Theophilus, 2011).

2.2.1.2 *Sensitivity to Climate Change*

Sensitivity is the degree to which a system is affected, adversely or otherwise, by climate-related stimuli'. It is the degree to which a system is modified or affected by an internal or external disturbance or set of disturbances. This measure, which reflects the responsiveness of a system to climatic influences, is influenced by both socioeconomic and ecological conditions and determines the degree to which a system will be affected by environmental stress.

2.2.1.3 *Adaptive Capacity*

Adaptive capacity is the ability or potential of a system to respond successfully to climate variability and change, and includes adjustments in both behaviour and in resources and technologies. The presence of adaptive capacity has been shown to be a necessary condition for the design and implementation of effective adaptation strategies so as to reduce the likelihood and the magnitude of harmful outcomes resulting from climate change (Brooks and Adger, 2005). Adaptive capacity also enables sectors and institutions to take advantage of opportunities or benefits from climate change, such as a longer growing season or increased potential for tourism.

All societies have inherent abilities to deal with certain variations in climate, yet adaptive capacities are unevenly distributed, both across countries and within societies. The poor and marginalized have historically been most at risk, and are most vulnerable to the impacts of climate change. Recent analyses in Africa, Asia and Latin America, for example, show that marginalized, primary resource-dependent livelihood groups are particularly vulnerable to climate change impacts if their natural resource base is severely stressed and degraded by overuse or if their governance systems are in or near a state of failure and hence not capable of responding effectively (Leary, 2006).

2.2.2 Effects of Climate Change on Agriculture in Nigeria

Despite technological advances, such as improved varieties, genetically modified organisms, and irrigation systems, weather is still a key factor in agricultural productivity, as well as soil properties and natural communities. The effect of climate on agriculture is related to variability in local climates rather than in global climate patterns. The Earth's average surface temperature

has increased by 1.5 °F (0.83 °C) since 1880. Consequently, agronomists consider any assessment has to be individually considering each local area. The effects of climate change on crop production, livestock production and public health in Nigeria are discussed below:

2.2.2.1 *Crop Production*

Irregular and unpredictable rainfall and sunshine hours (albedo and photoperiods) in Nigeria continue to take the toll on hitherto low-level harvests of rice, maize, cassava, melon, sorghum and yam with at least 2.5% decline of harvests per annum. Cocoa, cashew, oranges, kola nut, oil palm, rubber, cotton and coffee production suffer severe setbacks under reduced photoperiods with flower and fruit abortion trends that shot down annual yields by 5.5 metric tones/ha. Pest and disease incidences which become varied and uncontrollable under extreme weather events continue to cause decline in crop harvests, especially that of cowpea, tomatoes, pepper and groundnuts. Drought and flood extremes feature prominently north wards of the country, affecting crops farming and harvests as well as livestock production, the feed of which are mostly crop-based. Flooded farm lands/wetlands expansion cause arable land losses for crops within the areas with limited crop facility capacities and thus reduce root/tuber crops harvest (yam, cassava,. sweet potatoes, Irish potato and cocoyam) by at least (Idewu, *et al, 2011*).

2.2.2.2 *Livestock Production*

Climatic variations between the Northern and Southern parts contribute to the distribution of animals in the country. Generally, the large ruminants, geese, guinea fowls and turkeys are more common in the Northern parts of the country where rainfall and humidity are lower, the dry season is longer the diurnal and seasonal temperature fluctuations are wider. The availability of natural grasses for grazing is very limited and highly dependent on rainfall which is low in most

parts of the North. The Southern parts of the country which have more rainfall and more grazing are wetter and have more parasites and endemic diseases. This is because; high temperature and high humidity increase the rate of growth of parasites outside their host. Climatic stress reduces feed, water intake, grazing time and hence rate of growth and productivity.

High temperatures have hindered livestock (sheep and goat, cattle, poultry and piggery) production through retarded reproductive cycles, reduced meat and milk outputs, as well as their grazing lands. Livestock mortalities (stock losses) have increased in poultry, piggery and rodentary production systems to the level of at least 15% per annum. Animal production as well is affected by increases in disease and pests (including PPR, foot rot, mange, etc.) under the influence of climate change impacts that cut investment profits in livestock production system by more than 20% per annum (Idewu, *et al, 2011*).

2.2.2.3 *Public Health*

The attendant impact of climate change on the public health of the Nigeria's citizens' farming communities (over 70% of the population) was reported as follow:

i. Respiratory diseases due to increases in the level of pollutants.
ii. Malaria (in more widespread levels within the population (70% annually).
iii. Skin ailments (45% annually).
iv. Heat stroke (4% annually).
v. Loss of productivity (40% annually).
vi. Portable water shortages (60% annually) due to floods and/or saltwater intrusion (Idewu, *et al, 2011*).

2.2.3 Adaptation to Climate Change

Adaptation to climate change takes place through adjustments to reduce vulnerability or enhance resilience in response to observed or expected changes in climate and associated extreme weather events. Adaptation occurs in physical, ecological and human systems. It involves changes in social and environmental processes, perceptions of climate risk, practices and functions to reduce potential damages or to realize new opportunities. Adaptations include anticipatory and reactive actions, private and public initiatives, and can relate to projected changes in temperature and current climate variations and extremes that may be altered with climate change. In practice, adaptations tend to be on-going processes, reflecting many factors or stresses, rather than discrete measures to address climate change specifically (IPCC, 2007).

There are well-established observations of human adaptation to climate change over the course of human history (McIntosh, Tainter and McIntosh, 2000; Mortimore and Adams, 2001). Despite evidence of success stories, many individuals and societies still remain vulnerable to present-day climatic risks, which may be exacerbated by future climate change. Some adaptation measures are undertaken by individuals, while other types of adaptation are planned and implemented by governments on behalf of societies, sometimes in anticipation of change but mostly in response to experienced climatic events, especially extremes (Adger, 2003; Kahn, 2003; Klein and Smith, 2003). Adaptation is influenced by the quality of the resistance and resilience of a system. It is also affected by the readiness of a given system to act on the potential opportunities for adaptation. Systems that are resilient are able to return back to a steady state after a period of perturbation (Francis and Theophilus, 2011).

2.2.3.1 *Global Adaptation Practices*

Adaptation practices refer to actual adjustments, or changes in decision environments, which might ultimately enhance resilience or reduce vulnerability to observed or expected changes in climate (Burton and van Aalst, 2004; ADB, (2005). With an explicit focus on real-world behaviour, assessments of adaptation practices differ from the more theoretical assessments of potential responses or how such measures might reduce climate damages under hypothetical scenarios of climate change. According to IPCC FAR, 2007) adaptation practices can be differentiated along several dimensions:

i. By spatial scale (local, regional, national);
ii. By sector (water resources, agriculture, tourism, public health, and so on);
iii. By type of action (physical, technological, investment, regulatory, market);
iv. By actor (national or local government, international donors, private sector, NGOs, local communities and individuals);
v. By climatic zone (dryland, floodplains, mountains, Arctic, and so on);
vi. By baseline income/development level of the systems in which they are implemented (least-developed countries, middle-income countries, and developed countries); or
vii. By some combination of these and other categories.

Moreover, proactive practices to adapt to climate variability have advanced significantly in recent decades with the development of operational capability to forecast several months in advance the onset of El Niño and La Niña events related to ENSO (Cane, Zebiak and Dolan, 1986), as well as improvements in climate monitoring and remote sensing to provide better early

warnings on complex climate-related hazards (Dilley, 2000). Since the mid-1990s, a number of mechanisms have also been established to facilitate proactive adaptation to seasonal and interannual climate variability. These include institutions that generate and disseminate regular seasonal climate forecasts (National Oceanic and Atmospheric Administration, 1999), and the regular regional and national forums and implementation projects worldwide to engage with local and national decision makers to design and implement anticipatory adaptation measures in agriculture, water resource management, food security, and a number of other sectors (IPCC Fourth Assessment Report, 2007).

Furthermore, there are various types of adaptations that have been implemented by different countries around the world and a range of actors including individuals, communities, governments as well as the private sector. Measures involve a mix of institutional and behavioural responses, the use of technologies, and the design of climate resilient infrastructure. They are typically undertaken in response to multiple risks, and often as part of existing processes or programmes, such as livelihood enhancement, water resource management and drought relief. Table 2.1 shows various adaptation initiatives undertaken by different countries and regions across the globe relative to present climate risk and conditions associated with climate change.

Table: 2.1 Examples of Adaptation Initiatives by Region to Climate Risks and Conditions

REGION/COUNTRY	Climate-related stress	Adaptation practices
AFRICA		
EGYPT	Sea-level rise	Adoption of National Climate Change Action Plan integrating climate change concerns into national policies; adoption of Law 4/94 requiring Environmental Impact Assessment (EIA) for project approval and regulating setback distances for coastal infrastructure; installation of hard structures in areas vulnerable to coastal erosion.
SUDAN	Drought	Expanded use of traditional rainwater harvesting and water conserving techniques; building of shelter-belts and wind-breaks to improve resilience of rangelands; monitoring of the number of grazing animals and cut trees; set-up of revolving credit funds.
BOTSWANA	Drought	National government programmes to re-create employment options after drought; capacity building of local authorities; assistance to small subsistence farmers to increase crop production
ASIA & OCEANIA		
BANGLADESH	Sea-level rise; salt-water intrusion.	Consideration of climate change in the National Water Management Plan; building of flow regulators in coastal embankments; use of alternative crops and low-technology water filters.
PHILIPPINES	Drought; floods	Adjustment of silvicultural l treatment schedules to suit climate variations; shift to drought-resistant crops; use of shallow tube wells; rotation method of irrigation during water shortage; construction of water impounding basins.

Source: IPC, 2007

PHILIPPINES	Sea-level rise; storm surges.	Capacity building for shoreline defense system design; introduction of participatory risk assessment; provision of grants to strengthen coastal resilience and rehabilitation of infrastructures; construction of cyclone-resistant housing units; retrofit of buildings to improved hazard standards; review of building codes; reforestation of mangroves.
	Drought; salt-water intrusion	Rainwater harvesting; leakage reduction; hydroponic farming; bank loans allowing for purchase of rainwater storage tanks.
AMERICANS		
CANADA	Permafrost melt; change in ice cove	Changes in livelihood practices by the Inuit, including: change of hunt locations; diversification of hunted species; use of Global Positioning Systems (GPS) technology; encouragement of food sharing.
	Extreme temperatures	Implementation of heat health alert plans in Toronto, which include measures such as: opening of designated cooling centres at public locations; information to the public through local media; distribution of bottled water through the Red Cross to vulnerable people; operation of a heat information line to answer heat-related questions; availability of an emergency medical service vehicle with specially trained staff and medical equipment.
UNITED STATES	Sea-level rise	Land acquisition programmes taking account of climate change (e.g., New Jersey Coastal Blue Acres land acquisition programme to acquire coastal lands damaged/prone to damages by storms or buffering other lands; the acquired lands are being used for recreation and conservation); establishment of a 'rolling easement' in Texas, an entitlement to public ownership of property that 'rolls' inland with the coastline as sea-level rises; other coastal policies that encourage coastal landowners to act in ways that anticipate sea-level rise . Adjustment of planting dates and crop variety (e.g., inclusion of drought-resistant plants such as

MEXICO AND ARGENTINA	Drought	agave and aloe); accumulation of commodity stocks as economic reserve; spatially separated plots for cropping and grazing to diversify exposures; diversification of income by adding livestock operations; set-up/provision of crop insurance; creation of local financial pools (as alternative to commercial crop insurance).
EUROPE		
AUSTRIA, FRANCE, SWITZERLAND,	Upward shift of natural snow-reliability line; glacier melt	Artificial snow-making; grooming of ski slopes; moving ski areas to higher altitudes and glaciers; use of white plastic sheets as protection against glacier melt; diversification of tourism revenues (e.g., all-year tourism).
UNITED KINGDOM	Permafrost melt; debris flows	Erection of protection dams in Pontresina (Switzerland) against avalanches and increased magnitude of potential debris flows stemming from permafrost thawing.
	Floods; sea-level rise	Coastal realignment under the Essex Wildlife Trust, converting over 84 ha of arable farmland into salt marsh and grassland to provide sustainable sea defences; maintenance and operation of the Thames Barrier through the Thames Estuary 2100 project that addresses flooding linked to the impacts of climate change.

Source: IPCC, 2007.

2.2.3.2 *Adaptation Strategies for Nigeria*

Nigeria is vulnerable to the impacts of climate change largely because approximately70% of Nigerians is engaged in small holder rain-fed agriculture. The impact of climate change is very visible in most communities in Nigeria, from the Sahel in the north to the rainforest and coastal zone in the south. The high population coupled with high poverty levels and rapid economic growth, are making huge demands on Nigeria's natural resources. Climate change impacts compound existing pressures on these resources. Drought in the north, for example, has led to poor crop yields, water scarcity and forced migration. In the south, sea level rise combined with increased storm surge has contributed to coastal erosion; this has led to the displacement of people. The vulnerability of major urban areas, including Lagos, Warri and Port Harcourt, has increased. Loss of biodiversity is now a common trend in all ecological zones of Nigeria and this trend only makes natural resource-dependent communities more vulnerable (NEST, 2011).

Hence, the following adaptation strategies were suggested by Francis and Theophilus (2011) for Nigerian agricultures and forestry sectors; the actions that could be taken to make communities live better under a changed climate.

2.2.3.3 *Adaptation strategies to address crop production*

Relevant adaptation strategies that can be adopted in addressing crop failures are as follows:

Provision of accurate and timely weather forecasting

Timely and accurate weather forecasting is crucial to improving faming activities. This would require developing human capacity and appropriate infrastructure for weather forecasting and information sharing. Responsible agencies are the relevant research institutes and their extension arms. The option is of very high priority in every part of the country

Enhancing agricultural extension services

Agricultural extension officers are trained to link farmers with scientist working on how to improve farm operations. They also help farmers to deal with difficulties that they may have on the field. In adapting to climate variability and change, this category of professionals would need to be further developed and empowered to function effectively. They would for instance be relevant in providing weather information based on local and indigenous knowledge and information about adaptive efforts that are working elsewhere.

Expanding and optimizing existing irrigation infrastructures;

Expansion and efficiency of irrigation facilities are important to reduce or completely eliminate crop failures due to drought and increased evaporation. Efficient irrigation also allows extended farming into the dry season. This strategy is appropriate throughout the country but is of overwhelming relevance in the drier north. The option is of high priority although it involves heavy financial input.

Adoption of drought-tolerant and early maturing varieties of crops

This strategy is relevant in every part of the country as water stress may be limiting or soil productivity has declined. Switching to new crops will become crucial in many locations for farmers to have rewarding harvests. This practice is by no means a new phenomenon. The adoption of cassava for example derived from a realization that it offered better returns on soils of lower fertility than many other crops. Cassava is also tolerant to drought.

Stabilizing gullies and erosion sites

Large and expanding gullies are found in many parts of the country especially in the north-east and the south east zones (Hurault, 1998; Dale, 2000). These are serious environmental problems and are significant threat to food production. Gullies can be prevented or stabilized using cover cropping and mechanical methods. Methods that can be used include the Silt Terrace Erosion Prevention inventions (STEP), Revetment panel and Erosion Control bags. The need to adopt these options is urgent in threatened areas but the costs are high.

Helping farmers to secure agricultural insurance

Although globally, the insurance sector is becoming weary of taking up risks in climate-related ventures especially after the Katrina experience in the US, the sector has a major role to play in the nation's effort to build resilience to climate change. The sector should be strengthened and supported beyond the recent recapitalization to assist individuals particularly farmers to cope with the adverse effects of climate change such as crop failures, damages to farms and crops and loss of life.

2.2.3.4 *Adaptation options for wetlands*

The changing state of wetlands requires urgent response and the following measures could be adopted: Provide frequent artificial flooding downstream of earth dams Wetlands are dying as a result of decrease in the floodwater down slope of earth dams. For instance, the famous Hadejia-Nguru wetland complex is being impacted by reduced seasonal flooding due to water storage upstream (Amerasinghe, Galbraith and Huber-Lee, 2005). One option is to release water for artificial flooding downstream from time to time. This measure is relevant especially in areas with large dams such as Challawa, Tiga and Bakolori in the northern part of the country. Responsible agencies are the Ministry in charge of water resources and river basin development

authorities under them; switching to short-lived hardy crops; as soil water level drops in many wetlands, switching to short-lived hardy crops could be an excellent option that the farmer can consider. The option is suitable across the country. Its cost is low once the variants of the crops to be grown are identified. Recharging wetlands, digging boreholes & providing additional irrigation water; Wherever feasible, recharging wetlands with alternative sources of water should be attempted. This can be achieved by building more small reservoirs or mining water from boreholes located around the wetlands. The option is good but the cost is high.

2.2.3.5 *Adaptation options for forestry sector*

A suite of adaptation strategies can be adopted. These are biodiversity improvement, control of access to protected areas and social re-engineering approaches. The first has to do with afforesting with suitable indigenous and exotic species. This strategy is applicable nationwide i.e. including the desert-threatened environment of the north and the swamps of the coastal areas. They are as useful in developing windbreaks against the incursion of deserts in the north and as they are relevant in restoring the mangroves of the coastal areas in the south. The cost is high but it is of high priority to meet wood and other needs. The implementers are NGOs, research institutes, Government agencies and the communities. The second category of options relate to controlling access to the forest. It also involves controlling wildlife population particularly in fragile ecosystems. Access control involves physical fencing and legislation. The third approach is social re-engineering which is to assist local people in developing positive attitudes towards forests resources and their maintenance. When communities are made to own the forests and are encouraged to have the right attitude to the ecosystem, bush burning and careless felling of trees can be significantly reduced. The cost is low but it is generally of high relevance.

2.2.3.6 *Limits and barriers to climate change adaptation*

Most studies of specific adaptation plans and actions argue that there are likely to be both limits and barriers to adaptation as a response to climate change. Limits are defined here as the conditions or factors that render adaptation ineffective as a response to climate change and are largely insurmountable. These limits are necessarily subjective and dependent upon the values of diverse groups (IPCC, 2007). These limits and barriers include:

i. **Physical and ecological limits**

There is increasing evidence from ecological studies that the resilience of coupled socio-ecological systems to climate change will depend on the rate and magnitude of climate change, and that there may be critical thresholds beyond which some systems may not be able to adapt to changing climate conditions without radically altering their functional state and system integrity, Dramatic climatic changes may lead to transformations of the physical environment of a region that limit the possibilities for adaptation (Nicholls and Tol, 2006). In the Sudano-Sahel region of Africa, persistent below-average rainfall and recurrent droughts in the late 20th century have constricted physical and ecological limits by contributing to land degradation, diminished livelihood opportunities, food insecurity, internal displacement of people, cross-border migrations and civil strife (Mortimore and Adams, 2001; Leary, 2006; Osman-Elasha, Goutbi, Spanger-Siegfried, Dougherty, Hanafi, Zakieldeen, Sanjak, Atti and Elhassan 2006).

ii. **Technological limits**

Technology is developed and applied in a social context, and decision-making under uncertainty may inhibit the adoption or development of technological solutions to climate

change adaptation. Although some adaptations may be technologically possible, they may not be economically feasible or culturally desirable. For example, within the context of Africa, large-scale engineering measures for coastal protection are beyond the reach of many governments due to high costs (Ikeme, 2003).Adaptations that are effective in one location may be ineffective in other places, or create new vulnerabilities for other places or groups, particularly through negative side effects.

iii. **Financial barriers**

The implementation of adaptation measures faces a number of financial barriers. At the international level, preliminary estimates from the World Bank indicate that the total costs of 'climate proofing' development could be as high as US$10 billion to US$40 billion /yr. (World Bank, 2006). While the analysis notes that such numbers are only rough estimates, the scale of investment implied constitutes a significant financial barrier. At a more local level, individuals and communities can be similarly constrained by the lack of adequate financial resources. Deep financial poverty is a factor that constrains the use of seemingly inexpensive health measures, such as insecticide-treated bed nets, while limited public finances contribute to choices by public health agencies to give low priority to measures that would reduce vulnerability to climate-related health risks (Taylor, Chen, Rawlins, Heslop-Thomas, Amarakoon, Bailey, Chadee, Huntley, Rhoden, and Stennett, 2006). Lack of resources may also limit the ability of low-income groups to afford proposed adaptation mechanisms such as climate-risk insurance.

iv. **Social and cultural barriers**

Social and cultural limits to adaptation can be related to the different ways in which people and groups experience, interpret and respond to climate change. Individuals and groups may have different risk tolerances as well as different preferences about adaptation measures,

depending on their worldviews, values and beliefs. Conflicting understandings can impede adaptive actions. Differential power and access to decision makers may promote adaptive responses by some, while constraining them for others. Thomas and Twyman (2005) analyzed natural-resource policies in southern Africa and showed that even so-called community-based interventions to reduce vulnerability create excluded groups without access to decision-making. In addition, diverse understandings and prioritizations of climate change issues across different social and cultural groups can limit adaptive responses (Ford and Smit, 2004).

2.3. TRENDS AND FLUCTUATIONS OF ANNUAL PRECIPITATION AND TEMPERATURE

Analysis of precipitation changes over Northern and Southern Hemisphere land masses showed that during the last few decades, precipitation has tended to increase in the mid-latitudes, but decreased in the northern hemisphere sub-tropics and generally increase throughout the Southern Hemisphere. However, these large scale features contain considerable spatial variation (Folland, Palmer and Parker, 1986). The spatial patterns of trends in annual precipitation (percentage per century or per decade) during the period, 1901 to 2005 and 1979 to 2005 show that for most of North America and especially over high latitude region in Canada, annual precipitation has increased during the 105-year period. The primary exception is over the south-west USA, north-west Mexico and the Baja-Peninsula where the trend in annual precipitation has been negative (1 to 2 percent per decade) as drought has prevailed in recent years. Across South America, increasingly wet conditions were observed over the Amazon basin and south-eastern South America, including Patagonia, while negative trends in annual precipitation were observed over Chile and parts of western coast of the continent. The largest negative trends in annual precipitation were observed over western Africa and the Sahel (Trenberth et al, 2007).

Ampiaw, Gyimah, and Nyatuame (2014) conducted a study to establish the rainfall trends in Volta Region and also to provide the evidence of climate change by analyzing available rainfall record for 30-year period of 1981 to 2011. Significant differences were observed among the three zones. Northern zone recorded the highest precipitation followed by the middle zone and lastly the coastal zone. However the rainfall trends within the aforementioned zones were oscillatory. The highest annual mean rainfall was 202.6 mm and the lowest was 29.9 mm. Linear regression analysis revealed upward and downward trend in the data in some months and years in the mentioned zones but statistically insignificant

In their work, Abaje, Ati and Iguisi (2012) used Cramer's test to show recent trends and fluctuations of annual rainfall in the Sudano-Sahelian Ecological Zone of Nigeria from1949-2008 in eight meteorological stations. The results of the test revealed that there was a change towards wetter conditions in the last 30-year period. The student's t-test, td, was also used to examine the temporal changes in the rainfall series between the two non-overlapping sub-periods (1949-1978 and 1979-2008) and the result shows that Nguru and Katsina were significantly drier than the long-term mean. The 10-year running mean shows that annual rainfall for all the stations were below the long-term mean from the late 1960s to the early 1990s and above-average afterwards. The results of the linear trend lines revealed an increase in rainfall supply over the period of study. Some of the implications of these findings are that models built on the perceived decreasing rainfall, such as drainages, dams, have to be reviewed.

Ifabiyi and Ojoye (2013) examined rainfall trends in Sudan-Sahelian ecological zone of Nigeria from 1960-2009 using The Standardized Anomaly Index and Spearman Rank Statistics to test

the fluctuations and trends in rainfall. The study revealed that there was a downward trend in rainfall amounts in the 1970s and 1980s which was responsible for the drought episodes of 1972/73 and 1980 and an upward trend in the amount of rainfall between 1990 and 2009 which accounts for the flood episodes in Northern Nigeria. There is a general increase of 5% in annual rainfall over the entire fifty years under study in the zone due to an observable 5.4% increase in mean rain-days and 4% increase in the rains that fall as heavy rain, which was found to be responsible for the increase in runoff, ground water recharge and the frequent flood episodes in the zone.

