FARMERS ADAPTATION STRATEGIES TO DROUGHT IN KATSINA AND ITS ENVIRONS

BY

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MSC/SCIEN/03839/2009-2010

A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES AHMADU BELLO UNIVERSITY, ZARIA, IN PARTIAL FULFULMENT OF REQUIREMENTS FOR THE AWARD OF A MASTER DEGREE IN GEOGRAPHY

DEPARTMENT OF GEOGRAPHY,
FACULTY OF SCIENCE,
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JULY, 2014

DECLARATION

I declare that the work in this thesis entitled FARMERS ADAPTATION STRATEGIES TO DROUGHT IN KATSINA AND ITS ENVIRONS has been carried out by me in the Department of Geography, Ahmadu Bello University, Zaria under the supervision of Dr. I.A Abdulhamid and Dr. I. J Musa. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at this or any other Institution.

Umar Bambale SULEIMAN _____ _____

Signature Date

CERTIFICATION

This thesis entitled FARMERS ADAPTATION STATEGIES TO DROUGHT IN KATSINA AND ITS ENVIRONS by Umar Bambale SULEIMAN M.Sc./Scien /03839/ 2009-2010 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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DEDICATION

I dedicate this work to almighty Allah the evolver and the sustainer of the universe for the gift of life, health, and strength to accomplish this thesis.

ACKNOWLEDGMENTS

All praises and thanks belong to almighty Allah for his love, wisdom, knowledge, and understanding, retentive memory, patience and perseverance throughout this study period. I am very grateful for without Him, this work would not have been successful as my contribution to the development of knowledge in my beloved country.

I would like to extend my sincere appreciation to my supervisors Dr. I. A. Abdulhamid and Dr. I. J. Musa for their patience to go through my work and to ensure all necessary guide and corrections despite their tight official commitments. I sincerely appreciate their fruitful comments, suggestion and rational criticisms for this work to resist the test of time.

My sincere appreciation to both academic and non academic staff of the Department of Geography A.B.U Zaria for their tremendous contribution in the course of my studies and in the aspect of broadening my cognitive, affective and psychomotor domains. In the same vein, I wish to deeply appreciate the vast contribution of Malam A.M Yamusa of the Department of Soil Science, Faculty of Agricultural Science, Ahmadu Bello University, Zaria for his guide, support and encouragement.

I am highly indebted to my late parents Alhaji Suleiman Muhammad Malami and Hajiya Rabiat S. Waziri . This achievement would not have been possible without their love, prayers, moral and financial support, may their gentle soul be in perfect rest in peace. I also want to acknowledge the support and encouragement I got from my wife Juwairiyya Abdulkadir (Mrs), my elder brother late Alhaji Rilwanu Sambo, my elder and younger brothers and sisters and other relations. God bless you all.

My acknowledgment cannot be complete without recognizing the effort of Brother Yusuf Gide who led me to the Nigerian Meteorological Agency (NIMET) Umaru Musa Ya'ardua Air Port Katsina where I obtained rainfall data for this Research. My big thanks to the authority of (NIMET) Katsina for availing me with the data requested. My thanks goes to a colleague Mal. Sadiq Sani who was my field assistant during questionnaire administration. I will also not forget to acknowledge Mr. Bitrus Abaje for his contribution and encouragement to my research and others too numerous to mention. Thank you all.

I wish to specially thank the Management of Federal College of Education Zaria for giving me the opportunity to further my studies.

Lastly, I am very thankful to my friends and postgraduate students of the geography Department for their mutual cooperation and support, especially Suleiman Musa Balarabe, Elisha Ikpe, Obasanjo, Hajara Salahudden, Inusa Musa, Gaddafi Adamu and others too numerous to mention. May Allah extend our lives to reap the fruits of our labour.

ABSTRACT

This research examines farmers' adaptation strategies to drought in Katsina and its environs. The objectives of the research are to characterize rainfall trend of the study area, to determine the intensity and years of occurrence of drought in the study area, to assess the awareness of farmers on drought issues, to examine the socio economic effects of drought in the study area, and identify the farmers adaptation strategies within the farming system of the study area. Rainfall data from 1971 to 2010 were sourced from the Nigerian Meteorological Agency (NIMET) Katsina air port. These data were used to characterize the rainfall trends for monthly and annual total, which are the determinants of cropping season. Statistical tools were used to achieve the above objectives. The 5-year running mean shows that below average rainfall was experienced from the early 1970s up to 2000. On the other hand, above average rainfall is being experienced from the year 2000 afterward. The result of changes in monthly rainfall revealed that there is a significant decrease in rainfall amount in the month of June, little change in the month of July and substantial increase in the months of August and September. The result of Normalized Rainfall Index shows that moderate to severe drought was experienced in 1970s to 1990s with the peak in 1984. The 13 years of all drought intensities occurrence represents about (32.50%) of study period (40years) for this station. However, the last decade (2000s) has been witnessing decreasing number of drought occurrences due to apparent increase in wet condition. A total of 385 questionnaires were administered to farmers whom were purposively sampled using Krejcie and Morgan's (1970) method from the sixteen (16) selected wards. The result also revealed that farmers awareness of the causes and effects of drought, extension services along with increasing wet condition are the factors that enhance adaptive capacity to drought in the study area. The main adaptation strategies to drought which the farmers employ include: planting drought resistant variety of crops (e.g. millet and sorghum), cross-ridging, irrigation practices, delay farm clearance, application of fertilizer/manure, planting of more trees in the farm. The study concludes that rainfall characteristics of the study area affects crop yield and that adaptation strategies have significant contribution on crops production in the study area. Based on the findings of the research, the study recommends that farmers should learn water harvesting techniques, promote dry planting and adopt drought resistant and early maturing varieties of crops. Government on the other hand, should develop small scale irrigation schemes, promote information delivery, and invest in soil and water conservation in the area.

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CHAPTER ONE: INTRODUCTION

1.1 Background to the Study

Drought is one of the most important climate-related disasters which climate change is set to exacerbate (ECA, 2007). Drought, like a Hurricane, flood, earthquake, or tornado, is both a hazard and a natural disaster (Riefler, 1978; Paulo et al, 2005): a hazard because it is a natural accident of unpredictable occurrence but of recognizable recurrence; a natural disaster because it corresponds to the failure of precipitation regime, causing the disruption of the water supply to the natural and agricultural ecosystems as well as to other human activities (Paulo *et al*, 2005).

Unlike other natural disasters, drought events evolve slowly in time and their impacts generally span a long period of time (Bacanli *et al*, 2008). Drought occurs in virtually all climatic zones, but its characteristics vary significantly from one region to another. Drought is a temporary aberration; it differs from aridity, which is restricted to low rainfall regions and is a permanent feature of climate (Abaje, 2010).

There is, however, no universal definition of drought due to the wide variety of sectors affected by drought, its diverse geographical and temporal distribution and the