Adakayi (2012) assessed rainfall and temperature variations in parts of Northern Nigeria. Time series analyses were carried out to determine the trends and predict future values of the variables. The results achieved indicate that: the region could be divided into two periods on the basis of years with lower temperatures and rainfall (1970s and 1980s) and periods with higher temperatures and rainfall (1990s and 2000s). During the predicted period, 2007-2030, rainfall declines until 2019 and from 2020, rainfall begins to increase until 2030, mean annual number of rain days decrease from 6.5 days per month in 2007 to 5.2 days per month in 2030, mean annual maximum temperature and mean annual minimum temperature continue to increase from 34.50C in 2007 to 36.60C in 2030 and 21.10C in 2007 to 21.50C in 2030 respectively. The southern part of the region has higher rainfall and lower temperatures compared to the northern parts. Temperatures vary very slightly in the region; none of the elements have departed significantly from the normal. There is a general increase in rainfall in the forecast period and a corresponding decrease in the number of rain days. There is also a general increase in mean annual temperature and annual minimum temperature.

The Sahel is characterized by strong climatic variations and an irregular rainfall that ranges between 200mm to 600mm with coefficients of variation ranges from 15 to 30 percent (Fox and Rockstorm, 2003; Kandji, Verchot, and Marckensen 2006). According to the IPCC report, a rainfall decrease of 29 to 49 percent have been observed in the 1968 to 1997 period compared to the 1931 to 1960 base line period within the Sahel region (McCarthy, Canzaiani, Leary, Dokken, and While, 2001). For most of Africa, the increase in temperature causes an increase in potential evaporation that overwhelms any increases in precipitation and results in a reduction in soil moisture. Soil moisture contents throughout most of Saharan Africa are expected to decline by less than 1.0cm.The northern portion of the Sahel is projected to have up to 3.0cm reduction (Odada, Totolo, Stafford and Ingram, 2006). These could also be used as explanations for the decreasing rainfall in the sudano-sahelian zone of Nigeria (Adakayi, 2012).

Several studies on temperature variability have been carried out at different temporal scales and in different parts of the globe. For example, Karl, Janes, Knight, Kukia, Plummer, Razuwayev, Gallo., Lindesay, Charison and Peterson, (1993) analyzed temperature data from 37% of global land mass and found high increment in the minimum compared to the maximum temperature. Easterling 1997, Fan et al. 2010 reported separately that diurnal temperature range (DTR) has been on the decrease in most regions of the world. Hassanean (2001) examined trends and periodicity of air temperature from eight meteorological stations in the east Mediterranean and observed positive significant trends in Malta and Tripoli, and negative trend in Amman. Turkes, Sumer and Demir (2002) evaluated mean, maximum and minimum air temperature data in Turkey during the period 1929–1999. Their analysis revealed spatiotemporal patterns of long-term trends, change points, and significant warming and cooling periods.

Amadi, Ewona and Udo (2014) conducted a study on trends and variations of monthly mean minimum and maximum temperature data over Nigeria for the period 1950-2012. The results show latitudinal dependence of basic temperature characteristics with the northern part of the country exhibiting higher temperature variability than the south. The Mann-Kendall tests indicate that 17 stations(representing 85%) show significant increasing trends in the minimum temperature at the 0.01level of significance while 16 stations (representing 80%) show significant increasing trends in the maximum temperature at the 0.01 and 0.05 significance levels. Port Harcourt and Ikeja have greatest trend coefficients among the 20 stations. The minimum temperatures have higher trend coefficients than the maximum temperatures for almost all the stations. The inter station spatial coherence revealed by correlation coefficients indicates that almost all the station's minimum and maximum temperatures are positively correlated with others at the 0.01 level of significance. The Mann-Kendall's test results show a general warming trend across the stations. Studies on the spatio-temporal variability and trend in temperature are very limited in Africa.

The impact of increasing temperature on yields is further explained by Dempewolf, Eastwood, Guarino, Khoury, Müller and Toll (2014) where it was predicted that by the year 2050, much of the world will experience a growing season that will likely have higher temperatures than the hottest growing seasons of recent times and this increase in temperatures will probably be accompanied by more variable rainfall resulting in drought and dry spell. Crops will be impacted in various ways, such as increased sterility at higher temperatures and starting of early senescence under warmer conditions (Lobell, Sibley and Ivan Ortiz-Monasterio, 2012). Shortage of soil moisture in the dry rainfed areas often occurs during the most sensitive growth stages of

flowering and grain filling of the crops. As a result, rainfed crop growth is poor and yield is consequently low. Guarino and Lobell (2011) forecasted possible yield losses of 6–10% per 1 ^{0}C of warming in the average temperature of the growing season. This means the world could see significant production losses in the future.

2.4 RAINFALL AND TEMPERATURE IN SUDANO- SAHELIAN ZONE

Rainfall is by far the most important element of climate change in sudano-sahelian zone (Adejuwon, 2004).The amount and regularity of rainfall vary with location and climate types and affect the dominance of certain types of vegetation as well as crop growth and yield. Consistent reduction in rainfall leads to a reduction in the natural regeneration rate of land resources (Fasona and Omojola 2005). This makes people to exploit more previously undisturbed lands leading to depletion of the forest cover and increase on sand dunes/Aeolian deposits.

The Suadno-Sahelian zone of Nigeria is generally characterized by short rainfall periods and a long dry season (Otegbeye, 2004). The annual precipitation in this area varies from less than 500mm in the extreme northeastern part to about 1000mm in the southern part (FRN, 2000).The northeast region of Nigeria is increasingly becoming an arid environment at a very fast rate per year occasioned by fast reduction in the amount of surface water, flora and fauna resources on land (Obioha 2008). Sawa and Adebayo (2011) affirmed that the Sudano-Sahelian bioclimatic zone of northern Nigeria has been experiencing a general tendency towards a decreasing number of wet spells, and a drier than normal condition as from 1969/70, thus proving that there is an apparent and real increasing aridity in the region. The pattern of rainfall in the zone is highly variable in spatial and temporal dimensions with inter—annual variability of between 15 and 20 percent (Oladipo, 1993a; FRN, 2000).The spatial variability in the sudano-sahelian region

reveals that the lower latitudes have lower rainfall variability than the upper latitudes. This is expected, as it agrees with the general trend in Nigeria (Adakayi, 2012).

Seasonal variations in rainfall in the Sudano-Sahelian region are directly influenced by the interaction of two air masses. The relative warm and moist tropical maritime ($_{m}T$) air mass, which originates from the Atlantic Ocean, associated with Southwest winds in Nigeria; and relatively cool, dry and stable tropical continental ($_{c}T$) air mass that originates from the Saharan desert. The tropical continental air mass is associated with the dry, cool and dusty Northeast trades known as Hamattan (Ayoade, 1982b; Oguntoyinbo, 1982; Oladipo and Salahu, 1993; FRN, 2000; Sawa, 2002; Ayoade, 2004; Abaje, 2007; Ati, Iguisi, and Afolayan 2007). The boundary zones between the two air streams have been given various names by tropical weather analysts. Such terms as the Inter-tropical front (ITF), Inter-tropical Convergence Zone (ITCZ), Inter-tropical Confluence (ITC), Equatorial Front (EF) and Inter-tropical Discontinuity (ITD) have been used to describe this feature of tropical weather and climate (Ayoade, 2004).

The two air-masses (mT and cT) meet along a slanting surface called the inter-tropical discontinuity (ITD); the equatorial easterlies are rather erratic and relatively cool air masses from the east in the upper troposphere along the ITD. The movement of the ITD Northwards across the country between January and August, and its retreat from the Southern fringe of the Sahara desert, after August, causes much of Nigeria to experience seasonal rainfall (Ojoye, 2012). Within the mT air mass is enclosed a number of rainfall producing system such as the disturbance lines (especially the easterly waves), squall lines and the two tropospheric jet streams. Ojoye (2007) reported that it is the magnitude of these systems that influence the amount and seasonal distribution of rainfall over the region. The surface position of the ITD in the Sudano-Sahelian region exhibits not only seasonal but also day-to-day variations (Oladipo

and Salahu, 1993). The movement of the ITD is very irregular, varying according to the season from 2^0 to 5.6^0 of latitude per month (Oladipo and Salahu, 1993). The northward advance of the ITD at the rate of about 160km per month and its southward retreat at about 320km per month accounts for the gentle onset of the rainy season and rather its abrupt end (Ayoade, 2004).

Nigerian Meteorological Agency (NIMET) (2010) stated that The Inter-Tropical Discontinuity (ITD) in 2010 was located at an average position of latitude 7.9^0N in January. It then oscillated northwards to reach a northermost position of latitude 20.9^0N in August. Thereafter, the ITD began its seasonal southward movement to reach latitude 7.8^0N in December. The decadal movements and average monthly positions of the ITD were, in most cases, above normal but lagged behind long term conditions in April and December but were near normal in May and November. The higher than normal ITD positions accounted for the high rainfall in many cities across the country, particularly in the north.

Temperature in the region is high throughout the year with a mean minimum value of about 23°C and mean maximum of about 34 °C (Ojoye, 2008). In the rainy season, temperature is fairly steady because cloudiness and humidity prevent back radiation, thus the diurnal range of temperature is relatively small, and it is about 2 °C (Oyebande, 1995). In the dry season the much back radiation is witnessed in the night and it tends to lower night temperature values. Thus, a high diurnal range of temperature sometimes as high as 12 °C is observable. Notwithstanding of temperature, the optimum temperature for growing crops and plants growth is obtainable at all periods of the year.

Many studies in the Sudano-Sahelian Ecological Zone of West Africa in general, and Nigeria in particular, have established a general trend in rainfall towards aridity at the drought years

(Powel, Casey, Folland, Colman, and Mehta 1999a; Nicholson, 2001; Hulme, Sheard, and Chilcott 2001; Dami, 2008; Odekunle, Andrew and Aremu 2008). Recently, however, some scenarios (based on greenhouse gas emissions) have suggested that the observed trend towards aridity will be put on hold or be reversed in the twenty-first century. In fact, it was reported that rainfall has been increasing in the Sahel region of West Africa. Based on climate data for the period extending from 1960 to 2009, Ifabiyi and Ojoye (2013) have confirmed that drought conditions have persisted in the Sudano-Sahelian Ecological zone of Nigeria up to 1990 and that an upward trend of rainfall was also being observed since the last episode of the 1980s drought an implication that the Sudano Sahelian Ecological zone of Nigeria is getting wetter.

Studies have shown that, although rainfalls generally experienced in Sudano-Sahelian Ecological zone between early June and the first ten days of September, its distribution and characteristics are adequate for crop germination, establishment and development for roughly only two months – between the first ten days of July and the first five days of September (Odekunle, 2004). Apart from its short growing season, the ecological zone has a persistent and severe drought tendency (Nicholson, 2001). The rainfall intensity in this zone is very high between the months of July and August. As a result, rapid surface run-off, soil erosion and water-logging are experienced though the environment is generally dry. Besides, inter annual variability is high (Iwegbu, 1993) which subject the zone to frequent dry spells, often resulting in severe and widespread droughts, capable of large scale destruction of plants, animals and human life (Ati, Stigter and Oladipo, 2002). Dry spell is defined by Barron, Enfors, Cambridge and Moustapha (2010) as a maximum of 5mm of rainfall within a 14-day period implies temporal water shortages during the season and a deficit of moisture in the root zone, which is a major constraint to farming.

2.5 METHODS OF DETERMINING ONSET OF THE RAINY SEASON

Various methods for determining onset exist thus:

Sivakumar (1998) described the onset date in the southern Sahelian and sudanian climatic zones of West Africa as the date after 1 May when rainfall accumulated over three consecutive days was at least 20mm and when no dry spell within the next 30 days exceeded 7 days.

Benoit (1977) described the onset date for northern Nigeria as the date when accumulated daily rainfall exceeded half of the potential evapotranspiration of the season, provided that no dry spell longer than 5 days occurs immediately after that date.

Kowal and Knabe (1972) defined the onset date as the 10-day in which rainfall is equal to or greater than 25mm, but where the subsequent 10-day rainfall total is greater than half of the potential evapotranspiration

Adefolalu (1993) described an Ogive method as follows;

Firstly, the twelve months of the year are divided into pentads, using the pentad calendar. This gives a total of 73 pentads. Secondly, pentad rainfall is calculated for each pentad and cumulated. Then, the cumulated rainfall is plotted against pentad to give an Ogive. Thirdly, to determine the onset and cessation dates, the points on the pentad axis corresponding to the first and the last point of maximum curvature on the Ogive, gives the onset and cessation pentad respectively.

Walter (1976) described the onset of a location as the date when an accumulate rainfall of 51mm is received. If this planting date is followed by prolonged dry spell, such a planting date is disregarded and new planting date is re-established (Olaniran, 1998).

Maurya, Adeoti and Shebayan (1995) observed that the farmers of the scale irrigation project in Sokoto State have improved the crop yield per unit area: cropping intensity (increase to around 220 percent); some new crop introduction and overall management of privately owned irrigation system during the last five years. Bruce, El-Ganzor, El-Shinnawy, Joel, McCarl, Mohamed, Mossad, Smith, Paul and Russell (2013) carried a research on Climate change vulnerability and adaptation strategies in Egypt's agricultural sector using a partial equilibrium model that simulates crop and livestock production. It revealed that climate change has damaged the Egyptian agricultural sector and the damages increase over time. Price for agricultural commodities has increased which has a negative impact on consumers.

Pouliotte, Islam, Smit and Islam (2006) undertook a study on livelihood in rural climate change Bangladesh and suggested Consideration of climate change in the National Water Management Plan; building of flow regulators in coastal embankments; use of alternative crops and low-technology water filters. In Botswana, climate change adaptation practices includes; National government programmes to re-create employment options after drought; capacity building of local authorities; assistance to small subsistence farmers to increase crop production (FAO, 2004).

Francis and Theophilus (2011) assessed the climate change adaptation in Nigeria: some background to Nigeria's response-III. The vulnerabilities of the various parts of the country were computed, using a wide range of socio-economic parameters and physical environmental factors. The results show that there had been important variability in the rainfall and temperature regimes which 'expose' the country to severe impacts of climate change. The vulnerability assessment further shows that the country's resilience to climate change impact is very weak especially in the Sudano-Sahelian zone.

CHAPTER THREE: THE STUDY AREA AND METHODOLOGY

3.1 INTRODUCTION

This chapter is divided into two; the first part covers physical characteristics and human activities prevailing in the study area. The second part gives an account of methods involved in collecting, processing and analyzing rainfall, temperature and respondents' data.

3.2 THE STUDY AREA

3.2.1 Location of the Study Area

Yobe state is located in North Eastern Nigeria approximately between latitudes10^0 33 /N and $13^0$22 /N and longitudes $9^0$40 /E and 12.^{0}25 /E. The state borders Bauchi and Gombe to the South West, Borno to the East and South East and Jigawa to the North West. It also shares an international border with the Republic of Niger stretching to over 320km to the North (Barsky, 1999). This is shown in figure 3.1.

3.2.2 Climate

Yobe State has hot and dry climatic features in the northern part for most of the year. In the southern part, especially in the rocky area of Gujuba and Fika local government areas, it is hotter for most part of the year. The hottest months are March, April and May with temperatures ranging between 39°C and 42°C (Bello, 2013).The State exhibits a remarkably high annual range of mean monthly temperatures. Rainfall amounts are generally related to the thickness of the Tropical Maritime air mass. The Tropical Maritime air mass is wedged shaped and thins northwards (Adams and Hollins, 1987). Consequently, rainfall decreases northward both in

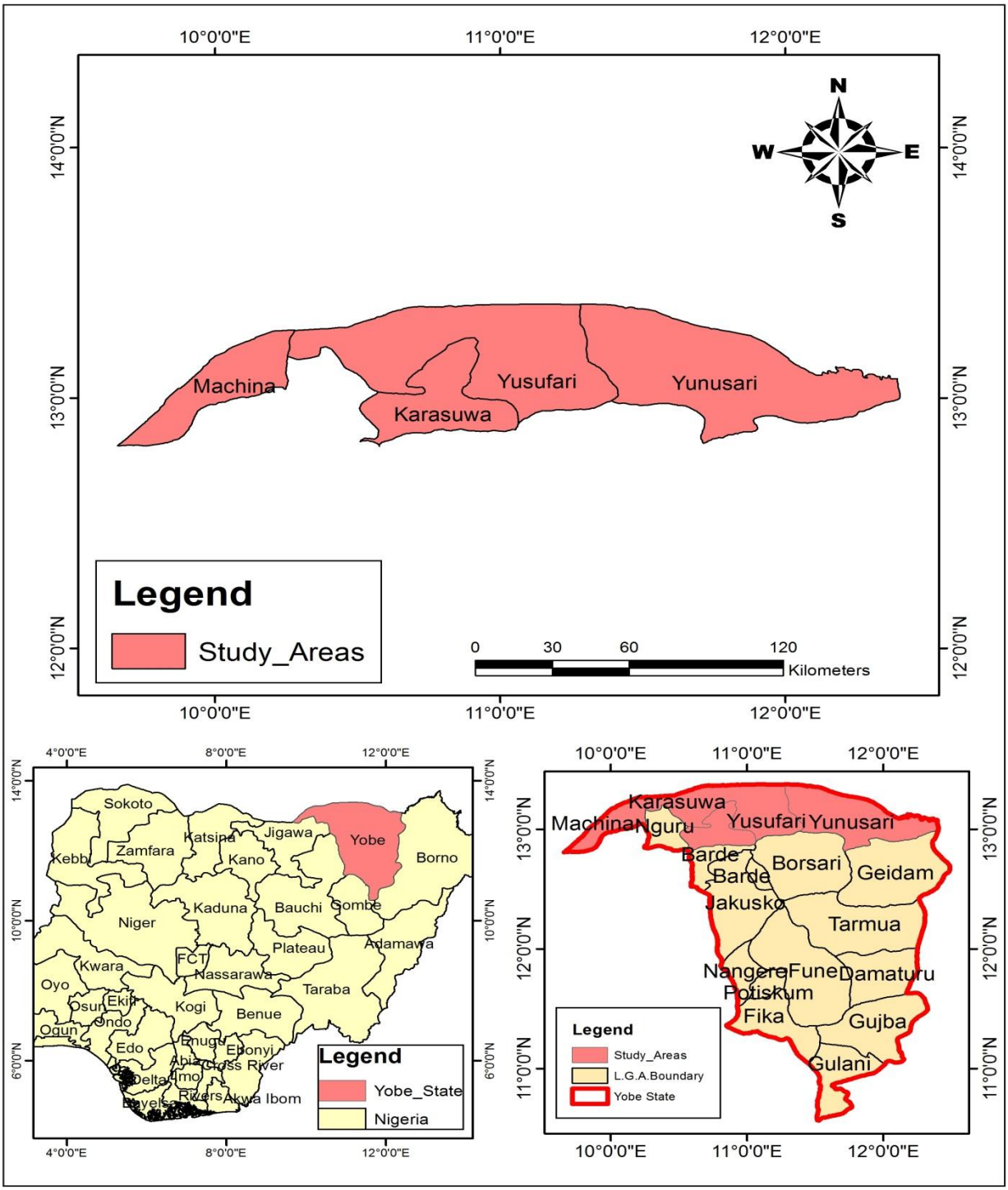


Figure 3.1: The Study Area

Source: Adapted from the Administrative Map of Yobe State.

duration and amount. It lasts for less than 90 days in the northern part of the state and more than 110 days in the south (Audu, 2012).

Yobe State is located in the tropic with definite wet and dry seasons. The wet and dry seasons are characterized with frequent dry continental Northeast trade wind which originates from Sahara desert, and the moist maritime South-westerly monsoon which originates from the Atlantic Ocean respectively. The rainy season spans between June and September with peak of rainfall in August, and the dry season between November and April. The mean annual rainfall is about 500mm with highest ambient temperature hovering over 40^0C in the hottest Months of April and May. The average daily temperature ranges between 27-31^0C (Bello, 2013).

There is a marked dry season of between eight to nine months and a wet season of only three to four months. Rainfall in the state is highly irregular in space and time, which makes farming difficult since small differences in the amount and timing of rain received at a site, may determine the success or failure of critical stages in vegetation development and hence crop production. The development of agriculture would, therefore, effectively depend on irrigation farming especially in the drier parts of the state.

3.2.3 Soil

Soil in the study area is tropical ferruginous and pockets of hydromorphic soils along river channel. The soil in most parts of the state is derived from materials which vary in textural characteristics, but are mainly silt clay or clayey. The profile of the soils is poorly developed, and it has a low water retention capacity (Price, Justice and Los, 1990). The productivity of the soil is greatly impaired due to lack of adequate vegetation cover to supply organic matter. Wind

erosion poses a serious threat to the quality of soil in the active areas of the north. This compounds the effects of climate change in the area especially on rain-fed crops. It has been observed that the windblown fine soil particles have nutrients essential for plant growth. Alluvial soils are also found in the major river valleys, such as the Yobe, and are suitable for the cultivation of crops like rice and wheat, around Gashua (Bello, 2013).

3.2.4 Vegetation

The vegetation is Sahel in the north and Sudan savanna in the south. Vegetal cover is sparse as the grass grows closely at the base leaving bare surfaces in between. The grasses in the Sahel are short and tussocky, 0.5m to 1.0m high. The vegetation interspersed with sand dunes are the most common types here. The vegetation of the State is characterized by sparse shrubs, grasses and trees such as *Acacia albida* (Gum Arabic), *Acacia Nilotica* (Gum Arabic), *Pennisetum maximum.* (Guinea grass), *Cenchrus ciliaris*. (Buffel grass), *Cynodon nlemfuensis. (*Star grass), *Pennisetum purpureum*. (Elephant grass), *Andropogon gayanus* (Gamba grass), *Andosonia digitata* (baobab tree), *Butyrospermum parkii*. (Shea tree, *Kadanya),* and *Azandrata indica*. (Neem tree). The nature of rainfall of this area makes grasses dry up completely during the dry season (Bello, 2013).

3.2.5 Geology, Relief and Hydrography

The geology of Yobe principally comprises crystalline and sedimentary rocks, underlain by basement complex rocks. The crystalline rocks are represented by older granites found in pockets of places in the southern part of the state. Another crystalline rock formation of younger age is located in the northwestern tip of the state in the Machina area. The older granite is Precambrian in origin consisting of metamorphic structures of gneiss and amphibolites. The younger granitic

rocks are of Jurassic period, deposited between 195 and 135 million years before the present. The sedimentary rocks that are found in most parts of the state were deposited on the basement crystalline rocks.

In the southern fringe of the state, the sedimentary deposits are made up of the cretaceous Bima, Pindiga, Fika and Gombe formations. The Karekare formation is also found in this part of the state. However, in the greater part of Yobe, all these sedimentary formations were uncomfortably overlaid by a large expanse of Quaternary Chad formation that stretched into Jigawa and Borno States. The influence of climatic fluctuations is reflected in the superficial deposits overlaying most of Yobe State. This, for instance, has led to the deposition of series of longitudinal and traverse dunes around Yunusari, Yusufari, Machina, Geidam and Bade local government areas. These sand dunes constitute an ecological problem that inhibits daily economic activities that forced the farmers to employ a number of adaptation strategies in order to survive in the area.

Yobe State generally lies between 300m and 600m above sea level, except in the southern part of the state where volcanic rocks occur. The rock formation also contains water bearing aquifers from which much of the water supply in the state is derived. The River Yobe, from which the state derived its name, is the biggest river in the state. It flows eastwards and drains into Lake Chad. It has few tributaries, one of the most important being River Alkalam, where the famous yearly Bade fishing and cultural festival takes place. The presence of River Yobe makes irrigation possible. The farmers can easily use the irrigation as a strategy against climate change.

3.2.6 Commerce and Industry

Research has shown the existence of commercial quantities of gypsum, limestone, diatomite, trona, quartz, gum Arabic and potash. This makes the state an ideal location for industries such

as cement, glass, chalk, soap detergent and adhesives as well as pharmaceuticals (Barsky, 1999). Leather works and the export of hides and skins to neighboring countries also represent a significant opening for investors. The existing industries in Yobe State can be classified into the traditional local crafts and the modern factories. The major local craft industries include leather work, pottery and weaving. The major factories include Nguru Oil Mills, Nigerian Food Company Limited, Yobe Flour and Feed Mills Company Limited (Mamman, Oyebanji and Peters, 2002). These industries could be alternatives for farmers if all their adaptation strategies prove abortive.

3.2.7 Tourism

Yobe state has numerous tourist attraction centres among which are Dokshi Spring Water in Gulani, Dagona Birds Sanctuary in Bade, Old Gogaram city in Jakusko, Birnin Gazargamu in Geidam, Old Daniski Settlement and Goya Valley in Fika, 8000 year old Dafuna Canoe in Fune, Grave yard of past Emirs of Fika, Wetlands and Bade fishing and Cultural Festival in Jakusko (Yobe State Administrative Document, 2008). The constant reduction of tree biomass as a result of change in climate poses a threat to tourist centres as tourists may not find them attractive.

3.2.8 People and Population

Yobe State is pluralistic in ethnic composition with a rich and diverse historical and cultural heritage .There are five major ethnic groups in the state. These are the Kanuri, Fulani, Karekare, Bade and Hausa. The official language, as in every state of the country, is English. However, Hausa has gained wide acceptability as a medium of communication.

Yobe state with a land area of about 44,881sqkm has a total population of 2,321,591 as indicated in Table 3.1. It has an average population density of 52 persons per square kilometer (NPC,

2006). The pattern of population distribution in Yobe State can be divided into three density levels as follows:

1. Sparsely populated areas with less than forty (40) persons per sq. km such as Tarmowa, Yunusari and Yusufari
2. Moderately populated areas, with densities of between forty (40) and sixty (60) persons per sq.km. examples: Damaturu, Gulani and Karasuwa
3. Densely populated areas with population densities of over hundred (100) persons per sq. km. examples: Potiskum, Gashua and Nguru.

The study area falls within sparsely populated areas and as such the pressure on land resources will be minimal and the farmers will have more lands for farming activities

Table 3.1: Yobe State Local Government; Population, Area and Population Density

S/N	LGA	POPULATION	AREA (KM^2)	POPULATION DENSITY
1	Bade	139, 782	772	181
2	Bursari	109, 124	3, 818	29
3	Damaturu	88, 895	2, 366	37
4	Fika	136, 895	2, 208	62
5	Fune	300, 760	4, 948	61
6	Geidam	157, 290	4, 357	36
7	Gujuba	130, 088	3, 239	40
8	Gulani	103, 510	2, 090	50
10	Karasuwa	106, 606	1, 162	92
11	Machina	61, 606	1, 213	51
12	Nangere	87, 823	980	90
13	Nguru	150, 632	916	164
14	Potiskum	205, 876	559	368
15	Yunusari	125, 821	3, 790	32
16	Yusufari	111, 086	3, 928	28
17	Tarmuwa	77, 204		17
	TOTAL	2, 321, 591	44, 881	Average: 52

Source: National Population Census, 2006

3.2.9 Agriculture

Agriculture is the main economy of the people of Yobe State, even though there are other mineral resources present. The sustainability of agriculture in Yobe economy requires a strategic balance in the ecological and socio-economic activities as well as political considerations. In this region, rainfall occurs seasonally with a pronounced dry season. The seasonal rainfall and prolonged dry season bring about dynamics in the ecosystem and sour relationships resulting in a sharp division between the Fulani herdsmen and farmers (Bello, 2013). Millet, sorghum and beans are the major economic crops produced in the state. Rice cultivation is also prominent along river Yobe especially around the fadama in Nguru and Gashua.

3.3 METHODOLOGY

3.3.1 Reconnaissance Survey

The researcher undertook a reconnaissance survey in May and July 2015 in order to be well acquainted with the study area. During the survey, the researcher was able to meet with relevant people such as village heads, rural dwellers, (especially farmers) and herdsmen who helped in giving their experiences and knowledge on climate change.

3.3.2 Types and Sources of Data

3.3.2.1 *Types of data*

The data used in the study includes:

i. Rainfall and Temperature data of the study area from 1975 to 2014.

ii. Administrative map of the study area.

iii. Data on effects of climate change in the study area.

iv. Farmers' adaptation strategies to climate change in the study area.

3.3.2.2 *Sources of Data*

i. Rainfall and temperature record for 40 years (1975-2014) were sourced from the archives of Nigerian Meteorological Agency (NIMET) Nguru station No.65064 located on latitude $12^0$53'N and longitude $10^0$28'E.

The station was chosen to represent the entire study area because of the following reasons:

a. It is the only synoptic station closest to the study area
b. According to the standard given by World Meteorological Organization, a synoptic station can serve an area of 9000km^2 if the terrain is plain. The terrain of the entire study area is plain and friendly.
c. None of the LGA in the study area is more than 50km away from the synoptic station
d. The station has not been relocated since its establishment in 1946.

ii. Data on the effects of climate and adaptation strategies to climate change were obtained through field social survey using closed and open ended questionnaire.

iii. Existing literature from journals, textbooks, conference proceedings, seminar papers, thesis, reports and web references were also consulted.

3.3.3 Sampling

Yobe state is made up of seventeen (17) LGAs and three senatorial districts:

Zone A/Yobe East (Borsari, Damaturu, Geidam, Gujba, Gulani, Tarmua and Yunusari)

Zone B/Yobe South (Fune, Fika, Nangere and Potiskum)

Zone C/Yobe North (Barde, Karasuwa, Jakusko, Machina, Nguru and Yusufari)

The research did not cover the entire state; it only covers areas that border Niger Republic to the north. Hence zone B is excluded. The four LGAs chosen as the study area (Karasuwa, Machina, Yusufari and Yunusari) are the areas worst hit by desertification. As reported by Hir (2010) sand dunes and harsh arid climate in Sahel area of Yobe state are evidence of climate change reality. Also, with the exception of Karasuwa LGA, the entire three LGAs border Republic of Niger to the north where encroaching sand dunes threaten the few surviving oases and even the houses within. The content of the questionnaire was structured into four parts as follows;

i. Respondents'' personal biodata- This covers the socioeconomic status of the farmers such as sex, age, marital status, political status, educational qualification, etc.
ii. Evidences of Climate change- This investigates those factors that informed the farmer farmers of the incidences of climate change in the four LGA.
iii. Effect of climate change- This assessed the combined climatic and socioeconomic effects of climate change.
iv. Farmers' adaptive initiatives- This appraises both traditional and modern adaptation strategies used by farmers to curb the harmful effect of climate change.

The wards and selected wards from each LGA are presented in Table 3.2 for easy identification.

Table 3.2: Local Government Areas, Wards and Selected Wards

KARASUWA WARDS		MACHINA WARDS		YUSUFARI WARDS		YUNUSARI WARDS	
	Sampled Wards		***Sampled Wards***		***Sampled Wards***		***Sampled Wards***
Bukarti		Bogo		Bultuwa		Alanjirori	
Fajiganari		Damai		Dagaltura		Gumshi	
Garin Gawo	Garin Gawo	Dole	Dole	Dikwa	Dikwa	Guya	Guya
Gasma		Falmaran		Dilala Kalga		Jebuwa	
Jajeri		Kwankwamma		Maraira		Kaska	
Jajimaji	Jajimaji	Kuka-yasku		Mozogu	Mozogu	Kumaganan	Kumaganan
Karasuwa Galu		Lamisu	Kuka-Yasku	Ngrabo		Maimalari	
Karasuwa		Machina		Toshia		Mayori	
		Mask-kandare	Mask-kandare	WadiKafia -	WadiKafia	Sumbur	Sumbur
Wachakal	Wachakal	Taganama		Zajiburidi		Tulo Tulo	
Waro						Yusufari	

Source: Yobe State Administrative Document, 2014

Each of the LGA chosen has ten (10) wards as shown in Table 3.2. Three (3) wards in each of the LGA were selected using systematic random sampling based on every third ward at interval in alphabetical order (i.e. 3rd, 6^{th} and 9^{th}). The size of the three wards selected in each of the LGAs was considered enough to represent the entire LGA. Moreover, the reconnaissance survey revealed that all the wards in each of the LGA share common characteristics (dry and agrarian), so, using all the wards is not fundamental.

With reference to Table 3.2, the study area has a total population of 553,672. To determine the sample size for this research, Krejie and Morgan's (1970) method of determining sample size was adopted which states that for an area with a population of 75,000-999,999 the sample size would be 382. However, for the purpose of accuracy and fair representation of each community, 384 copies of questionnaire were produced and administered.

The reconnaissance surveys conducted revealed that majority of the dwellers in the study area are farmers. As stated by Mortimore (2009), greater proportions of the population in the semi-arid zone are agrarians and depend on land for their livelihood. Hence farming community was the target population. The questionnaire was administered proportionate to the population of each LGA as indicated in table 3.3. Purposive sampling technique was adopted in administering the questionnaires in the twelve (12) selected wards. The questionnaire were administered to farmers from 10th to 21st Dec. 2015 in their farms as well as houses with the help of village heads/leader of farmers (*sarkin noma*) who helped in identifying the farmers that have lived long enough in the study areas.

Table: 3.3 Distribution of Questionnaire by Wards and LGA

S/N	LGAs	Wards	2006 Population	Projected Population 2015	Questionnaire Administered		
					Size	Percentage	Retrieved
1	**Karasuwa**	Garingawo	11,245	16,200	29	32%	
		Jajimaji	10.050	14,357	23	25%	
		Wachakal	15,514	21,125	40	43%	
			105,514	**145,026**	**92**	**24%**	**82**
2	**Machina**	Dole	6,099	8,340	15	25%	
		Kuka Yasku	5,700	10,200	18	30%	
		Maskandari	9,354	12,355	27	45%	
			60,994	**83,507**	**60**	**16%**	**53**
3	**Yunusari**	Dikwa	10,600	14,400	40	30%	
		Mozogu	14,308	18,938	49	37%	
		WadiKafia	12,594	16,945	43	33%	
			125,940	**171,886**	**132**	**34%**	**122**
4	**Yunusari**	Guya	11,298	14,765	23	23%	
		Kumaganan	12,345	16,596	28	28%	
		Sumbur	20,145	31,465	49	49%	
			110,739	**153,253**	**100**	**26%**	**93**
Total			**403,187**	**553,672**	**384**	**100%**	**350**

Source: NPC, 2006 and Yobe State Administrative Document, 2008.

3.4 Methods of Data Analyses

3.4.1 Trends in Climatic Parameters

The changes in climatic conditions in the area were examined and analyzed using time series analysis between 1975 and 2014.

3.4.1.1 *Trends in rainfall attributes*

The long term average annual rainfall was derived and plotted against the years of records. The mean annual rainfall for the months of June, July, August and September were calculated and analyzed. This is because 95% of annual rainfall in the area is received within this period. Time series analysis was also employed in examining changes in rainfall over the period of the study (1975-2014). Linear trends and trend line equations were fitted.

The long term average rainfall was determined as:

$$\overline{x} = \sum \frac{x}{n}$$

Where;

$\overline{x}$ = Long term mean monthly and annual rainfall

x = Annual rainfall for each year

n = Number of years on records

3.4.1.2 *Trends in Temperature attributes*

The mean monthly and mean annual minimum and maximum temperatures were derived and plotted graphically against the years of records. The mean of annual temperature for the months of, December, January, April and May being the coldest and hottest months in the area were calculated and analyzed. Time series analysis was also employed in examining changes in temperature over the period of the study (1975-2014). Linear trends and trend line equations were fitted.

The long term mean annual temperature was calculated thus:

$$\overline{x} = \sum \frac{x}{n}$$

Where:

$\overline{x}$ = long term mean monthly and annual temperature

x = value of temperatures observation for each year and

n = number of years on record

3.4.2 Determination of Onset and Cessation Dates of the Rainy Season

Onset refers to the time a place receives an accumulated amount of rainfall sufficient for plant germination and growth. It is not the first day the rain falls. Cessation means termination of the effective rainy season. It does not imply the last day the rain fell, but when rainfalls can no more be assured or be effective (Stewart, 1991 in Ati, 2002).

However, for the purpose of this study, Walter's method (1976) was adopted. This is because the results obtained are close to realities. Also, many researchers such as Olaniran (1988) and Elisha

(2014) have used this method. Hence it is one of the most appropriate methods of determining onset and cessation dates of the rainy season. Onset date was described thus:

$$\mathbf{OD} = \frac{D\,(51 - F)}{R}$$

Where

D = Number of days in the first month with accumulated

rainfall equals or greater than 51mm;

F = Accumulated rainfall total of previous month;

R = Total rainfall in the month whose accumulative rainfall $\geq$ 51mm.

However, for the cessation date, the formula was applied in reverse order from December.

The long term average onset and cessation dates were derived and plotted against the years of records. Time series analysis was also employed in examining changes in onset and cessation dates over the period of the study (1975-2014). Linear trends and trend line equations were fitted

3.4.3 Length of the Rainy Season

The length of the rainy season is the period between the onset and cessation dates (Walter, 1976). The annual length of the rainy season for each year was obtained by determining the number of days between the onsets and cessation dates. The long term average length of the rainy season was derived and plotted against the years of records. Time series analysis was also employed in examining changes in the length of the rainy season over the period of the study (1975-2014). Linear trends and trend line equations were fitted.

3.4.4. Effect of Climate Change

Descriptive statistics such as tables, component bar charts and pie charts were presented using frequencies and percentages in tabular form and bar charts were employed to summarize the

respondents' responses to the questionnaire. This was meant to determine the evidences and effects of climate change in the study area

3.4.5 Adaptation Strategies to Climate Change

Descriptive statistics such as tables, component bar charts were presented using frequencies and percentages in tabular form and bar charts were employed to summarize the respondents' view in order to determine the adaptation strategies to climate change in the study area. Pairwise Comparison Matrix was also used to identify the strongest or most preferred adaptation strategies used by farmers in the study area to minimize the harmful effect of climate change. Pairwise comparison matrix is a scientific tool for comparing entities in pairs to judge which of the entity is preferred or has a greater amount of some quantitative property (Thurstone, 1927). The pairwise comparison matrix used in this study was created using the following steps:

1. A square matrix was created with adaptation strategies on first row and first column.
2. Diagonal entries in the matrix were crossed out.
3. If one adaptation strategy is more preferred than the other, **"1"** was put, if not **"0"** was put.
4. All the scores were tabulated horizontally and added up.
5. The adaptation strategy that has the highest score will then be considered as the strongest or most preferred adaptation strategy to climate change in the study area.

A group of farmers were gathered each of them carrying cards with different adaptation strategies. They were then asked to pick the most preferred adaptation strategy and put in a cup. The cups were collected and the adaptation strategies in the cups were then compared with one another and the strongest or most preferred adaptation strategy was identified in the matrix using the above mentioned steps.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1. INTRODUCTION

This chapter presents and discusses the results of the study.

4.1.2 Rainfall and Temperatures Records for the Station (1975-2014)

Annual rainfall and temperature records for the station over the period of the study (1975-2014) are presented in Table 4.1.

Table 4.1 Rainfall and Temperatures Records for the Station (1975-2014)

Years	Annual Rainfall (In mm)	Mean Temp. (^{0}C)	Years	Annual Rainfall (in mm)	Mean Temp. (^{0}C)
1975	558.6	27.3	1995	370.6	28.3
1976	431.0	27.1	1996	420.9	29.0
1977	509.0	28.0	1997	526.5	30.0
1978	496.7	28.1	1998	510.1	29.0
1979	587.8	28.1	1999	482.7	28.3
1980	339.6	35.4	2000	353.8	28.1
1981	428.9	34.1	2001	414.2	28.0
1982	409.9	35.1	2002	503.1	28.1
1983	224.7	27.1	2003	485.0	28.2
1984	332.4	27.1	2004	292.4	28.3
1985	229.2	30.0	2005	499.2	29.0
1986	240.6	35.0	2006	416.6	30.3
1987	250.3	29.0	2007	484.2	28.0
1988	320.6	28.1	2008	355.0	27.4
1989	338.6	28.1	2009	366.5	29.3
1990	418.1	28.1	2010	467.2	28.1
1991	227.1	29.0	2011	399.7	28.4
1992	417.2	28.0	2012	656.1	28.1
1993	335.6	27.0	2013	399.0	28.1
1994	686.1	28.1	2014	712.1	28.3

Source: NIMET (Nguru Station), 2015

4.2 TRENDS IN MEAN MONTHLY RAINFALL

From the analysis of rainfall data within the study period, 95% of annual rainfall was received within the months of June-September. Hence rainfall trends for these months were analyzed separately. To further specify the character of rainfall during the periods, the 5-year running means were used.

4.2.1 Trends in Mean Monthly Rainfall (June)

Trend in mean monthly rainfall for the months of June from 1975-2014 is shown in Fig. 4.1

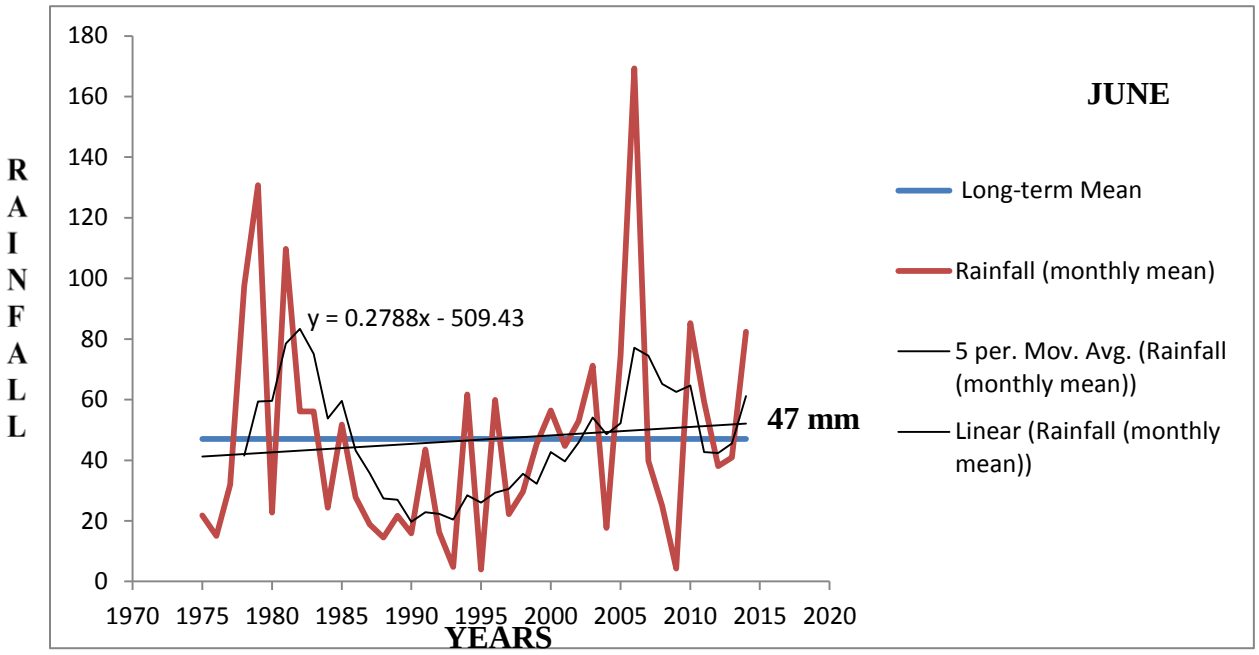


Figure 4.1 Trends in June Rainfall in Yobe North, Yobe state (1975-2014)

The linear trend in Fig. 4.1 is slightly above the long-term mean of 47mm from 2004 to the end of the study period (2014). The 5-year running mean showed June rainfall values above the long-term mean from 1978 to 1986. The rainfall values then fell below the long-term mean from 1987 to 2005. Sudden rise in mean rainfall amount then occurred till 2011. The heaviest June rainfall of about 170mm throughout the study period was received in 2007 and the lowest (10mm)

occurred in 2009. The linear trend line indicates an increase in rainfall amount of approximately 11.12mm at the rate of 0.3mm year^{-1}. The increased June rainfall reduces the likely occurrence of dry spell at the beginning of the rainy season. This is because the frequencies of the rainy events are at increase and as such farmers could plant early to take the advantage of increased number of rainy days in the month of June.

4.2.2 Trends in Mean Monthly Rainfall (July)

Figure 4.2 shows trend in mean monthly rainfall for the month of July from 1975-2014.

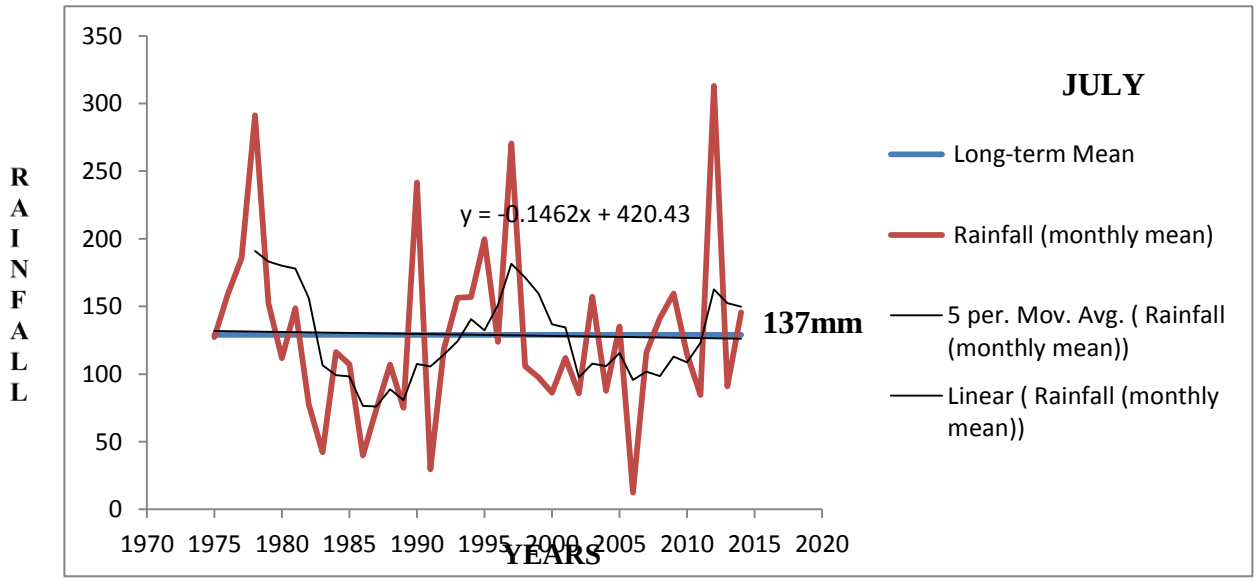


Figure 4.2 Trends in July Rainfall in Yobe North, Yobe state (1975-2014)

The 5-year running mean was irregular and highly variable. The July mean rainfall amounts were above long-term mean from 1974 to 1982. Sudden fall below the long-term mean occurred from 1982 to 1994. The values again went above long-term mean from 1995 to 2002 and then, the rainfall amounts were below the long-term mean for a decade (2002-2012).However, the highest mean monthly rainfall amount for July was recorded in 2012 which was about 313mm. This

value was more than the annual rainfall recorded in 1986 and 1987. While the lowest occurred in 2006 which was mere 10 mm. This is because in July 2006, there was long period of dryspell (more than 20days). Rain only fell once throughout the month. The linear trend line shows a downward trend of approximately 5.84mm at the rate of 0.146mm year^{-1}. The downward trend in July rainfall means reduced rainfall amounts. Although the figure is very small, it could create limited temporary shortage of meaningful rains before August sets in.

4.2.3 Trends in Mean Monthly Rainfall (August)

Figure 4.3 shows trend in mean monthly rainfall for the month of August from 1975-2014 in the Study area

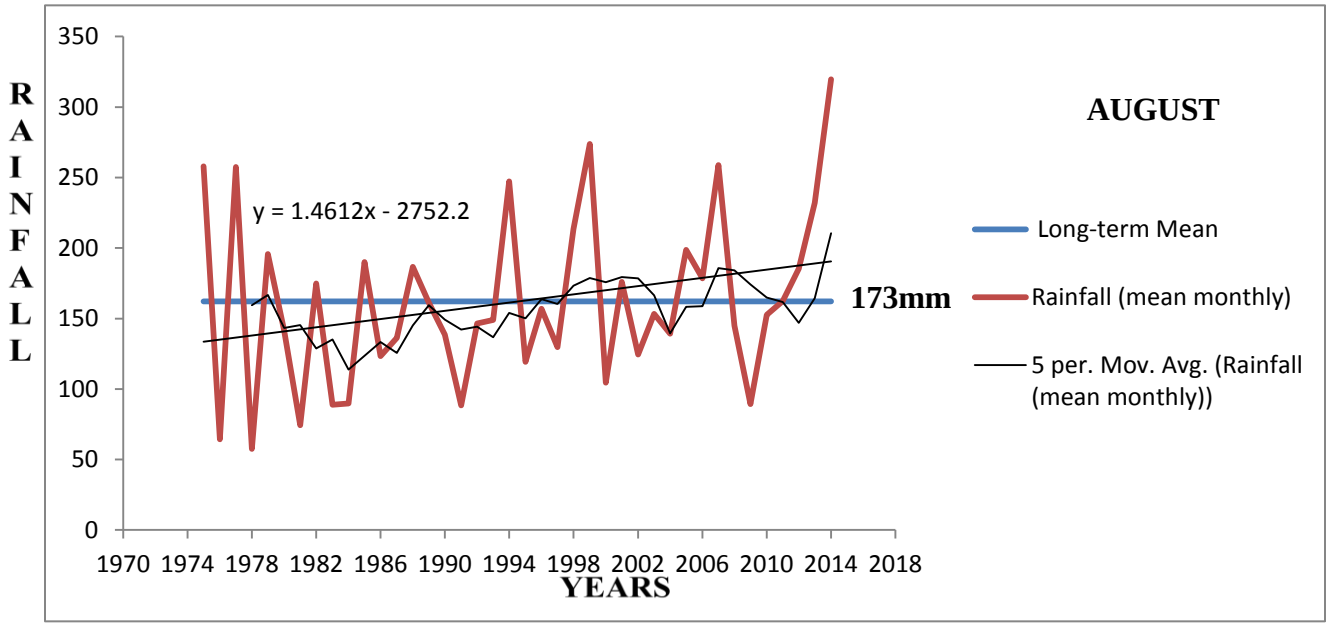


Figure 4.3 Trends in August Rainfall in Yobe North, Yobe state (1975-2014)

Figure 4.3 indicates that the heaviest mean monthly rainfall for August of about 320mm was received in 2013 and the lowest which was mere 46mm occurred in 1978. However, the 5-year running mean showed rainfall amounts below the long-term mean from the beginning of the

study period to 1994. Then, there were fluctuations (rising and falling) above and below long-term mean till the end of the study period. The linear trend line shows a positive upward trend with trend line equation (1.461x - 2752.2). It indicates an increase in rainfall amounts of approximately 58.44mm at the rate of 1.46mm year^{-1}. The trend line is clearly above the long-term mean which signifies an increase in August rainfall amounts in Yobe north. Heavy and frequent rainfall is always recorded in August. The increasing rainfall trend is therefore a source of joy to farmers as plants/crops do well. However, if the current trend continues, there could be flooding in the area as the excess rains will flow overland.

4.2.4 Trends in Mean Monthly Rainfall (September)

Figure 4.4 shows trend in mean monthly rainfall for the month of September from 1975-2014

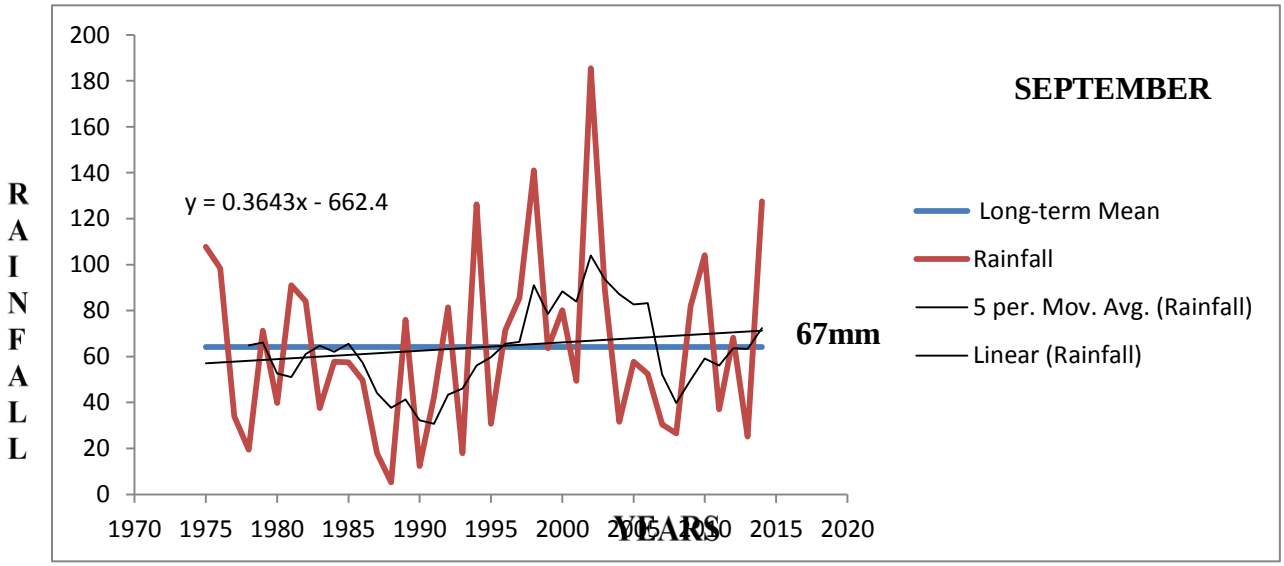


Figure 4.4 Trends in September Rainfall in Yobe North, Yobe state (1975-2014)

The 5-year running mean in Fig. 4.4 shows rainfall amounts below the long-term mean from 1976 to 1998. Then, there was a sudden rise up to 2006 and, from there the rainfall amounts were below the long-term mean till the end of the study period. The linear trend line of September

rainfall indicates a slight increase in rainfall amounts of approximately 15mm at the rate of 0.364mm year$^{-1.}$ The heaviest September rainfall (192mm) was received in 2002, while the lowest September rainfall (6mm) occurred in 1988. However, the rainfall data from the beginning to the end of the study period revealed that most of the September rainfall amounts were received within the first ten (10) days of September. The implication of increase in September rainfall is lengthening the rainy season and pushing the cessation date further. Hence this should be a source of joy to farmers. This might also reduce the usual occurrence of drought towards the end of rainy season

4.3 TRENDS IN MEAN ANNUAL RAINFALL OF THE STUDY AREA

Figure 4.5 shows trend in mean annual rainfall of the study area from 1975-2014

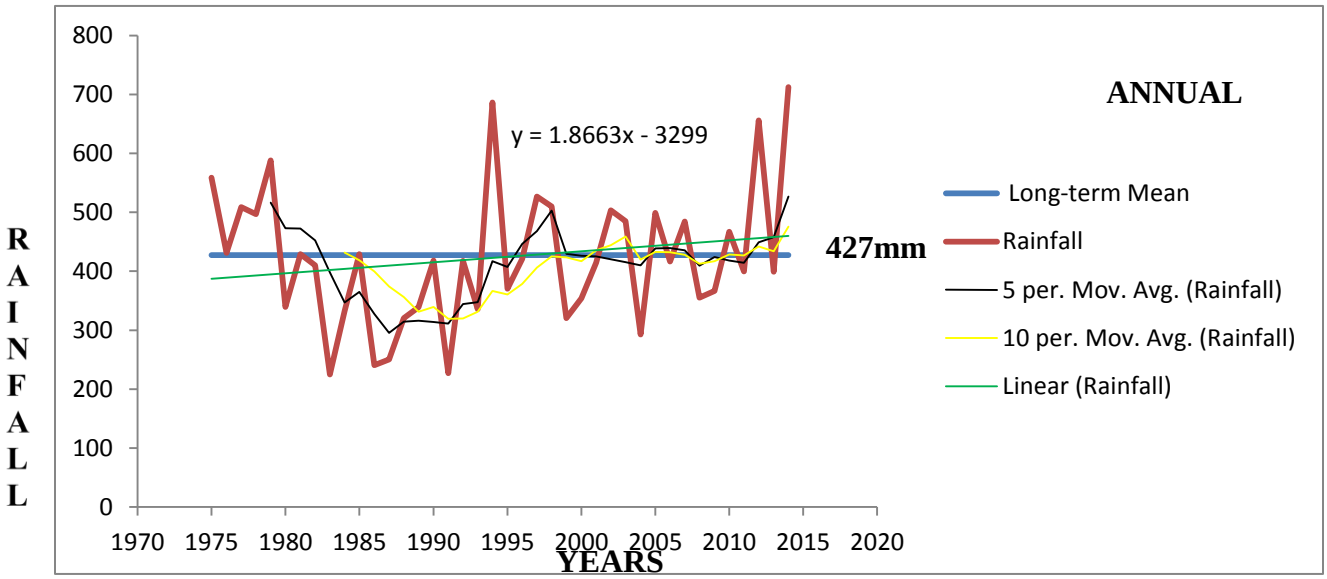


Figure 4.5 Trends in Annual Rainfall in Yobe North, Yobe state (1975-2014)

The linear line trend in Fig. 4.5 is above the long-term mean (upward trend). The 5-year running mean generally showed rainfall amounts above the long-term mean from 1974 to 1982. Then, the values were below the long-term mean till 2011 with a little rising in 2012 - 2014. The 10year

running mean depicted rainfall values below the long-term mean from 1986 to 1996. The values then rose above the long-term mean from1996 to 2000. The rainfall values then fell below the long-term mean till 2010. However, both 5-year and 10-year running means indicated rainfall amounts above the long-term mean towards the end of the study period. Hence the area receives more rains now than before. This is attributed to the increase in June, August and September rainfall in the area. Moreover, yearly fluctuations in the mean annual rainfall are observed, the linear trend line indicates an increase in annual rainfall of approximately 74.6mm at the rate of 1.86mm $year^{-1}$ with the best fit line equation put at ($y = 1.8663x – 3299$).

The rainfall trend analysis showed that 2014 recorded the highest mean annual rainfall during the period of the study. This is followed by 2012 and then 1994. The higher rainfall amounts are therefore found in 1990s and 2000s. The least mean annual rainfall occurred in 1983, 1986 and then 1987. This coincides with the periods of great drought in 1970s, 1980s and early 1990s in Northern Nigeria as described by Oladipo (1993). Hence below average rainfall was received from the beginning of the study period to early 1990s and, above average rainfall was received from late 1990s till the end of the study period. This was indicated by the 5-year and 10-year running means. However, the distribution of rainfall amount within these periods was highly variable both in time and space with no specific pattern of variability.

The analysis above generally indicates that the area is receiving more rainfall now than before with an increased August and September rainfall. The implication of this includes as stated by Adakayi (2012) halting the advance of the Sahara and even the greening of the Sahara, which is reducing its rate of expansion. This is further supported by Smith et al (2000) who observed that recent scenarios (based on greenhouse gas emissions) have suggested that the observed trend towards aridity of Sudano-sahelian zone will be put on hold or be reversed in the twenty-first

century. Infact, Ifabiyi and Ojoye (2013) confirmed that the Sudano-sahelian Ecological zone of Nigeria is getting wetter. Ati, Iguisi and Afolayon (2007), Abaje (2010) and Bambale (2014) have all observed that the Sudan-Sahelian Ecological zone of Nigeria has been experiencing decreasing number of drought occurrences and consequently increasing wetness over the recent years. Yield is therefore expected to improve and poverty might as well reduce in the area.

4.4 TRENDS IN MEAN MONTHLY TEMPERATURE

The coldest and hottest months in the area were plotted graphically in order to clearly see the trends in temperature during the period of the study. December and January were chosen as the coldest months because from the analysis of temperature trends in the study area, these two months (December and January) recorded the lowest mean monthly temperature (24.8^0 C and 23.2^0 C) throughout the period of the study. Hence analyzing the temperature trends of these months to clearly see the direction of change is of climatological importance indeed.

4.4.1 Temperature Trends for the Coldest Period (December – January)

The mean monthly temperature trends for December (1975-2014) is shown in Fig. 4.6

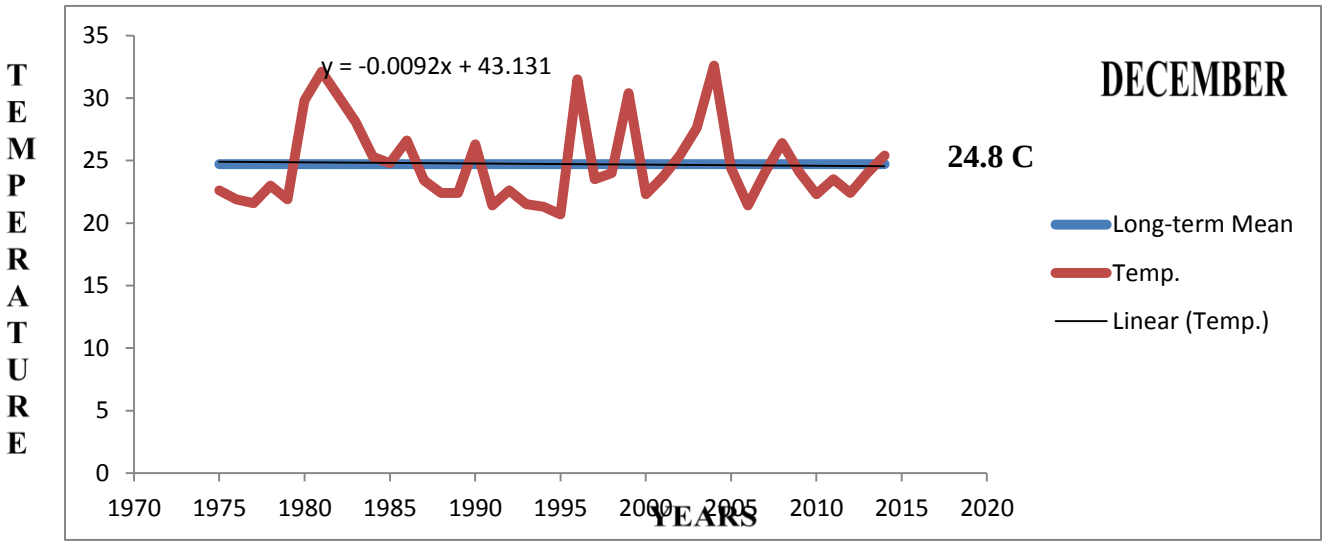


Figure 4.6 Trends in December Temperature in Yobe North, Yobe State (1975-2014)

The changes in December temperature in Fig. 4.6 are noticeable as the trend line slightly passes below the long-term mean of 24.72^{0}C. Although the December mean monthly temperatures are highly variable, the figure clearly indicates a decreasing trend (i.e. negative trend) with the best fit line equation put at (y = -0.009x + 43.13). The decrease in December temperature could increase the length of Hamattan in the study area.

The trends in the mean temperature for the month of January was plotted graphically as indicated in Fig. 4.7

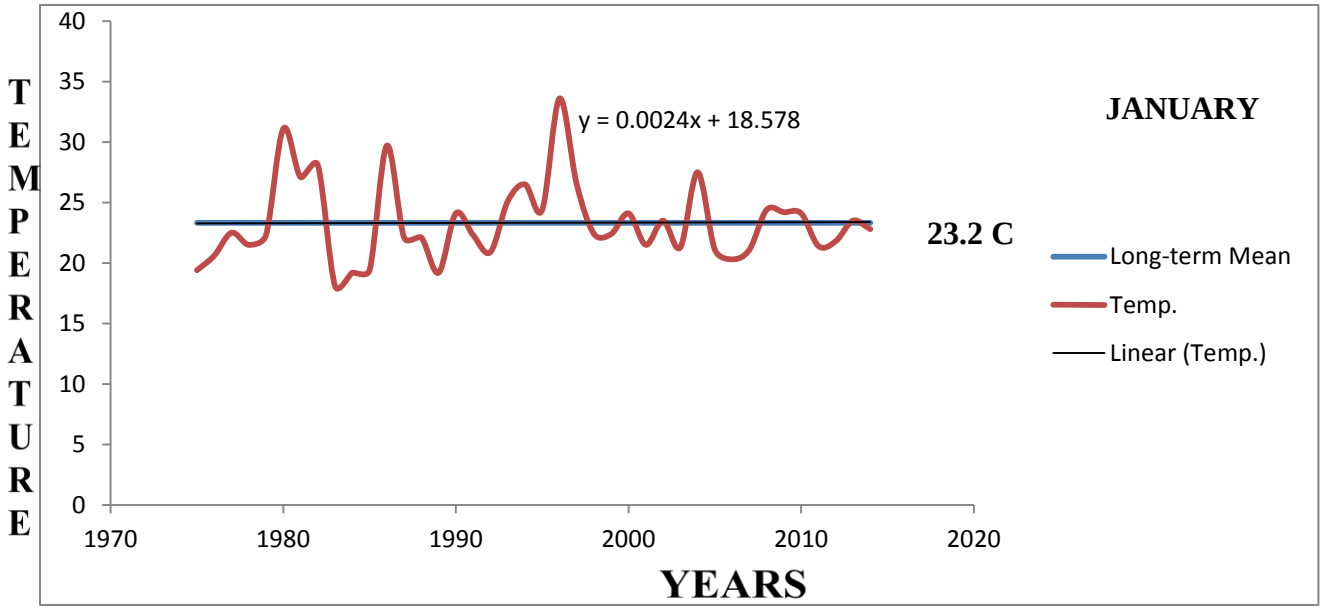


Figure 4.7 Trends in January Temperature in Yobe North, Yobe State (1975-2014)

The linear trend line and trend line equation for January mean monthly temperature in the study area as presented in Fig. 4.7 shows an upward trend (positive trend) with the best fit line equation expressed as (y = 0.0024x + 18.57). The January upward trend was put at 0.08^{0}C at the rate of 0.002^{0}C year^{-1}. If the current trend continues, the area could be experiencing reduced Hamattan or more cold days in December than in January. However, temperature variability in both December and January was small in space but more in time.

4.4.2 Temperature Trend for the Hottest Months (April - May)

April and May were chosen as the hottest months in the study area because these two months recorded the highest mean monthly temperature (33.1^0 C and 33.2^0 C) throughout the study period. Hence analyzing trends in temperature for these months to clearly see the direction of change in temperature is of paramount importance. The mean monthly temperature trends for the month of April in the study area (1975-2014) is shown in Fig. 4.8

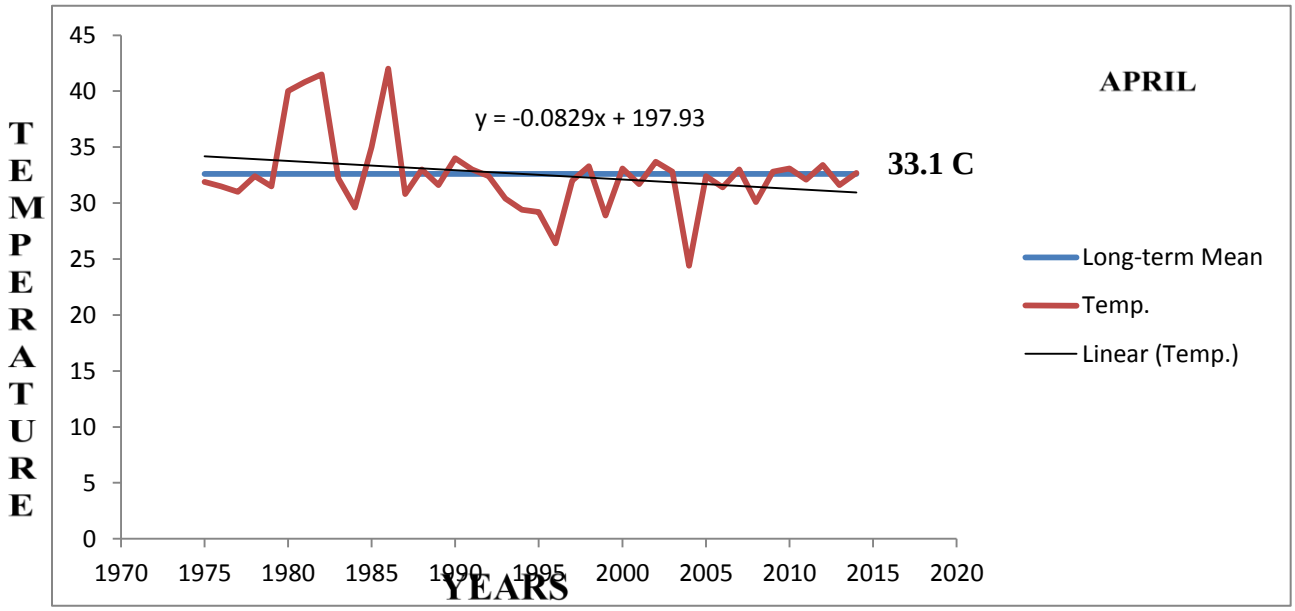


Figure 4.8 Trends in January Temperature in Yobe North, Yobe State (1975-2014)

From Fig 4.8, it can be seen clearly that the highest April mean monthly temperature (42^0 C) was recorded in 1986 while the lowest (23^0 C) was recorded in 2005. With the exception of 1980, 1981, 1986 and 2005, all the yearly fluctuations in mean monthly temperature are around the long term mean. The liner trend line and trend line equation as presented in Fig. 4.8 shows a downward trend (negative trend) with the best fit line equation expressed as (y = -0.0829x +

197.93). The decrease in April temperature is approximated to be 3.28^0 C at the rate of 0.082^0C $year^{-1}$.

The mean monthly temperature trends for the month of May in the study area (1975-2014) is shown in Fig. 4.9

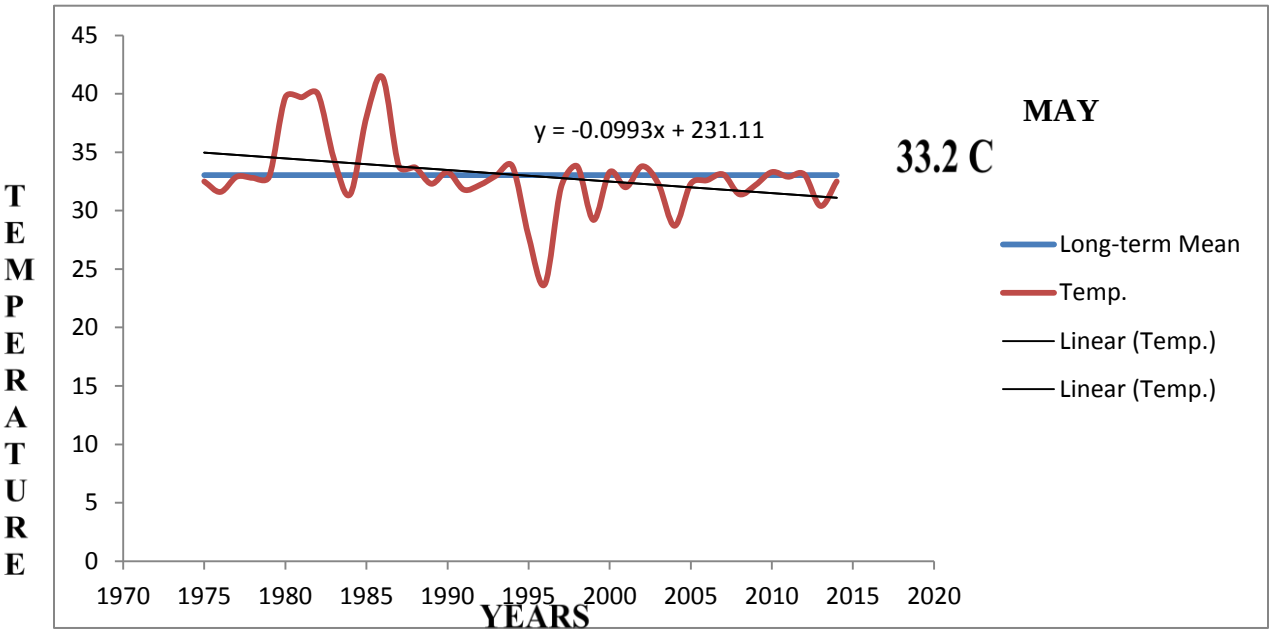


Figure 4.9 Trends in May Temperature in Yobe North, Yobe State (1975-2014)

The highest mean monthly temperature for the month of May is 41.4^0 C as indicated in Fig. 4.9. The average monthly temperature is found to be 33.2^0 C, while the lowest mean monthly (22.1^0C) was recorded in 1996. The liner trend line and trend line equation shows a downward trend (negative trend) with the best fit line equation expressed as (y = -0.99x + 231.1). Much of the yearly fluctuations in mean monthly temperature are centered around the long term mean temperature of 33.2^0 C except 1979, 1980 1985 and 1995 that are further away from the long term mean.

4.5 TRENDS IN MEAN ANNUAL TEMPERATURE (1975-2014)

The trend in mean annual temperature and fluctuations in the study area is presented in Fig 4.10

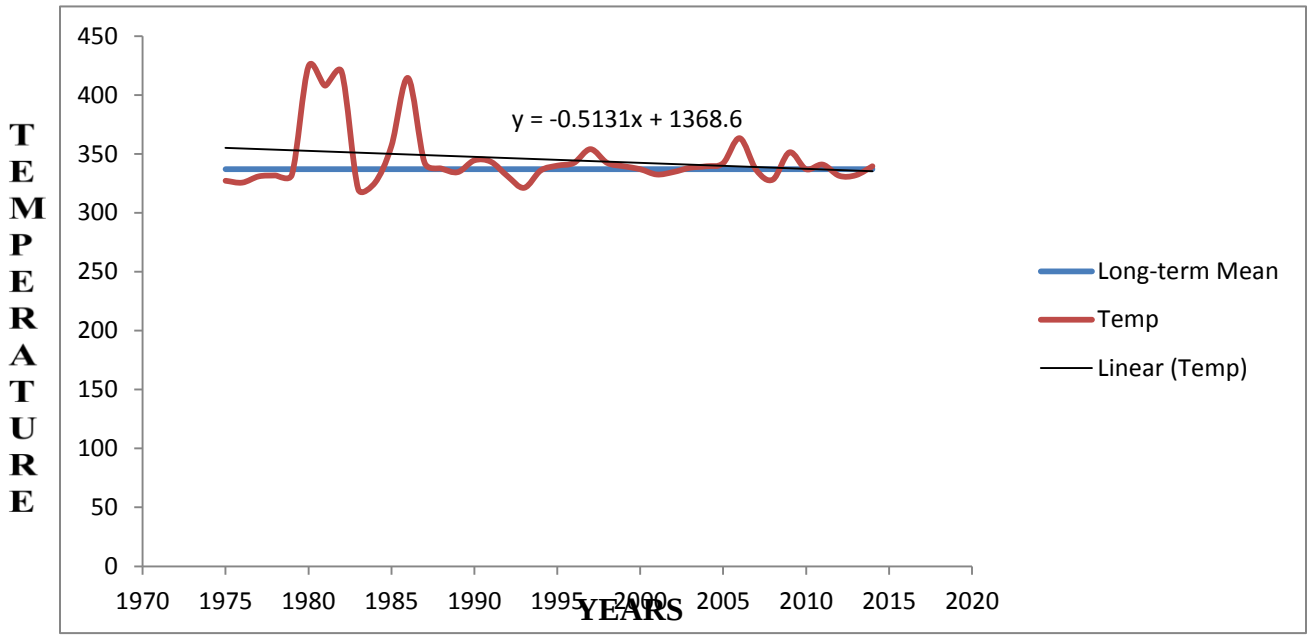


Figure 4.10 Trends in Annual Temperature in Yobe North, Yobe State (1975-2014)

From the annual temperature trend analysis, 1980 has the highest mean annual temperature. This was followed by 1982 and then 1986. Coincidently, the least annual rainfall amounts were recorded in 1980s; one of the decades of the great drought that hit most parts of Northern Nigeria. Hence the least rainfall amount could be the consequent of higher temperatures during the period. The lowest mean annual temperature during the period of the study was recorded in 1983, followed by 1993 and then 1975. Although a downward trend in April mean annual temperature was observed, the highest mean monthly temperature during the period of the study was recorded in April (42^0C) in 1986. With the exception of December and January being the

coldest months, temperature was high throughout the year with May and April appeared as the hottest months during the period of the study. The lowest mean monthly temperature is observed in January (18.1^0C) in 1983. It is interesting to note that since 2001, January mean monthly temperature below 20 ^{0}C has not been recorded in the study area. It has always been above 21^0C. Hence the January temperature is getting increased which could lead to reduced Hamattan as a manifestation of climate change in the area. This was observed by some of the respondents. Moreover, virtually all the yearly fluctuations centered around the annual long term mean temperature of 32.4^0 C except in few years whose annual mean was further away from the long term mean.

4.6 ONSET, CESSATION DATES AND LENGTH OF THE RAINY SEASON (1975-2014)

Table 4.2 shows all the records of onset, cessation dates and length of the rainy season in northern parts of Yobe

Table 4.2 Onset Dates, Cessation and Length of the Rainy Season (1975-2014)

Year	Annual Rainfall	Onset Dates	Cessation Dates	Length Of The Rainy Season
1975	538.6	12th July	19th Sept.	69
1976	431.0	10th July	17th Oct.	99
1977	509.0	9th July	26th Aug.	48
1978	496.7	16th June	9th Aug.	55
1979	587.8	12th June	12th Sept.	92
1980	339.6	14th July	21st Aug.	38
1981	428.9	14th June	15th Sept.	93
1982	409.9	27th June	15th Sept.	80
1983	224.7	27th June	4th Aug.	38
1984	332.4	14th July	6th Sept.	54
1985	229.2	30th June	8th Sept	70
1986	240.6	13th August	17th Aug.	4
1987	250.3	21st July	20nd Aug.	30
1988	320.6	15th July	22nd Aug.	38
1989	338.6	21st July	13th Sept	54
1990	418.1	7th July	21st Aug.	45
1991	227.1	18th August	31st Aug.	44
1992	417.8	13th July	14th Sept.	63
1993	335.6	10th July	21st Aug.	42
1994	686.1	25th June	21st Sept.	88
1995	370.6	6th July	19th Aug.	44
1996	420.9	26th June	12th Sept.	78
1997	526.5	6th June	15th Sept.	101
1998	510.1	15th July	22nd Sept.	69
1999	482.7	16th July	11th Sept.	57
2000	353.8	27th June	13th Sept.	79
2001	414.2	14th July	23rd Aug.	40
2002	503.1	30th May	23rd Sept.	115
2003	485.0	21st June	15th Sept	86
2004	292.7	18th July	20th Aug.	33
2005	499.2	21st June	8th Sept.	79
2006	416.6	9th June	5th Sept.	88
2007	484.2	14th June	25th Aug.	72
2008	355.0	11th July	21st Aug.	41
2009	366.5	10th July	13th Sept	64
2010	467.2	18th June	18th Sept	92
2011	399.7	26th June	22nd Aug.	57
2012	656.1	5th July	11th Sept.	68
2013	399.0	17th July	25th Aug .	39
2014	712.1	19th July	21st Sept.	94

Source: NIMET (Nguru Station,) 2015

4.6.1 Onset Dates of the Rainy Season (1975-2014)

The linear trends and trend line equations of the onset dates in the study area are shown in Fig. 4.11

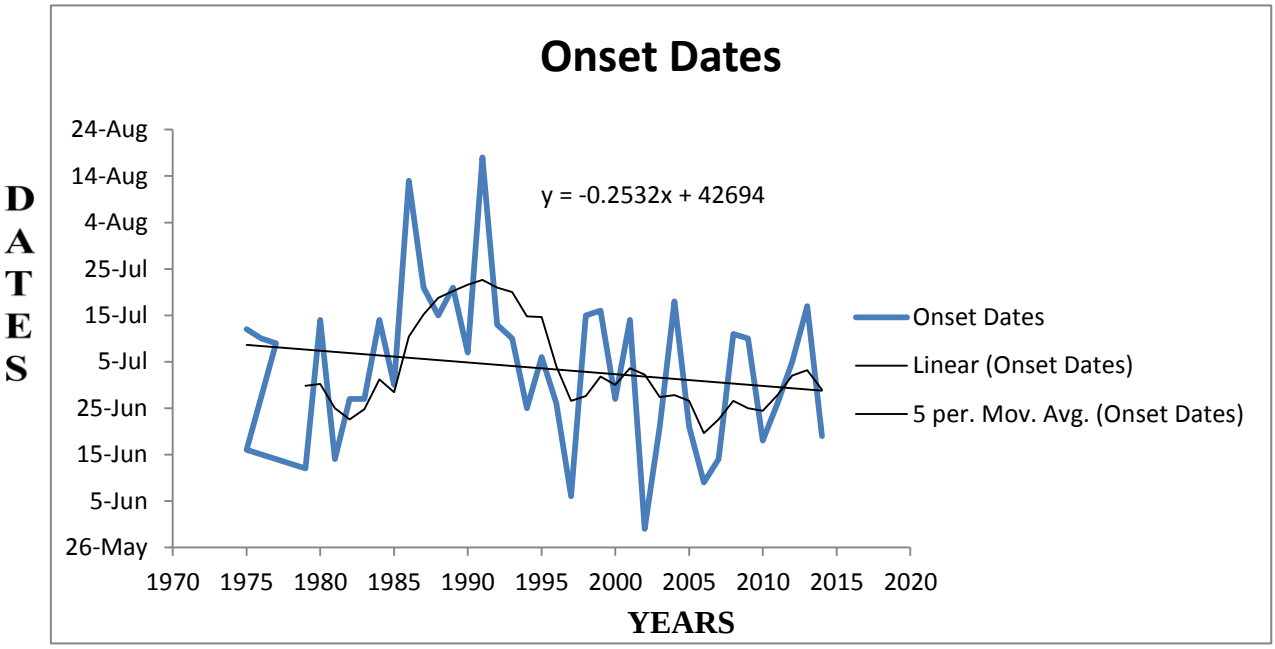


Figure 4.11 Trends in Rainfall Onset Dates in Yobe North, Yobe State (1975-2014)

Although the onset dates are highly variable, figure 4.11 clearly indicates a decreasing trend (i.e. negative trend) with the best fit line equation put at (y = -0.2532x +42694). This means that the rain starts earlier in recent times in the study area. This is supported by the work of Elisha (2014) who stated that rains are now coming earlier in Goronyo with 25th May as the mean onset date. However, in comparison with onset dates of other areas on the same latitudes such as Goronyo in Sokoto State, the rains start late in the study area. This is because the average onset date within the period of the study is 10th July, while the earliest onset date was 30th May in 2002 and the

latest onset date was 18th August in 1991. Hence, it can be concluded that relatively, the rains in the study area (10th July –Average onset date) start progressively late indeed.

4.6.2 Cessation Dates of the Rainy Season (1975-2014)

The linear trends and trend line equations of the cessation dates in the study area are shown in Fig. 4.12

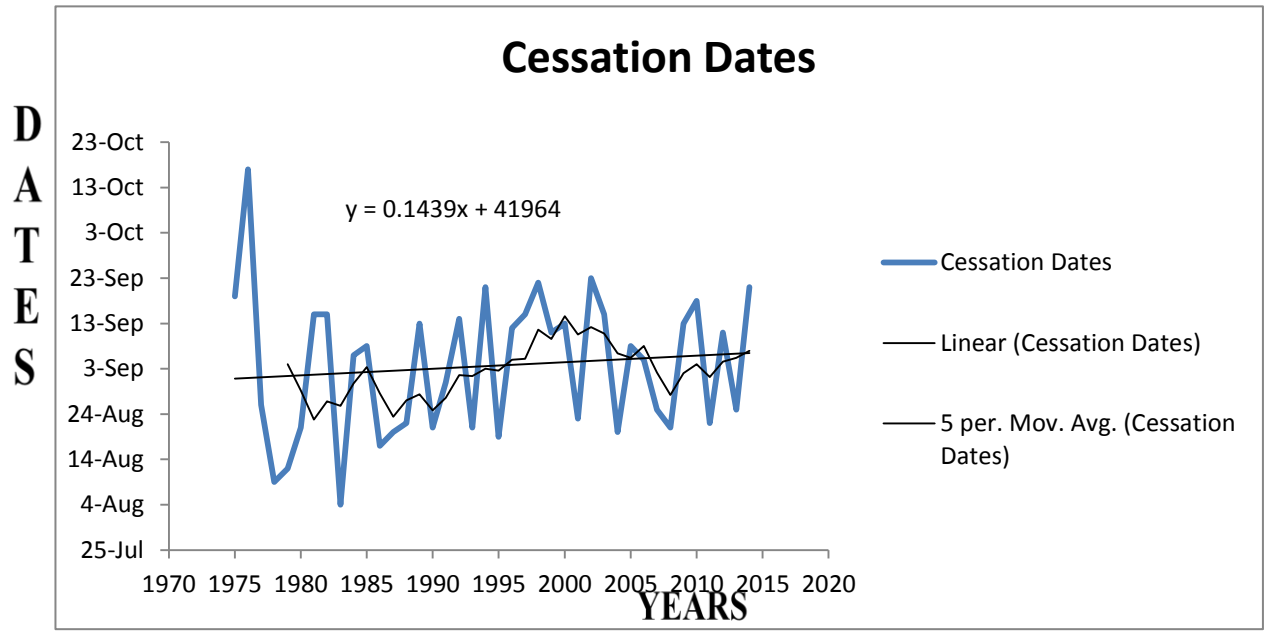


Figure 4.12 Trends in Rainfall Cessation Dates in Yobe North, Yobe State (1975-2014)

The mean cessation date in the study area as in indicated in Fig. 4.12 is 8th September. The trend in the cessation date is positive (i.e. upward trend) with the best fit line equation expressed as (y = 0.1439x + 41964). The earliest cessation date in the study area within the period of the study occurred on 4th August in 1984, while the latest cessation date was 17th October 1976.However, from the beginning of this decade to the end of the study area the cessation date has always been

mid-September and late August. Hence the marked noises (variability) are not as much as in onset dates.

4.6.3 Length of the Rainy Season (1975-2014)

The linear trends and trend line equations of the duration of the rainy season in the study area are shown in Fig. 4.13

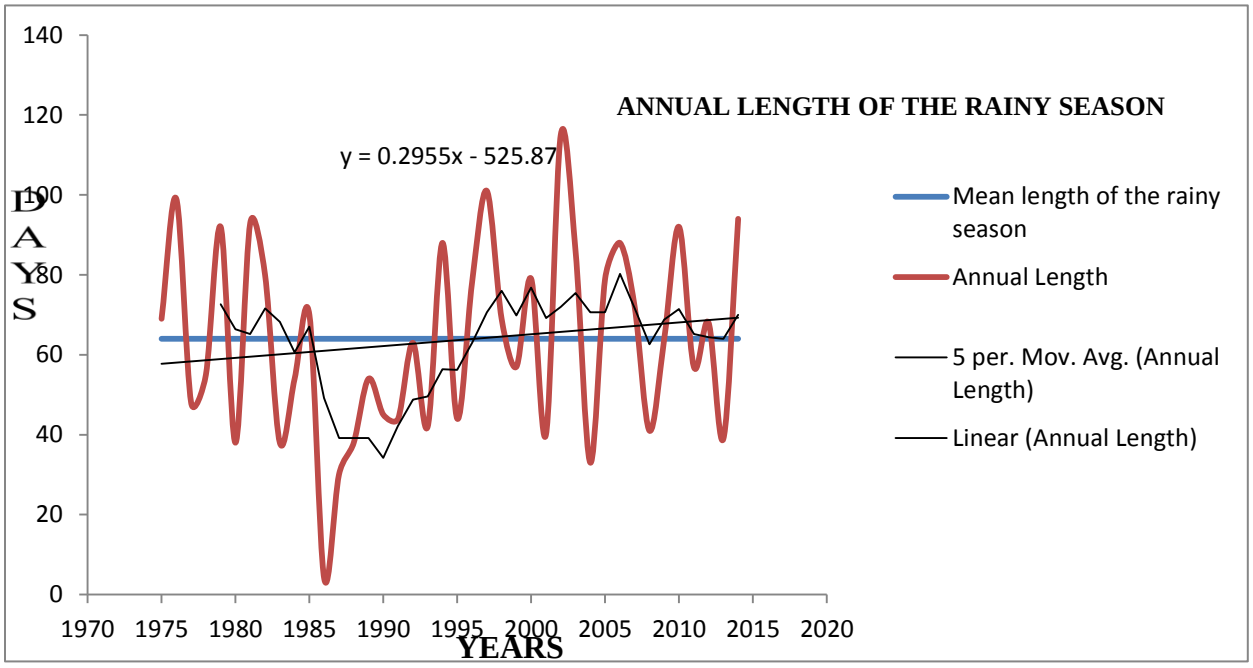


Figure 4.13 Trends in Length of Rainy Season in Yobe North, Yobe State (1975-2014)

The pattern of the length of the rainy season in the study area shown in Fig. 4.13 indicates that the long-term mean of the length of the rainy season in the study area is about 65 days. The linear trend line indicated an upward trend with the best fit line expressed as (y = 0.2955x + 525.87). This implies that the duration of the rainy season in the study area is increasing. However, like the onset dates the variability in the duration of the rainy season from year to year

is very high with no specific pattern. For instance, some years recorded short duration as short as 48 days but the rainfall amounts were 510mm, while in some years the length of the rainy season was as high as 93 days but the rainfall amounts were mere 428mm.

Moreover, the most fascinating year is 1986 where the length of the rainy season in the study area was less than 10 days but 240.6mm of rainfall were received. Hence the longer the length of the rainy season does not necessarily mean higher rainfall amounts and the shorter the duration of the rainy season does not necessarily mean lesser rainfall values in the study area. And, these marked noises (variability) in the onset, cessation and duration of the rainy season are really a source of worry to farmers especially that dry spell is very prevalent in the area.

4.7 RESULTS OF RESPONSES FROM QUESTIONNAIRE

A total of 384 questionnaire was administered, 34 were not retrieved and a sum of 350 were retrieved from the twelve sampled wards in the four LGA. Fifty three respondents were from Machina LGA, 82 from Karasuwa, 122 from Yunusari and 93 from Yusufari LGA. The thirty four (34) questionnaire not retrieved was as a result of sudden insurgency after the administration of the questionnaire in parts of Yunusari and Yusufari LGAs which forced many people to abandon their settlements.

4.7.1 Demographic Characteristics of the Respondents

The demographic characteristics of the respondents cover sex, marital status, household size, social status, educational levels of respondents in the twelve sampled wards in Yobe North.

4.7.1.1 *Sex status*

The distribution by sex of the respondents in each LGA is presented in Table 4.3

Table 4.3 Sex Composition of the Respondents

LGA	Male	Female	Total	Percentage
Machina	43	10	53	**15**
Karasuwa	75	7	82	**23.0**
Yunusari	115	7	122	**35.0**
Yusufari	90	3	93	**27.0**
Total	**323**	**27**	**350**	**100**
Percentage	**92**	**8**	**100**	

Source: Field survey, 2015

The proportion of the respondents by sex shows that 92% of the respondents are male while 8% are female. Yunusari LGA had the highest percentage of male respondents (36%) followed by Yusufari (28%), Karasuwa (23%) and then Machina (13%). However, Machina LGA recorded the highest percentage of female respondents (37). This was followed by Karasuwa and Yunusari (26% each) and then Yusufari (11). The predominance of the male respondents can be attributed to cultural and religious values in this part of the country that limits most women from engaging in farming and other related activities.

4.7.1.2 *Age distribution of the respondents*

The age distribution of the respondents in the sampled wards in four LGA is presented in Table 4.4. It shows that majority (56.4%) of the respondents fall within the age group of 41-50. This is followed by 31-40 age group (30.2%), 20-30 age group (10%) and then 51 and above age groups (3.4% each). Hence virtually all the respondents fall within the economically active population that are industrious and productive who will be able to speak on issues of climate change.

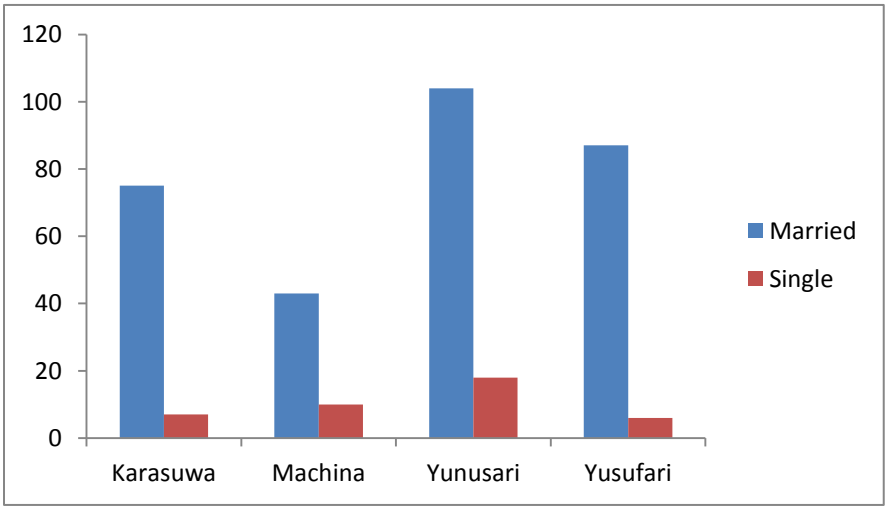
Table 4.4 Age of the Respondents

LGA	20-30	31-40	41-50	51 and above	TOTAL
Karasuwa	10	25	41	6	**82**
Machina	5	20	27	1	**53**
Yunusari	12	30	77	3	**122**
Yusufari	7	31	53	2	**93**
Total	**34**	**106**	**198**	**12**	**350**
Percentage	**10**	**30.2**	**56.4**	**3.4**	**100**

Source: Field survey, 2015

4.7.1.3 *Marital status*

The marital status of the respondents is broadly divided into married and single status. This is shown in the component bar chart in Fig. 4.14. The status indicated that 89% of the respondents are married while 11% are single.



Source: Field survey, 2015

Figure 4.14 Marital status of the respondents in sampled LGA

The higher percentage of the respondents being married may not also be unconnected with culture and religion especially that the area is predominantly Muslim whose religion encourages

early marriage. Marriage is also an important aspect of adulthood in most African societies (Solomon, 2014). Majority of the respondents being married will actively engage in adapting to climate change so that they can support their family.

4.7.*1.4 Household size*

The distribution of household size in the study area is presented in Table 4.5**.** The information obtained regarding the household revealed that the highest number of people per household is between 1 to 5 persons (29%). The next highest are those with 6 to 10 persons (23%), followed by those with the household size 20 and above (20%), then those with 11 to 15 persons (16%) and finally those with 16 to 19 persons had the least percentage (12%).

Table 4.5 Distribution of Household Size

LGA	1-5	6-10	11-15	16-19	20 and above	TOTAL
Karasuwa	20	18	6	12	26	**82**
Machina	15	13	14	8	3	**53**
Yunusari	50	21	20	17	14	**122**
Yusufari	15	30	16	5	27	**93**
Total	**100**	**82**	**56**	**42**	**70**	**360**
Percentage	**29**	**23**	**16**	**12**	**20**	**100**

Source: Field survey, 2015

Although Yobe state has the second highest annual growth rate of 3.4 in Nigeria! (Yakasai, 2006), majority of the respondents (29%) had the least household size (1 to 5 persons) as indicated in Table 4.5. This might be the result of increased awareness on family planning programmes and improved medical facilities that make family plan possible.

4.7.1.5 *Social status*

The political status of the respondents is divided into three groups; community head, family head and others. This is presented in Table 4. 6

Table 4.6 Social Status of the Respondents

LGA	Community head	Family head	Others	TOTAL
Karasuwa	3	60	19	**82**
Machina	3	40	10	**53**
Yunusari	5	90	27	**122**
Yusufari	3	47	43	**93**
Total	**14**	**237**	**99**	**350**
Percentage	**4**	**68**	**28**	**100**

Source: Field survey

Table 4.6 shows that only 4% (14) of the respondents are community heads, majority of the respondents (237) which is about 68% are family heads and others accounted for 28%. The majority of the respondents being the family heads have more burdens and this increased their seriousness to adapt to climate change so that they can continue supporting their families.

4.7.1.6 *Educational qualification*

The educational qualification of the respondents is presented in Table 4.7.

Table 4.7 Educational Qualification of the Respondents

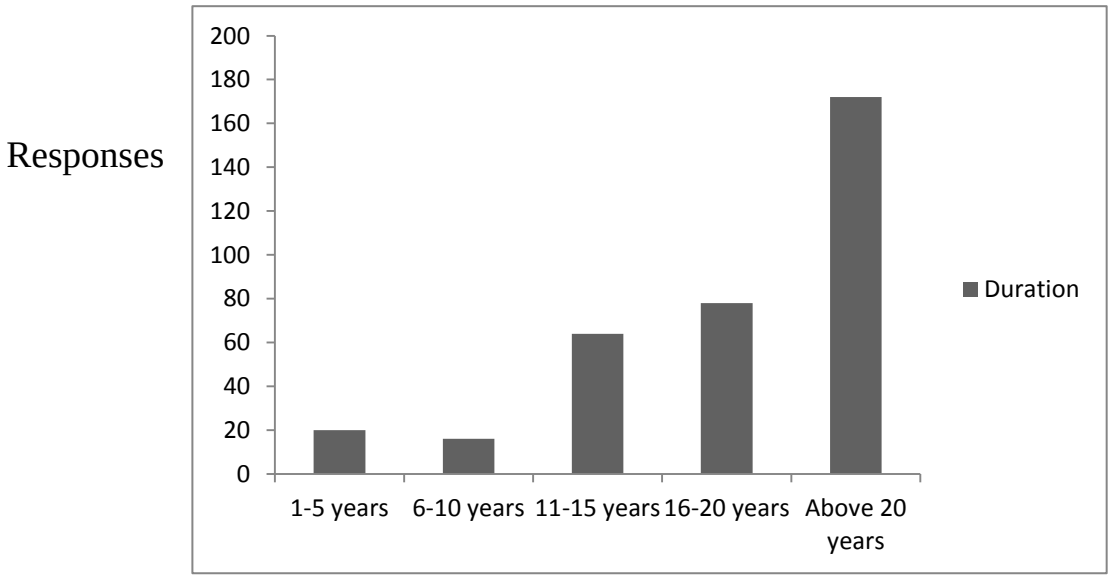
LGA	Prim.	Sec.	NCE	OND	HND	1st Degree	Masters	Illiterate	Total
Karasuwa	10	18	23	16	5	4	2	4	**82**
Machina	11	10	19	4	3	2	1		**53**
Yunusari	20	25	32	20	10	12	0	3	**122**
Yusufari	23	15	24	16	6	6	1	2	**93**
Total	**64**	**68**	**98**	**56**	**24**	**24**	**4**	**12**	**350**
Percentage	**18**	**20**	**28**	**16**	**7**	**7**	**1**	**3**	**100**

Source: Field survey, 2015

Tables 4.7 revealed that majority (28%) of the respondents in the study area are NCE holders. This is followed by secondary school leavers (20%), primary school leavers (18%), OND holders (16%), HND and first degree accounted for 7% each and then Masters which scored the least percentage (1%). Only 12 people were found to be illiterates (3%). The higher percentage of NCE and OND holders can be attributed to the presence of Umar Suleiman College of Education at Gashua that awards both NCE and OND. The low level of illiteracy is not unconnected with the introduction of Universal Basic Education (UBE) programme through which many junior secondary schools were established in rural communities under the supervision of Yobe State Universal Basic Education Board (YSUBEB). However, only 20% of the respondents (60 farmers) are part time farmers who attached themselves to other activities in the study area.

4.7.2 Duration of Residency in the Area

The years spent by the respondents in the study area is presented in the bar chart in Fig. 4.15.



***Source: Field Survey,* 2015**

Figure 4.15 Duration of Residency in the Study Area

Fig. 4.15 shows that 6% of the farmers (20 farmers) have been in the area for 1-5 years; 4.5% (16 farmers) have lived in the area for 6-10 years; 18% (64 farmers) have been living in the area for 11-15 years; 22% (78 farmers) have lived in the area for 16-20 years; 49% (172 farmers) have lived in the study area for 20 years and above. From the chart above, it is clearly obvious that majority of the respondents (49%) have lived in the area long enough to be able to provide the needed information on climate change scenario and, they might have adapted one strategy or the other to curb the harmful effect of climate change.

4.7.3 Types of Farming Practices

The type of farming practice in the study area is divided into three broad groups: commercial, subsistent and both. The type of farming practiced in the area is presented in Table 4.8.

Table 4.8 Types of Faming Practiced by the Respondents

LGA	Commercial	Subsistent	Both	Total
Karasuwa	**27**	**43**	**12**	**82**
Machina	**17**	**30**	**6**	**53**
Yunusari	**30**	**30**	**62**	**122**
Yusufari	**23**	**46**	**24**	**93**
Total	**97**	**149**	**104**	**350**
Percentage	**28**	**43**	**29**	**100**

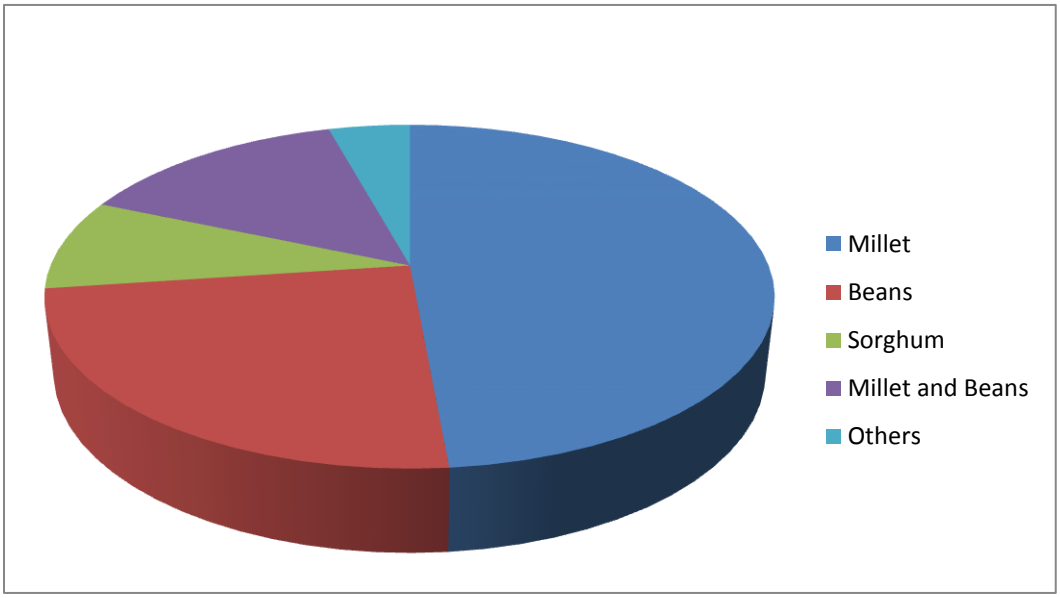
Source: Field survey, 2015

Table 4.8 indicates that 28% of the respondents are commercial farmers (whose aim is to make profit by selling the farm products), while 43% practice subsistent farming and 29% practice both commercial and subsistence farming. Yusufari LGA has the highest number of subsistent farmers (31%) i.e. farming only for family consumption. This is followed by Karasuwa LGA

(29%) and then Machina and Yunusari (30% each). Large number of commercial farmers is found in Yunusari LGA (31%). This is followed by Karasuwa LGA (285), Yusufari LGA (23%) and then Machina LGA (17%). While combined commercial and subsistent farming are largely practiced by 60% of farmers in Yunusari LGA. This is followed by Yusufari LGA (23), Karasuwa (11%) and then Machina LGA (6%). The higher percentage of subsistent farming is a typical example of a rural agriculture in Nigeria. This could be attributed to high level of poverty and primitive farming techniques. Even the commercial farmers are just local farmers and the quantity they produce per annum is very small. However, there are no known commercial farms in the area and the exact quantity produced per annum is not available.

4.7.4 Types of Crops Produced

Millet, beans and sorghum are the major crops produced in the area and responses of farmers on this are presented in Fig. 4.16



Source: Field survey, 2015

Figure 4.16 Types of Crops Produced in the Study Area

Fig. 4.16 shows that nearly 50% of the respondents engaged in millet cultivation. This is followed by beans farmers accounting for about 26% of the respondents, sorghum farmers (6%), farmers that combined millet and beans (18%) and then other minor crops accounting for only 2% of the respondents. The higher percentage of millet farmers can be attributed to the fact that millet is short duration drought-resistant crop that is largely grown in the Sudano-sahelian bioclimatic zone of northern Nigeria.

4.7.5 Evidences of Climate Change

The evidences of climate change in the study area are very obvious. As expressed by the respondents especially that the area is situated within the sudano-sahelian climatic zone. The factors that informed the farmers of the climate change are presented in Table 4.9.

Table 4.9 Percentage Distribution of the Evidences of Climate Change

Factors	No. of respondents	Percentage
Delay in the onset of rainfall	80	19
Early cessation of rainy season	42	10
Long period of dry season	53	13
Erratic distribution of annual rainfall	13	3
Heavy rainfall	45	11
Less rainfall	75	18
High temperature	52	13
Reduced Hamattan	11	3
Dry spell	30	7
Long period of Hamattan	6	1
Heavy winds	8	2
Total	**415**	**100**

Source: Field survey, 2015

From Table 4.9 it can be seen clearly that majority (19%) of the respondents (80 farmers) are of the opinion that delay in the onset of rainfall is one of the major evidences of climate change in the area. This opinion is supported by Sawa and Adebayo (2011) who observed that in recent times rainfall starts progressively late in northern Nigeria. The analysis of rainfall data in the area by this study also indicated that the average onset date in the area is 10th July compared to 25th May, the mean onset date in many parts of northern Nigeria. The delay in the onset of rainfall in the area has a profound impact on farming activities as farmers always find it very difficult to determine exact planting date. The second major evidence of climate change observed by the respondents is less rainfall accounting for 18% of the respondents (75 farmers). Although an upward trend in annual rainfall is observed, meaningful rainfall for plant growth is becoming less; coupled with short length of rainy season that barely lasts for 70 days with pronounced dry spells.

High temperature which accounts for 13% of the respondents (52 farmers) is the third major evidence of climate change in the area. Temperature is always high throughout the year with March-July being the hottest months as observed by the respondents. The next major factor that informed the farmers of climate change is long period of dry season accounting for about 13% of the respondents (53 farmers). Dry season in the area lasts for more than 9 months. This is because from the analysis of rainfall data (1975-2014), the average length of rainy season is 65 days. Also, with the exception of 2002 whose onset date was 30th May, all other years had onset date either in June, July or August. The cessation date too has always been in September and August except 1976 whose cessation date was 17th October. Hence the dry season is very long and has an implication on rain-fed crops.

The next major sign is heavy rainfall observed by 11% of the respondents (45 farmers). The frequency of heavy rains is not high in the area, but whenever heavy rain occurs it is always devastating and followed by long period of rainless days. Early cessation of rainy season is observed by 10% of the respondents (42 farmers) as an evidence of climate change in the study area. The study revealed that the average cessation date in the area throughout the period of study is 8th September which is earlier than average cessation date in northern Nigeria (27th September) as observed by Sawa and Adebayo (2011). Dry spell was identified by 7% of the respondents (30 farmers) in the study area. The occurrence of dry spells is very common and pronounced in the area. It occurs every year and severely affects the planting timing or within the onset season especially in recent times.

The next evidence is erratic distribution of annual rainfall noticed by 3% of the respondents (13 farmers) in the study area. Rainfall in the area is highly variable both in time and space. Heavy rainfall is often followed by subsequent long days of light shower or unusual heavy rainfall preceded by long period of dry days. Reduced Hamattan is the next evidence of climate change as observed by 3% of the respondents (11 farmers). This could be attributed to upward trend in January temperature. Heavy winds and long period of Hamattan had the least respondents (2% and 1%). The long period of Hamattan could be related to the observed downward trend in December temperature.

4.7.6 Effects of Climate Change

The effect of climate change in the study area is discussed under two headings: climatic effect and socio-economic effect both of which are noticed by the respondents in the study area.

4.7.6.1 *Climatic effects*

Climatic effects are those effects that are mostly the consequences of change/variability in climate and weather conditions and to very large extent anthropogenic activities. This is presented in Table 4.10. It clearly indicates that desertification is the most pronounced effect of climate change in the area accounting for 37% of the respondents (130 farmers). The area is already desertified! Houses and farmlands are frequently submerged by sand as observed by Francis and Theophilus (2012). The encroaching sand inhibits farming activities and more often forces the farmers to move to other site or abandon farming entirely. Some even migrate to other places and live as refugees. Plate 1 shows the threat posed by desertification in the study area.

Table 4.10 Climatic Effect of Climate change

Effects	**No. of respondents**	**Percentage**
Overflowing of stream/rivers	4	1
Thunderstorms	14	4
Floods and erosion	19	5
Loss of soil fertility	45	13
Drought	70	20
Drying up of rivers	6	2
High sunshine intensity	43	12
Increased desertification process	130	37
Loss of biodiversity	9	3
Unusual dust that covers the atmosphere	10	3
Total	**350**	**100**

Source: Field survey, 2015

Plate I: Houses submerged by desert in Bula-tura, Yusufari LGA

Drought is noticed as the second major climatic effect of climatic change by 20% of the respondents (70 farmers). Although, in recent times the occurrence of drought in the study area is not as obvious as desertification, many farmers lost farm products because rainfall stops unexpectedly after they have planted. This is further highlighted by Farauta et al (2012) that in the Sahel zone of northern Nigeria, the most pronounced climate change-related forms of land degradation are wind erosion and related sand dune formation as well as drought and desertification.

High solar intensity is next major effect of climate change in the study area which is noticed by 12% of the respondents. In this part of the world, sun shines everyday irrespective of the season and the average mean monthly temperature is more than 30 ^{0}C except during Hamattan. The high

solar intensity has a tremendous effect especially on health and yield. Flood and erosion was observed by 5% of the respondents in the study area. Flooding is one of the extreme weather events caused by climate change and related global warming. With the exception of Karasuwa LGA, the other three LGAS do not usually experience flooding. This is because the area lies in the desert where there is no single body of water and rainfall hardly flows overland. Hence all the 19 farmers came from Karasuwa LGA. However, 4% of the respondents affirmed that thunderstorm is another effect of climate change in the study area which occurs during the rainy season. The convectional rainfall is normally accompanied by thunderstorm and in recent times it's becoming rampant as observed by the respondents.

Finally, loss of biodiversity and unusual dust storm that covers the atmosphere was identified by (3% each) and then overflowing of stream/rivers noticed by only 1% of the respondents. Floral and faunal community is shrinking. The few scattered trees are becoming fewer and many wild animals have relocated southward as observed by the respondents. The change also affects the agro-pastoral system as animals have to trek very long distance in search of green grass (De Chavez and Tauli Corpus, 2008).

4.7.6.2 Socioeconomic effect

This covers those effects that directly affect socioeconomic activities of man in the study area. This is presented in Table 4.11.

Table 4.11 Socioeconomic Effects of Climate Change

Effect	No. of respondents	Percentage
Poverty	113	32
Unemployment	60	17
Hunger and Starvation	15	4
Reduction in farm yields	40	11
High rate of disease incidence	23	7
Increase in the price of foodstuff	33	9.5
Making it difficult for people to Work	20	6
Premature deaths	5	1.5
Scarcity of foodstuff	41	12
Total	**350**	**100**

Source: Field survey, 2015

Table 4.11 shows the resultant negative effects of climate change on man in the study area. It is obvious from Table 4.11 that poverty is the major socioeconomic effect of climate change as seen by 27% of the respondents. Poverty is normally the end product of other effects of climate change in the area. While 11% of the respondents complained of unemployment which could be attributed to low farming activities as a result of change in climate. Loss of soil fertility is noticed by 12% of the respondents in the study area. This has severely affected farm produce and led to drastic reduction in yields as observed by 11% of the farmers in the study area. Loss of soil fertility and the consequent reduction in farm yields have led to scarcity of food stuff as

noted by 12% of the respondents in the study area. The limited supply in foodstuff has inflated the price of foodstuff and related consumer goods. This is noticed by 10% of the respondents.

High rate of disease incidence is also prevalent in the area with 7% of the respondents agreeing that pests and disease have severely damaged their crops especially in recent times. The prevalence of pest and diseases can hinder storage when the need arises because of temperature increase. Some of the respondents (6%) indicated that climate change incidences have made it difficult for them to work. According to World Health Organization (2004) skin eruption, heat fatigue, heat cramps, heat exhaustion and heat stroke are classical heat related illnesses which are resultant from climate variations. Hence it is not a surprise when about 2% of the respondents observed that variations in climate are causing premature deaths in the study area. Hunger and starvation are also the resultant effects of climate change as observed by 3% of the respondents in the study area. This could possibly force some of the respondents to travel outside their environment and import food items in order to meet their daily demands – feeding.

However, from the effects of climate change identified by the farmers it can be seen clearly that there is a chain of effects which are interlinked e.g. Lose of soil fertility—Poor yield—Poverty—Hunger and Starvation—Diseases –Death. The depletion of soil nutrients makes the soil infertile and consequently poor/low yield. This creates poverty as the farmers invest large amount in farms and the output is very poor. Hunger and starvation will therefore prevail. This will lead to spread of diseases and premature death.

4.7.7 Farmers' Adaptation Strategies

This investigated farmers' adaptation initiatives/strategies to climate change in the study area.

4.7.7.1 Farmers' ability to successfully adopt adaptation strategies to climate change

Figure 4.17 indicated the respondents' ability to successfully employ adaptation strategies to climate stress in the study area.

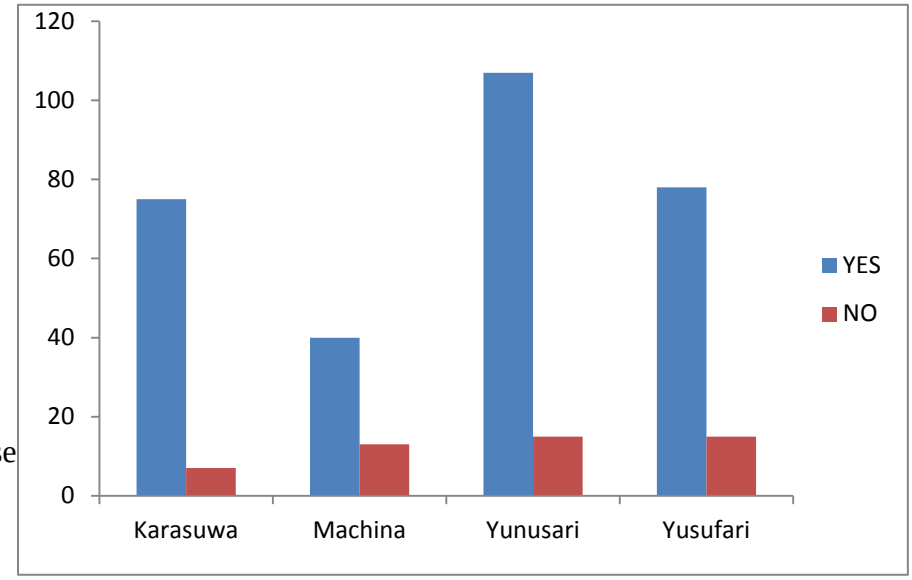


Figure 4.17 Respondents' Ability to Adapt Adaptation Strategies to Climate Change

From Fig. 4.17, it can be seen clearly that about 86% of the respondents in the four LGA have been able to successfully adapt to climate change and the result is quite encouraging especially in Yunusari and Yusufari and Karasuwa LGA. However, 14% of the farmers indicated that they have not been able to successfully employ any of the adaptation strategy to climate change.

4.7.7.2 Farmers' adaptation strategies to climate change

Farmers in Yobe north have been able to employ different adaptation strategies to curb climatic stress. The adaptation initiatives range from traditional to modern methods which are made known to farmers through research and other agencies such as North East Arid Zone Development Programme (NEAZDP). Although NEAZDP is no longer active in the area, some of the adaptation initiatives set up by NEAZDP in the 1990s and early 2000s are still being used

by the farmers and are yielding positive results. The adaptation strategies to climate change in the study area are presented in Table 4.12.

Table 4.12 Farmers' Adaptive Strategies to Climate Change

LGA Adaptive Strategies	Karasuwa	Machina	Yunusari	Yusufari	Total	%
Irrigation practices	10	2	2	2	16	**5**
Use of wetlands/fadama	5	0	2	2	10	**3**
Change in planting date	8	5	20	10	43	**12**
Change in harvesting date	5	4	15	5	28	**8**
Intensive manure application	10	2	10	14	37	**11**
Planting of early maturing crops	10	10	15	10	45	**13**
Use of resistant varieties	6	4	15	5	30	**9**
Move to different site	5	5	14	15	39	**11**
Multiple cropping	8	5	12	9	34	**10**
Increased weeding	3	2	2	3	10	**3**
Use of pesticides & insecticides	6	4	5	10	25	**7**
Construction of canals in the farm	1	2	1	1	5	**1**
Southward migration	2	2	2	2	8	**1**
Prayers for God's intervention	3	5	7	6	20	**6**
Total	**83**	**53**	**122**	**93**	**350**	**100**

Source: Field Survey, 2015

Table 4.12 shows different adaptive strategies employed by farmers in Yobe North to cushion the effects of climate change. It can be seen from Table 4.12 that majority (13%) of respondents

have chosen to plant early maturing crops (millet) as a strategy against climate stress in the area. The decision of the farmers to employ this strategy could be attributed to the short length of rainy season (65 days) and less amounts of annual rainfall in the area (sometimes less than 300mm). This could also be the reason for millet (early maturing and drought resistant variety) to be the dominant crop produced by majority of the farmers in the area. This is because this type of millet which is locally called *gero* requires 2-3months of growing season (65-90 days). The next major strategy is change in planting date which is adopted by 12% of the respondents in the study area. The variability in onset date might have forced them to shift the planting period to June/July as against May/June.

Intensive manure application and movement to different site were indicated by 11% (each) of the respondents and formed the next major strategies used by farmers in the study area. Application of fertilizer and organic manure can help the farmers to regain fertility of the soil and eventually improves farm yields. However, 11% of the respondents had to abandon their farmlands as a result of the threat posed by encroaching sand. Infact many farmlands have been buried by sand. Hence the farmers were left with no option than to relocate or move to different sites where the threat is minimal. This is very serious in Yunusari and Yusufari LGA. The BBC (Tuesday, January 23, 2007) reported that many homes, farms and wells are buried annually by sand from the Sahara desert in Yobe State. In some areas especially in Kaska, Bula-Tura and Toshia villages of Yusufari and Yunusari LGAs the prominent shelter belts and sand dune fixation proved abortive as the encroaching sand buried most of the trees recommended by NEAZDP in particular.

About 10% of the farmers have adapted multiple cropping as a strategy to curb climate stress in the study area. Multiple cropping entails planting of more than two types of crops in the same farmland. Millet, beans and sorghum are the common crops that are planted in the area. The crops have for a very long time been the dominant crops in the area. The use of resistant varieties is noticed by 9% of the farmers as their strategy against climate change. The variety of millet called *gero* has been identified as the resistant crop that suits arid climatic condition in the area. This variety according to Maurya, Adeoti and Shebayan (1995) requires less than 3 months of growing season and its maturity days range from 65-90 days. Change in harvesting date is also identified by 8% of the respondents as an adaptation strategy to climate change. The change in harvesting date is necessitated by the shift in planting date. This is practiced in such a way that the farmers will delay the harvesting period in an anticipation of torrential rain that usually fall once in October. This improves the quality of the crops especially millet.

About 7% of the respondents have identified the use of pesticides and insecticides as a strategy to climate change in the area. For example, some fungal diseases such as Head smut attacked millet and sorghum and darken the crops seeds thereby turned them into powder which most often leads to loss of yields. Even Solomon (2014) reported the presence of Blister Beetle in the Sudano-Sahelian ecological zone. The Blister Beetle affects millet by sucking the pollen grain and condemning the crops. The use of pesticides and insecticides would therefore be a source of relief to farmers and might help in no small way in controlling the spread of the aforementioned diseases in the study area. However, 6% of the respondents have resorted to prayers for God's intervention. They might have felt that all the methods are not yielding any positive outcome.

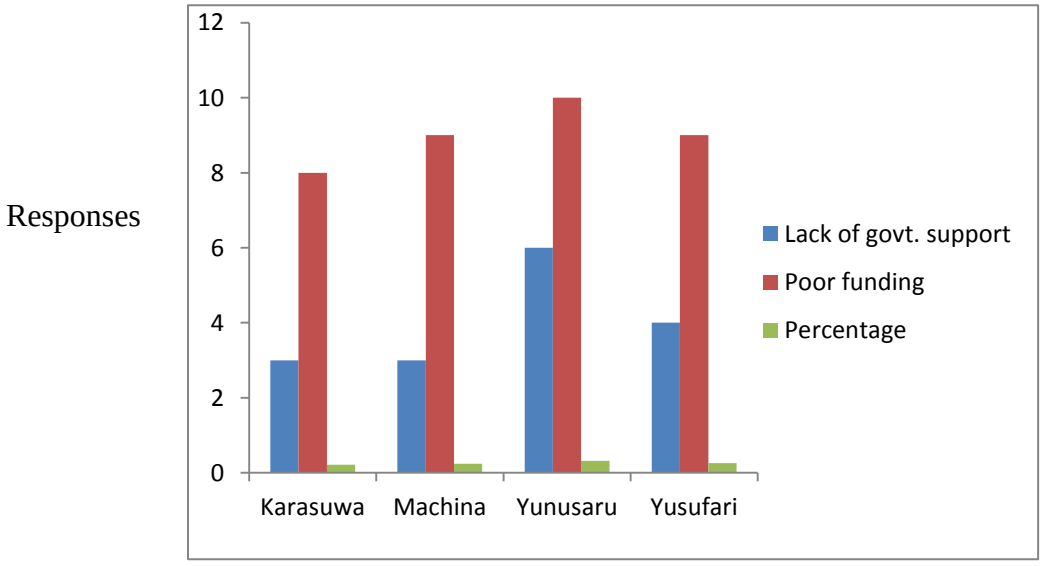
Irrigation practice has not received wider acceptance as only 5% of the farmers have identified it as an adaptation strategy to climate change in the area. This could be attributed partly to the

absence of water bodies in three of the four LGAs and partly to the nature of physical characteristics (dry and arid) of the area. This is because out of the 16 farmers that are engaged in irrigation practices, 10 came from Karasuwa LGA where there is a body of water. Hence the nature of the physical conditions made irrigation practices unpopular in the study area indeed. Only 3% of the farmers have chosen the use of wetland/fadama to cushion the impact of climate change. This is also related to the nature of the physical condition of the study area. Increased weeding was identified by 3% of the respondents.

Finally, construction of canals within the farmlands and southward migration were identified by 1% (each) of the respondents. This implies that farmers in the study area are no longer migrating southward in mass. They have been able to develop some resilience under hardships risk and variability to cope with changes in climate.

4.7.7.3 Reasons for failure to adapt adaptation strategies to climate change

The reasons for the failure of some of the farmers to successfully employ any strategy to mitigate climate change impact are presented in Fig 4.19.



Source: Field survey, 2015

Figure 4.18 Respondents' Reasons on their Failure to Adapt to Climate Change

From Fig. 4.18 it can be seen that 72% of the farmers who are not successful in adopting strategies against climate change in the study area have identified poor funding as the main reason behind their failure to successfully adapt to climate change. Majority of these farmers are from Yunusari LGA. Twenty eight percentage of the farmers identified lack of government support as the main reason behind their failure to successfully adapt to climate change. The presence of government agencies such as NEAZDP is no more felt in the area. Research institutes on climate and agriculture related programmes are no found in the study area. This could be attributed to absence of any higher institution in the area. Hence much need to be done indeed

4.7.7.4 Strongest adaptation strategy to climate change

A number of major adaptation strategies to climate change identified by the respondents have been analyzed and put together and the strongest of these adaptation strategies has been identified using Pairwise Comparison Matrix. This is presented in Table 4.13. The Table was derived from the information the farmers provided in Table 4.12 (see page 87). The list of adaptation strategies identified by the farmers in Table 4.12 were then used and compared with one another to generate Table 4.13.

Table 4:13 Pairwise Comparison Matrix Comparing Major Adaptation Strategies

Adaptation Strategies	Planting of early maturing Crops	Change in harvesting dates	Use of insecticides and pesticides	Intensive Manure application	Use of resistant varieties	Change in planting dates	Move to different sites	**Total**
Planting of early maturing crops	####	**1**	**1**	**1**	**1**	**1**	**1**	**6**
Change in harvesting dates	**0**	####	**1**	**0**	**0**	**0**	**0**	**1**
Use of insecticide and pesticides	**0**	**0**	####	**0**	**0**	**0**	**0**	**0**
Intensive manure application	**0**	**1**	**1**	####	**1**	**0**	**1**	**4**
Use of resistant varieties	**0**	**1**	**1**	**0**	####	**0**	**0**	**2**
Change in planting dates	**0**	**1**	**1**	**1**	**1**	####	**1**	**5**
Move to different sites	**0**	**1**	**1**	**0**	**1**	**0**	####	**3**

Source: Field survey, 2015

An entry **"1"** indicates that the adaptation strategy in that **"row"** is stronger and more preferred than that of the **"column"** in which it is entered, while an entry **"0"** indicates that the adaptation strategy in that **"row"** is less preferred and weaker than that of the **"column"** in which it is entered. Therefore, it can be seen from the matrix that planting of early maturing crops which has the highest score **(6)** is the strongest and most preferred adaptation strategy in the study area. This followed by change in planting date with a score of five (5). Then intensive manure application (4) and lastly abandoning the farmland for another.

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter gives the summary of this study and concludes the overall study with meaningful recommendations that would help in properly addressing issues surrounding climate change adaptation strategies.

5.2 SUMMARY

The research assessed the farmers' adaptation strategies to climate change in northern parts of Yobe state. Rainfall and temperature data for forty (40) years (1975 to 2014) were sourced from the Nigerian Meteorological Agency (NIMET) Nguru station and used. Means of annual rainfall and temperature for some selected months also determined. Trends in annual rainfall and temperature were subjected to time series analysis and linear trend and trend line equations were fitted on each and the direction of change was determined. Onset and cessation dates and length of rainy season were determined as well. They were also subjected to time series analysis. Information from questionnaire helped to explain the effect of climate change in the area and adaptive initiatives employed by farmers against climate vagaries. These were analyzed using descriptive statistics and pairwise comparison matrix.

The findings revealed that the long-term mean of annual rainfall during the period of the study was 427.5mm. The annual maximum rainfall (712.1mm) was recorded in 2014, while the annual minimum rainfall (224.7mm) was recorded in 1983. An upward trend in annual rainfall was observed with an increasing rainfall of an approximately 74.6mm at the rate of 1.86mm year^{-1}. The 5-year and 10-year running mean showed values below the long-term annual mean in 1970s, 1980s and mid-1990s. Then increased and relatively steady rainfall was observed from the

beginning of the millennium years till the end of the study period. To further examine the changes in climate, trend in annual rainfall for the months of June, July, August and September were determined separately. Positive (upward) trend in June, August and September rainfall was observed. However, negative (downward trend) trend in July rainfall was recorded. Temperature was found to be high throughout the year with the maximum mean monthly temperature (42^0C) recorded in April 1986 and the lowest temperature (18.1^0C) recorded in January 1983.

The onset date of the rainy season was highly characterized by marked noises (variability). The average onset date during the period of the study was found to be 10th July, while earliest onset date was 30th May and the latest onset was 18th August. This variability in the start of the rains has severely affected the timing of planting period. The termination of the rainy season was not as variable as the start of the rainy season. The mean cessation date was found to be 8th September. The earliest cessation date (4th August) was recorded in 1984 while the latest cessation date was 17th October which was recorded in 1976. The length of the rainy season is relatively short. The average duration of the rainy season was 65 days.

The analysis of the demographic characteristics of the respondents revealed that more married men within the age bracket of 41-50 lived in the area long enough that allowed them to experience climate change scenario. Majority of the respondents had a house hold size of 1-5 persons with improved literacy level as only 3% of them were found to be illiterates. Millet and beans were found to be the major crops produced by both subsistent and commercial farmers in the 12 sampled wards in Yobe North.

Evidences of climate change were very obvious and glaring as respondents identified many factors that informed them of climate change. Late onset and early termination of rainy season,

reduced Hamattan, high temperature, long period of dry season, less rainfall, dry spell, among others were all identified by the respondents. Of all these evidences, less rainfall, delay in the onset of the rainy season and long period of dry season were identified as the major evidences of climate change in the area.

The changes in climate over time have seriously affected farmers and caused hardships in their daily activities. The most pronounced effects were found to be desertification and drought as many farmlands and houses were buried by the encroaching sand dunes. The degradation of land has reduced the yields and caused scarcity of foodstuff. This has rendered many farmers unemployed and consequently poverty became very high. However, extreme weather events in form of flooding and overflowing of rivers/streams were very minimal as virtually the whole area lies within desert where there are no bodies of water. Prevalence of pests and diseases was noticed and has caused a lot of damages to millet farmers especially.

In spite of all the challenges posed by climate stress, virtually all the respondents are still farming and continue to live in the area as only 1% of the farmers have decided to migrate southward. The farmers have been able to develop some resilience under hardships, risks and variability to cope with changes in climate. The major adaptation strategies employed by farmers included: Planting of early maturing crops, moves to different sites, use of resistant varieties, use of insecticides and pesticides, while some farmers have decided to change the planting and harvesting time. Intensive manure application was also preferred by many of the farmers. However, analysis revealed that planting of early maturing crops is the strongest and most preferred adaptation strategy employed by the farmers in the sampled wards to minimize the harmful effect of climate change.

5.3 CONCLUSION

This study provided valuable insight into farmers' adaptation strategies to climate change in Yobe State. The results revealed that there is a significant increase (positive trend) in annual rainfall in the study area which could be the result of increased June, August and September rainfall. Although temperature was high all the year round, a negative trend in temperature was observed within the years of consideration. The length of the rainy season was very short with marked noises in onset and termination dates.

The incidence of climate change in Yobe state is on the increase as highlighted by delay in the start of the rainfall and early termination of the rainy season, long period of dry season, desertification, reduced farm yields, encroaching sand dunes, high rate of disease incidence, high temperature, less and erratic rainfall, reduced Hamattan and heavy winds. The farmers are aware of climate change and as such have developed some resilience to adapt to the changing environment. The adaptive strategies being used by the farmers to minimize the effect of climate change included: Planting of early maturing crops, moving to different sites, intensive manure application, change in planting and harvesting dates, use of insecticides and pesticides, multiple cropping and prayers for God's intervention.

5.4 RECOMMENDATIONS

In spite of the efforts put forward by the farmers in employing climate change adaptation strategies, much is still needed to be done. Therefore, the following recommendations are considered important.

1 Yobe State government should partner with NGOs and international communities to further enlighten the farmers on climate change scenario. This will cover the appropriate steps the farmers should take in dealing with the changing environment. If the climate change situation is better known and understood, it will be properly addressed.

2 Polices and laws that will ban illegal cutting down of tress in the northern parts of Yobe should be introduced by both Federal and State and properly implemented and monitored. Because desertification is one of the most climate change-related challenges the area is currently facing. The policy will help in greening the desert and halting its expansion especially when planting of shelterbelts and sand dune fixations are encouraged. Provision of New Model Kerosene Stove and subsidizing kerosene should also be taken into account by Government in the study area. This will go a long way in reducing deforestation and serve as an alternative to illegal use of tree biomass

3 The use of more resistant varieties of millet such as *Pennisetum glaucum (*pearl millet) and *panicum milliaceum (*proso millet) should be encouraged by the Government. These varieties are best fitted to the harsh climatic conditions of the area.

4 Soil conservation practices such as mulching, terracing, crop rotation to control pest attack, afforestation/shelterbelts (wind breakers), intensive use of pesticides and insecticides should all be encouraged by the Government. This will help in retaining the soil nutrients and thus conserving the fertility of the soil

5 Research centres and institutes that will update the farmers on climate change related issues should be established by both State and Federal Government and existing ones revived. For instance, NEAZDP should be brought back to life to continue to execute its normal functions. These research centres keep meteorological data and make predictions

which help to find out the direction of changes in climate. This will therefore strengthen the farmers' capacity to adapt new measures against climate vagaries.

6 Banks should be encouraged and stake holders to offer low-interest loans to farmers even without collateral securities. This is because majority of the farmers are poor and depend solely on farming for their livelihood and sustenance. This will therefore afford the farmers the opportunity to obtain modern and sophisticated adaptation strategies in cushioning the effects of climate change.

7 Provision of New Model Kerosene Stove and subsidizing kerosene should also be taken into account by Government in the study area. This will go a long way in reducing deforestation. Subsidized cooking gas should also be made available in the area.

8 Modern and emerging adaptation techniques such as cultivation on marginal lands, changing of crops formerly grown and replacing them with new ones (such as drought resistant and short duration variety of millet), application of agro-allied chemicals, construction of canals within the farmlands which will help to store water, should be encouraged by the Government and its agencies. Supplementary irrigation will play a role in controlling drought.

REFERENCES

Abubakar, I.L. (2010). *Adaptive Strategies developed by local farmers to cope with Climate Change in Jibya Local Government, Katsina State.* (Unpublished Undergraduate Project). Ahmadu Bello University: Zaria, Nigeria.

Abaje, I.B. (2007). Drought and Desertification in Northern Nigeria: Implication for Sustainable Development. *Journal of the School of Arts and Social Sciences*. 1 (1) 226-239. Kaduna State College of Education Gidan waya, Kafanchan

Abaje, I. B., Ati, O. F. and Ishaya, (2009). Nature of Portable Water Supply and Demand in Jama'a Local Government Area in Kaduna State, Nigeria. *Research Journal of Environmental and Earth Sciences,* 1(1): 16-21. Maxwell Scientific Organization.

Abaje, I.B. (2010). *Occurrence of Drought in the Sudano Sahelian Zone of Nigeria* (Unpublished M.Sc. Thesis). Ahmadu Bello University: Zaria, Nigeria.

Abaje I. B, Ati O. F and Iguisi E.O (2012) Recent Trends and Fluctuations of Annual Rainfall in the Sudano-Sahelian Ecological Zone of Nigeria: Risks and Opportunities *Journal of Sustainable Society Vol. 1, No. 2, 2012, 44-51*

Adakayi, P.E. (2012): *An assessment of rainfall and temperature variations in parts of Northern Nigeria*. (Unpublished PhD. Thesis). University of Jos, Nigeria

Adams W.M. and Hollis G.E. (1987). *Hydrology and Sustainable Resource Development of a Sahelian Floodplain Wetland*: Hadejia-Nguru Wetlands Conservation Project.

ADB, (2005): *Climate proofing: A risk-based approach.* Asian Development Bank, Manila, pp. 219

Adefolalu, D.O. (2007). *Climate change and economic sustainability in Nigeria*, Paper presented at the International Conference on Climate Change and Economic Sustainability held at Namdi Azikiwe University, Enugu Nigeria. 12-14 June 2007.

Adefolalu, D. O. (1993). World Meteorological Organization, Lecture Series 1:1-4.

Adejuwon, J.O., Balogun, E.E. and Adejowon, S.A. (1990). On the Annual and Seasonal Patterns of Rainfall Fluctuations in Sub-Sahara West Africa. *International Journal of Climatology,* 10(8): 839-848.

Adejuwon S. A. (2004). *Impact of climate variability and climate change on crop yield in Nigeria.* Contributed Paper to Stakeholders Workshop on Assessment of Impact and Adaptation to Climate Change (AIACC): 2-8.

Adger, W.N., (2003): Social capital, collective action, and adaptation to climate change.

Economic Geography.79, 387-404.

Akinsanola, A. A and Ogunjobi, K. O. (2014. Analysis of Rainfall and Temperature Variability Over Nigeria: *Global Journal of Human Social Science:* B *Geography, Geo-Sciences, Environmental Disaster Management. Vol.* 14 Issue 3 Version 1.0.Global Journals Inc. USA

Amadi, S.O. Udo S. O., and Ewona, I. O. (2014) Trends And Variations Of Monthly Mean Minimum and Maximum Temperature Data Over Nigeria for the Period 1950-2012. *International Journal of Pure and Applied Physics Vol.2,No.4, pp.1-27, December 2014*

Ampiaw, F, Nyatuame, M. and Owusu-Gyimah, V (2014) Statistical Analysis of Rainfall Trend for Volta Region in Ghana. *International Journal of Atmospheric Sciences Volume 2014 (2014), Article ID 203245, 11 pages.* http://dx.doi.org/10.1155/2014/203245

Amerasinghe, A. Galbraith, H.and Huber-Lee., A. (2005) *The effects of agricultural irrigation on wetland ecosystems in developing countries*: A literature review. CA Discussion Paper 1 Colombo Sri Lanka, 2005.

Anna, K. And Somya, B. (2014) Climate Change Adaptation Strategies in Rural Areas of India. (CCA RAI) *Ministry of Environment, Forest and Climate Change.* Government of India

Artz. M. (2001). Science and Our Changing Climate: GIS Creates a Framework for Research and Modeling. *Redlands Daily Facts* (Redlands CA).

Ati, O.F., C.J. Stigter and E.O. Oladipo, (2002). A comparison of methods to determine the onset of the growing season in northern Nigeria. *International Journal Climatology*. 22: 731-742.

Ati, O.F, Iguisi, E.O. and Afolayan, J.O. (2007). Are we Experiencing Drier Conditions in the Sudano-sahelian Zone of Nigeria? *Journal of Applied Science Resources*, 99 3(12):1746-1751. Retrieved May 31, 2008 from http://www/insinet.net/jasr/2007/1746-1751.pdf

Audu. A. (2012). *An Assessment of Adaptation Strategies to Desertification in Yobe North*. (Unpublished Undergraduate project). Ahmadu Bello University: Zaria, Nigeria.

Ayoade, J. O. (1982) Climate 4: Evaporation, Evapotranspiration and Humidity. In: Barbour, K. M., Oguntoyinbo, J. S., Onyemelukwe, J. O. C. and Nwafor, J. C. (Eds.). *Nigeria in Maps.* Nigerian Publishers Services ltd., Ibadan pp. 20-21

Ayoade, J.O. (1995). *Climate and Human Welfare.* Inaugural lecture of the University of Ibadan, Ibadan Nigeria.

Ayoade, J.O. (2003). *Climate Change: A synoptic of its nature, causes, effects and management* Vantage Publishers, Ibadan, pp. 45-66.

Ayoade, J. O. (2004). *Introduction to Climatology for the Tropics.* (2nd Eds.). Spectrum Books Ltd. Ibadan.

Bambale, U.S. (2014): *Farmers adaptation strategies to drought in Katsina and its Envrons.* (Unpublished M.Sc Thesis) Ahmadu Bello University: Zaria, Nigeria.

Barron, J., Enfors, E., Cambridge, H. and Moustapha, A. (2010) Coping with rainfall Variability in semiarid agro-ecosystems: implications on catchment scale water balances by dry spell mitigation strategies among small scale farmers in Nigeria. *International Journal of Water Resources Development,* 26(4), pp. 543–559.

Barskey, J. (1999). Yobe State: The pride of determined people. *The Washington Times Advertising Department.* Retrieved October 23, 2008 from http//www.wikipidia.org/wiki/advertisement.

Bello, A. U. (2013) Herdsmen and Farmers Conflicts in North-Eastern Nigeria: Causes, Repercussions and Resolutions. *Academic Journal of Interdisciplinary Studies* Vol. 2 No. 5 MCSER-CEMAS-Saplenza University of Rome, Italy.

Benoit, P. (1977). The start of the growing season in northern Nigeria. *Agricultural Meteorology* 18: 91-99

Brooks, N. and W.N. Adger, 2005: Assessing and enhancing adaptive capacity. In: Lim, B., Spanger-Siegfried, E., Burton, I., Malone, E. L. and Huq, S(Ed) *Adaptation Policy Frameworks for Climate Change.* Cambridge University Press, New York, 165-182

Bruce, A., El-Ganzor, A., El-Shinnawy, I., Joel B. McCarl, M. M. Mohamed, A.A., Mossad, K., Smith, C. Paul, K., and Russell, J.(2013). Mitigation and Adaptation Strategies for Global Change: First online.

Burton, I. and van Aalst, M.K.(2004): *Look Before You Leap? A Risk Management Approach for Incorporating Climate Change Adaptation in World Bank Operations,* Final Draft, Prepared for the Climate Change Team. World Bank, Washington, District of Columbia, 57 pp.

Cane, M.A., S.E. Zebiak and S.C. Dolan, (1986): Experimental Forecasts of El-Nino. *Nature,* 321,827-832

Chindu, A. and Nyelong, P.N. (2005). Lake Chad: From Mega lake to Mini lake, *Arid Wetland Bull.* No. 6:24-27.

Commission for Sustainable Development (2008). Drought and Desertification in Nigeria. *A Pre-CSD 16th stakeholders forum report on the thematic areas of agriculture, land, rural Development, drought and desertification in Africa.* www.wepnigeria.net. Retrieved 17/09/2009.

Dale, S, (2000) Preventing Gully Erosion in Nigeria. http://www.dryland-solutions.com/gullyer

Dami, A. (2008). *A Predictive Study of Environmental Change in the Nigeria's section of the Chad Basin.*(Unpublished PhD Thesis) Obafemi Awolowo University: Ile-Ife.

De Chavez and Tauli-Corpus (2008): *Guide to climate change.* Accessed on 26/06/2009 from www.tebtebba.org.

Dempewolf, H., Eastwood, J. R., Guarino, R., Khoury, C.K., Müller, J. V. and Toll, J. (2014). Adapting Agriculture to Climate Change: A Global Initiative to Collect, Conserve and Use Crop Wild Relatives

De Weerdt, S. (2007). Climate change coming home: Global warming effects on populations. *World Watch,* 2(3) 6-13.

Dey, B. (1982). Nature and Possible Causes of Drought on the Canadian Praires- Case Studies. *Journal of Climatology.* 2:233-249.

Dilley, M., 2000: Reducing vulnerability to climate variability in Southern Africa: the growing role of climate information. *Climatic Change,*45, 63-73

Du, Y.-D., Wang, X.-Y., Yang.-F. (2008): Impacts of climate change on human health and adaptation strategies in South China. *Advance Climate. Change Res*earch, **4**(4), doi: 10.3724/SP.J.1248.2013.208

Easterling. D. R. (1997) Maximum and minimum temperature trends for the global. *Science,* 277: 364-367.

Elisha. I. (2014) *Adaptation Strategies to Climate Change Among Grain Farmers in Goronyo Goronyo Local Government Area, Sokoto State, Nigeria*. (Unpublished M.Sc thesis Ahmadu Bello University: Zaria)

Eltahir, E. A. B. and Gong, C. (1996). "Dynamics of Wet and Dry Years in West Africa", *Journal of Climate,*9 (5), 1030-1042.

Fan, Z., Brauning, A., Thomas, A., Li, J., and Cao, K. (2010). Spatial and temporal temperature Trends on the Yunnan plateau (Southwest China) during 1961-2004. *International Journal of Climatology,* doi: 10. 1002/joc.2214.

FAO, (2004): *Drought impact mitigation and prevention in the Limpopo River Basin, A situation analysis.* Land and Water Discussion Paper 4, FAO, Rome, 160 pp

Farauta, B. K., Egbule. C. L., Idrisa. Y. L. and Agu. V. C. (2011). *Climate Change and Adaptation Measures in Northern Nigeria: Empirical Situation and Policy Implications. African Technology Policy Studies Network Working Paper Series* No. 62. Nairobi, Kenya.

Fasona M.J. and Omojola SA (2005). Climate Change Human Security and Communal Clashes in Nigeria. *An International Workshop,* Holmen Fjord Hotel, Asker, near Oslo, 21–23 June 2005.

Federal Republic of Nigeria [FRN] (2000) National Action Programme (NAP) to Combat Desertification and Mitigate the Effect of Drought. Towards the Implementation of the United Nations Convention to combat Desertification and Mitigate the Effect of Drought in the Country.

Federal Republic Nigeria [FRN], (2003) Nigeria's First National Communication under the United Nations Framework Convention on climate Change. The Ministry of Environment of the Federal Republic of Nigeria.

Folland, C. K, Palmer, T. N. and Parker, D. E. (1986). Sahel rainfall and worldwide sea Temperature, 1901-85; Observational, modeling and simulation studies. *Nature*, 320, pp. 602-607

Ford, J. and B. Smit, 2004: A framework for assessing the vulnerability of communities in the Canadian Arctic to risks associated with climate change. *Arctic,* 57, 389-400.

Fox, P. and Rockstorm, J. (2003). Supplemental Irrigation for Dry -Spell Mitigation of Rain-fed Agriculture in the Sahel. *Agricultural Water Management,* 61:29-50.

Francis, A. A. and Theophilus, O. O.(2011) Climate change and adaptation in Nigeria: Some Background to Nigeria's Response. *International Conference on Environmental and Agriculture Engineering: IPCBEE Vol. 15 (2011) LACSIT* Press, Singapore.

Franklin, N. M., Gifty, S. and Samuel, D. (2014). Determinants of Choice of Climate Change Adaptation Strategies in Northern Ghana: *Macrothink Institute,* Vol. 6, No. 4.

Frei, C. and Shår, C. (2001). Detection Probability of Trends in Rare Events: Theory and Application to Heavy Precipitation in the Alpine Region. *Journal of Climatology*, 14: 1568-1584.

Garnett, S.T, Franklin, D.C, Ehmke, G, VanDerWal, J.J, Hodgson, L, Pavey, C., Reside, A.E, Welbergen, J.A, Butchart, S.H.M, Perkins, G.C & Williams, S.E,(2013), *Climate Change Adaptation strategies for Australian birds,* National Climate Change Adaptation Research Facility, Gold Coast, 925 pp.

Gashua. M. A. (1991). *An Evaluation of Indigenous Techniques of Coping with Drought in Bade Bade Local Government Area, Borno State*, (Unpublished M.Sc Thesis) Ahmadu Bello University: Zaria, Nigeria.

Giorgi, F., Bi XQ. and pal, J. (2004). "Mean, Inter-annual Variability and Trends in a Regional Climate change Experiment over Europe, II". Climate Change Scenarios (2071-2100), *Climate Dynamics*, 23: 839-858.

Guarino, L. and Lobell, D. B. (2011). A walk on the wild side. *Nature Climate Change,*

1:374-375.

Hassanean, H. M. (2001). Fluctuations of surface air temperature in the east Mediterranean. *Theorot Applied Climatology*, 68 (1-2):75-87.

Hir, J (2010). Sand dunes threaten Northern Nigeria – Climate Change group. (http://dailytrust.dailytrust.com/index.php?option=com_content&view=article &id=4517:sand-dunes-threaten-northern-nigeria—climate-changegroup&catid=10:environment&Itemid=11). Retrieved 20th February, 2011

Hirsch, K., Johnston, M., Neill, G. O., Webber, S. and Williamson T. (2009) *Second Climate Change Technology Conference:* May12-15, Hamilton, Ontario, Canada

Hulme, M. (1990).The Changing Rainfall Resources of Sudan. *Trans. Inst. Br. Geogr.* N.S 38:8-20.

Hulme, M. (1992). Rainfall Changes in Africa: 1930-1960 to 1961-1990. *International Journal Of Climatology: 685-699.*

Hulme, M., Sheard, N., & Chilcott, C. (2001). Climate Change Scenarios for Australia. Climatic Research Unit, University of East Anglia, Norwich, United Kingdom, p. 6. Retrieved May 10, 2009, from http://www.cru.uea.ac.uk

Hurault, J. (1998) Land crisis on the Mambila Plateau of Nigeria. *West Africa Journal of Biogeography*, 25 (2): 285-299(15).

Idowu, A. A., Ayoola, S. O., Opele, A. I. and Ikenweiwe, N. B. (2011) Impact of Climate Change in Nigeria. *Iranica Journal of Energy & Environment 2 (2): 145-152, 2011*

Ifabiyi, I. P., Ojoye, S (2013) Rainfall Trends in the Sudano-Sahelian Ecological Zone of Nigeria *Earth Science Research,* Vol. 2, No. 2; 2013 ISSN 1927-0542 E-ISSN 1927-0550

Ikeme, J., 2003: Climate change adaptational deficiencies in developing countries: the case of Sub-Saharan Africa. *Mitigation and Adaptation Strategies for Global Change*, 8, 29-52

Ikhile, C. I. (2007). *Impacts of climate variability and change on the hydrology of water.* Geography and Regional Planning Dept., University of Benin: Benin City, Nigeria.

Intergovernmental Panel on Climate Change (IPCC) (2001). Climate change: The scientific basis http://www.ipcc.ch/

Intergovernmental Panel on Climate Change (IPCC) (2007). Special Report on Regional Impacts of Climate Change: An Assessment of Vulnerability. Summary for policy makers. Available at: http://www.ipcc-wg1-ucar.edu/wg1/wg1-report.htm, (accessed 26 October 2009). Pp. 1-22.

International Energy Agency (2009) *Word Energy Outlook* 2009 IEP. Paris, France.

Iwegbu, I.A., (1993). *Some aspects of the spatial and temporal characteristics of drought*

in Nigeria: A statistical approach.(Ph.D. Thesis). Department of Geography, Ahmadu Bello University: Zaria, Nigeria.

Jones, R.N., 2001: An environmental risk assessment/management framework for climate change impact assessments. *Natural Hazards*, 23, 197-230

Kahn, M.E., 2003: Two measures of progress in adapting to climate change. *Global Environ. Change,*13, 307-312.

Kandji, S. T; Verchot, L. and Marckensen, J. (2006). Climate Change and Variability in the Sahel Region: Impacts and Adaptation Strategies in the Agricultural Sector. World Agro forestry Centre (ICRAF) United Nation Environmental programme (UNEP). 103 Retrieved February 13, 2009 from http://www.unep.org/themes/fresh water document pdf/climate change Sahel combined.pdf

Karl, T. R, Janes, P. D., Knight, R. W., Kukia, J., Plummer, N., Razuwayev, V,. Gallo, K. P., Lindesay, J., Charison, R. J and Peterson, T. C. (1993). A symmetric trend of daily maximum and minimum temperatures: empirical evidence and possible causes. *Bull Am Math Soc* 74:1007-1023.

Kelly, P.M. and W.N. Adger, 2000: Theory and practice in assessing vulnerability to climate change and facilitating adaptation. *Climatic Change*, 47, 325-352.

Klein, R.J.T. and J.B. Smith, 2006: Enhancing the capacity of developing countries to adapt to climate change: a policy relevant research agenda. In: Smith, J. B., Klein, R. J. T. and Huq, S. (Ed)*Climate Change, Adaptive Capacity and Development*. Imperial College Press London, 317-334

Kowal, J. M. and Knabe, D. T. (1972). *An Agroclimatological Atlas of the Northern States of Nigeria with Explanatory Notes.* Ahmadu Bello University: Zaria, Nigeria.

Krejie, R. V. and Morgan, D. W. (1970). Determining Sampling Size for Research Activities. *Journal of Educational and Psychological Measurement,* Pp. 30, 607-610.

Leary, (2006). For Whom the Bell Tolls: *Vulnerabilities in a Changing Climate.* AIACC Working Paper No. 30, International START Secretariat, Washington District of Columbia, 31 pp.

Lobell, D. B., Sibley, A. and Ivan Ortiz-Monasterio, J. (2012). Extreme heat effects on wheat senescence in India. *Nature Climate Change,* 2:186–189.

Mamman, A. B., Oyebanji, J. O. and Petters, S. W. (2002) Nigeria: *A people United, a Future Assured.* Nigeria: Longman ltd.

Maurya, P. R., Adeoti, A. A. and Shebayan, J. A (1995). *Crop Production Manual.* Sokoto

Agricultural Development Project. Sokoto. Pp 1-5

McCarthy, J. J. Canzaiani, O.F. Leary, N.A Dokken, D.J and While, K.S (Eds). (2001). Climate Change 2001: *Impacts, Adaptations and Vulnerability. Contribution of Working Group II to the 3rd Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press, Cambridge University: United Kingdom.

McIntosh, R.J., J.A. Tainter and S.K. McIntosh, Eds.,(2000): *The Way the Wind Blows: Climate, History, and Human Action.* Columbia University Press, New York,pp.448.

Mehdi, B. (2006): *Adapting to Climate Change: An Introduction for Canadian Municipalities, Occasional Paper,* Canadian Climate Impacts and Adaptation Research Network (C-CIARN), Ottawa. [Available online at http://www.c-ciarn.ca/pdf/adaptations_e.pdf].

Meissner, K., Weaver, A., Matthews, H. and Cox, P (2003). The role of land surface dynamics in Glacial inception: a study with the UVic earth system model. Clim. Dyn 21:515-537.

Mortimore, M.J. and Adams, W.M. (2001): Farmer adaptation, change and 'crisis' in the Sahel. *Global Environ. Change11*, 49-57.

Mortimore, M (2009). Dryland Opportunities: *A New Paradigm for People, Ecosystem and Development*: NEHAUSA SA; Buenos Aires, Argentina. IUCN.

Mshelia, B. A. (1981). Desertification in Borno State with special reference to Mongono and Konduga Local Government Area.

National Population Commission (2006). *Population Census of Federal Republic of Nigeria.* Analytical Result Report at the National Level. NPC Abuja.

Nicholas, O., Maduke, M.C., Enete, A. A., Amaechina, E.C., Onokala, P. and Eboh, E.C. (2012). A Framework for Agricultural Adaptation to Climate Change in Southern Nigeria. *International Journal of Agriculture Sciences* (5): 243-252.

Nicholls, R.J. and Tol, R.S.J.(2006): Impacts and responses to sea-level rise: A global analysis of the SRES scenarios over the 21st Century. *Philos. T. Roy. Soc. A*,364, 1073-1095

Nicholson, S. E. (2001). The Nature of rainfall fluctuations in subtropical West Africa. Monthly Weather period, 108(4), 473-487.http://dx.doi.org/10.1175/1520493(1980)108<0473: TNORFI>2.0.CO; 2.

Nigerian Environmental Study/action Team (NEST) (2003). Climate change in Nigeria: A Communication guides for reporters and educators, *NEST*; Ibadan.

Nigerian Meteorological Agency (NIMET) (2010). *Nigeria Climate Review Bulletin.*

National Oceanic and Atmospheric Administration, (1999): *An Experiment in the Application of*

Climate Forecasts: NOAA-OGP Activities Related to the 1997-1998 El Niño Event. Office of Global Programs National Oceanic and Atmospheric Administration U.S. Department of Commerce, Washington, District of Columbia, 134 pp.

Obioha, E. (2008). Climate change, population drift and violent conflict over land resources in north eastern Nigeria. *Journal of Human Ecology*, 23(4): 311-324.

O'Brien. K., Sygna, L. and Haugen, J. E. (2004) "Vulnerable or resilient? A multi-scale Assessment of climate impacts and vulnerability in Norway." *Climate Change*, 64:193-225

Odada, E., Totolo, O., Stafford-Smith, M. and Ingram, J. (2006). Global change and Subsistence Rangelands in Southern Africa: the Impacts of Livelihood Variability and Resource Access on Rural Livelihoods. *GCTE Working Document 20*, Stockholm, IGBP.

Odekunle, O. T., Andrew, O., & Aremu, O. S. (2008). Towards a Wetter Sudano-Sahelian Ecological Zone in the Twenty-First Century Nigeria. *Weather*, 63(3), 66-70. http://dx.doi.org/10.1002/wea.172 www.ccsenet.org/esr *Earth Science Research* Vol. 2, No. 2: 201-202.

Odekunle, T.O. (2004). Rainfall and the length of the growing season in Nigeria. *International Journal of Climatology*, 24: 467–479.

Odjugo, P. A. O. (2007). The impact of climate change on water resources; global and regional analysis, *Indonesian Journal of Geography., 39(1): 23-41.*

Odjugo, P. A. O. (2010). Regional evidence of climate change in Nigeria. *Journal of Geography And Regional Planning.* Vol. 3(6), Pp. 142-150, June 2010. Available online at http://www.academicjournals.org/GRP.

Odjugo, P. A. O. and Ikhuoria, A. I. (2003). The impact of climate change and Anthropogenic Factors on desertification in the semi-arid region of Nigeria, *Global Journal of Environmental Science*,2(2): 118-126.

Oguntoyinbo, J. S. (1982) 'Climate II & III': Precipitation (I) in: Barbour, K. M., Oguntoyinbo, J. S., Onyemelukwe, J. O. C. and Nwafor, J. C. (Eds.). *Nigeria in Maps.* Hadder and Stoughton. Pp. 16-19

Oguntunde, P. G., Abiodun, B. J. and Gunnar L. (2012). Spatial and temporal temperature trends In Nigeria, 1901-2000.*Meteorology and Atmospheric Physics* 118:95-105

Ojo, O. (1985). Drought Persistence in Tropical Africa since 1969.*Proceedings on long-range forecasting research, WMO, WORKSHOP on diagnosis and prediction on monthly and seasonal atmospheric variations over the* Globe College Park: WMO Report Series, Pp. 1(6):73-85.

Ojoye, S. (2007).*Rainfall Variability and its Influence on Maize Production in Northern Nigeria.* Conference Proceedings, School of Science and Science Education, Federal University of Technology: Minna. Nigeria.

Ojoye, S. (2008). Climate Change and Crop Production, *Journal of Science and Technology*. Federal University of Technology, Minna. Nigeria.

Ojoye, S. (2012). *Climate Change Impact and Adaptation Strategies to Water Resources in the Sudano-Sahelian Ecological zone of Nigeria.* (An Unpublished PhD thesis of the Department of Geography and Environmental Management) University of Ilorin: Ilorin, Nigeria.

Oladipo, E. O. (1993). Some Aspects of the Spatial Characteristics Drought in northern Nigeria, *Natural Hazards,* Kluwer Academic Publishers, Netherlands, 8:171-188.

Oladipo, E. O. and Salahu, S. (1993) Spatial and Temporal Variations of Rainy days and Mean Daily Rainfall Intensity in northern Nigeria. *Mausam,* 44, No. 1 pp. 69.

Olaniran, J. O. (1988). Climate and the Planting of Agricultural Land Use in Nigeria. The NRBDA Area as a Case Study. *Journal of Agr. Met.* 43(4): 258-294

Olaniran, J. O. (2002). *Rainfall Anomalies in Nigeria:* The Contemporary Understanding. Paper Presented at the 55th inaugural lecture, University of Ilorin, Nigeria. Pp. 55.

Omolola, A. E. (2009). Climate Change and Adaptations. *Staff/Post Graduate Seminar.* Department of Geography, University of Ibadan, Pp.7-

Osman-Elasha, B., Goutbi, N. Spanger-Siegfried, E. Dougherty, B. Hanafi, A. Zakieldeen, S. Sanjak, A. Atti, H and Elhassan H. (2006): *Adaptation strategies to increase human Resilience against climate variability and change: Lessons from the arid regions of Sudan*. AIACC Working Paper 42, International START Secretariat, Washington, District of Columbia, pp. 42.

Otegbeye, G.O. (2004) Drought and Desertification: Challenges in Afforestation in Nigeria Arid and Semi-Arid Regions. *Savannah,* 19(1): 1-11 Ahmadu Bello University, Zaria, Nigeria.

Oyebande, L. (1995). Effects of Reservoir Operation on the Hydrological Regime and Water Availability in Northern Nigeria. *Man's Influence on Freshwater Ecosystems and Water Use* (Proceedings of a Boulder Symposium, July 1995). IAHS Publ. no. 230.

Pouliotte, J., N. Islam, B. Smit and S. Islam, (2006): Livelihoods in rural Bangladesh. Tiempo, 59,18-22. Accessed 11 October 2006. [Available online at http://www.cru.uea.ac.uk/tiempo/portal/archive/pdf/tiempo59low.pdf]

Powel, S., Casey, T., Folland, C., Colman, A., & Mehta, V. (1999a). Decadal Modulation of the

Impact of ENSO on Australia. *Climate Dynamics*, 15, 319-324. http://dx.doi.org/10.1007/s003820050284

Prince, S. D., Justice, C.O., and Los, S.O. (1990) *Remote Sensing of the Sahelian Environment*: A Review of the Current Status and Prospects. Technical Centre for Agricultural and Rural Cooperation ACP/CEE Lome Convention Commission of the European Communities.

Rafindadi, I. A. (2011) Farmers Ideas of Climate Change and Strategies for Adaptation in Northern Parts of Katsina State. *JORIND*, 9(2). ISSN 1596-8303. www.ajol.info/journals/jorind

Sawa, B. A. (2002) Trend in the Temporal Variability of Occurrence of Wet and Dry Spells North of Latitude 10^0N in Nigeria. In: Iguisi, E.O (Ed) .*The Zaria Geographer*, 15(1): 34-41. Published by the Department of Geography, Faculty of Science, Ahmadu Bello University: Zaria, Nigeria.

Sawa, B. A. (2010) Climate Change and Spatio-temporal Variability in Occurrence of Dry Spells in Northern Nigeria. *The Zaria Geographer*, Vol.18 Department of Geography, Ahmadu Bello University: Zaria, Nigeria.

Sawa, B. A. and Adebayo, A. A. (2011) *Climate change and derived precipitation effectiveness Indices in northern Nigeria: A current synthesis.* A paper presented at the 52nd Annual Conference of the Association of Nigerian Geographers held from 14th–17th February 2011 Department of Geography, Usman Danfodio University: Sokoto, Nigeria.

Sivakumar, M. V. K. (1998). Predicting rainy season potential from the onset of rains in southern Sahelian and Sudanian climatic zones of West Africa. *Agriculture and Forest Meteorology* 42: 295-305.

Smith, I. N., McIntosh, P., Ansell, T. J., Reason, C. J. C., & McInnes, K. (2000), South-West Western Australia Rainfall and its Association with Indian Ocean Climate Variability. *International Journal of Climatology*,20, 1913-1930 http://dx.doi.org/10.1002/1097-0088(200012)20:15<1913: AID-JOC594>3.0.CO;2-J

Smit, B. and Wandel, J. (2006: Adaptation, adaptive capacity and vulnerability. *Global Environ. Chang*e, 16, 282-292.)

Solomon, U. N. (2014) *Vulnerability Assessment and Farmers Adaptation Strategies to Climate Change in Shinkafi Local Government Area, Zamfara State Nigeria.* (Unpublished M.Sc Thesis, Ahmadu Bello University: Zaria)

Stewart, J. I. (1991). Principles and performance of response farming. In: Ford, W., Muchow, R. C. and Bellamy, Z. A (Ed) *Climatic Risk in Crop Production, Models and Management for the Semi-Arid Tropics.* CAB International: Wallingford.

Synder, P. K., Delire, C. and Foley, J. A. (2004). Evaluating the influence of different vegetation biomes on the global climate. *Climate Dynamic*, 23:279-302.

Taylor, M., Chen, ARawlins, S. Heslop-Thomas, C. Amarakoon, A Bailey, W. Chadee, D Huntley, S Rhoden, C and Stennett, R (2006): *Adapting to dengue risk – what to do*? AIACC Working Paper No. 33, International START Secretariat, Washington, District of Columbia, pp. 31.

Thomas, D.S.G. and Twyman, C (2005): Equity and justice in climate change adaptation amongst natural-resource-dependent societies. *Global Environ. Change*, 15, 115-124.

Thurstone, L.L. (1927). A law of comparative judgment. *Psychological Review*, 34, 278–286.

Trenberth, K. E, Jones, P. D, Ambenje, P, Bojariu, R, Easterling, D, Klein Tank, A, Parker, D, Rahimzaden, F., Renwick, J.A. Rusticucci, M., Soden, B., and Zhai, P. (2007) Observation: Surface and Atmospheric Climate Change. In: Solomon , S., Quin, Manning M, Chen , Z., Marquis, M,.Averyt, K.B, Tignor M., and Miller, H.L (Eds) *Climate Change 2007: the Physical Science Basis,* pp 235- 336.Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. United Kindom and Newyork , N Y: Cambridge University Press Retrieved February, 5 2009 from http://www.ipcc.ch/pdf/assessmentreport/ar4/wg l/ar4-wg l-chapter2.pdf

Turkes, M., Sumer, U. M. and Demir, I. (2002). Re-evaluation of trends and changes in mean, Maximum and minimum temperature of Turkey for the period 1929-1999. *International Journal of Climatology*, 22: 947-977.

United Nations Framework Convention on Climate Change (UNFCCC) (1992). Article 1 http:/unfccc.int/essentialbackground/convention/bachground/items/2536.php Accessed on 02/07/10

United Nations Environmental Program me (UNEP) (2006). *Climate Change and Variability in The Sahel:* Impact and Adaptation Strategies in Agricultural Sector. United Nations Environmental Programme: Nairobi, Kenya.

Walter, M. W. (1976). Length of the rainy season in Nigeria. *Nigerian Geographical Journal* 10: 123-128

World Health Organization (WHO) (2004). In de Chavez and Tauli-Corpuz. (eds.) (2008). *Guide to climate change.* Retrieved on 26thJune, 2009 from www.tebtebba.org

World Bank, (2006): *Clean Energy and Development: Towards an Investment Framework*, Annex K. World Bank, Washington, District of Columbia, pp.157.

Yakasai, S. A. T. (2006) Appraisal of the 2006 Provisional Census Figures

Yobe State Document (2008). Yobe State Ministry of Environment: Damaturu

Yohe, G. and R.S.J. Tol, 2002: Indicators for social and economic coping capacity – moving towards a working definition of adaptive capacity. *Global Environ. Change,*12, 25-40.

Zheng, X. and Eltahir, E. A. B. (1998). "The Role of Vegetation in the Dynamics of West Africa Monsoons", *Journal of Climate,* 11, 2078-2096.

APPENDIX

DEPARTMENT OF GEOGRAPHY
AHMADU BELLO UNIVERSITY
ZARIA-NIGERIA

Dear Respondents,

I am an M.Sc student of the above named University undertaking a research on *An Assessment of Farmers' Adaptation Strategies to Climate Change in parts of Yobe State, Nigeria.* Please help fill this questionnaire. All the information you provide will be treated with all confidentiality and none will be used for any other purpose than this research. Thank you.

Please tick ( ) where appropriate

PERSONAL BIODATA

1. Ward
2. *Sex* Male ( ) Female ( )
3. Age Less than 20 ( ) 20-30 ( ) 31-40 ( ) 41-50 ( ) 51 and above ( )
4. Marital status Married ( ) Single ( )
5. Household size 1-5 ( ) 6-10 ( ) 11-15 ( ) 16-19 ( ) 20 and above ( )
6. Political status Community head ( ) Family head ( ) Others ----------
7. Occupation Farming ( ) Business ( ) Civil service ( ) others
8. Highest educational qualification Primary ( ) Secondary ( ) NCE ( ) OND ( ) HND ( ) First-degree ( ) Masters degree ( ) PhD ( )
9. For how long have you been in this area? 1-5years ( ) 6-10years ( ) 11-15years ( ) 16-20years ( ) Above 20years ( )
10. What type of farming are you practicing? Commercial ( ) Subsistent ( ) Both ( )
11. What type of crop are you producing? Millet ( ) Beans ( ) Sorghum ( ) Others ----------

EVIDENCES OF CLIMATE CHANGE

1. Which of these factors inform you of climate change:

   a. Delay in the onset of rainfall ( )

   b. Early cessation of rainy season ( )

   c. Long period of dry season ( )

   d. Erratic rainfall ( )

   e. Less rainfall ( )

   f. High temperature ( )

   g. Reduced Hamattan ( )

   h. Dry spell ( )

   i. Long period of Hamattan ( )

   j. Heavy winds ( )

   k. Others ----------

CLIMATE CHANGE EFFECT

1. Which of these factors is/are effects of climate change in your area

Climatic Effect		**Social/Economic Effect**	
a. Heavy rainfall	( )	a. Poverty	( )
b. Overflowing of stream	( )	b. Unemployment	( )
c. Thunderstorms	( )	c. Hunger and Starvation	( )
d. Floods and erosion	( )	d. Loss of soil fertility	( )
e. Drought	( )	e. Reduction in farm yields	( )
f. Drying up of rivers	( )	f. High rate of disease incidence	( )
g. High sun intensity	( )	g. Increase in the price of goods	( )

h. Desertification ( ) h. Making difficult for people to work

i. Loss of biodiversity ( ) i. Premature deaths ( )

j. Unusual dust that covers the atmosphere ( ) j. Scarcity of foodstuff ( )

FARMERS ADAPTIVE STRATEGIES

1. Have you been successful in adopting any strategy to curb climatic stress?

Yes ( ) No ( )

2. If yes, what strategies have you adopted?

a. Irrigation practices ( )

b. Use of wetlands/fadama ( )

c. Change in planting date ( )

d. Intensive manure application ( )

e. Increased weeding ( )

f. Move to different sites ( )

g. Multiple cropping ( )

h. Change in harvesting dates ( )

i. Use of resistant varieties ( )

j. Planting of early maturing crops ( )

k. Construction of dam or drainage within the farm ( )

l. Use of insecticides and pesticides ( )

m. Southward migration ( )

n. Others ----------

3. If no, why? Poor funding ( ) Lack of government support ( )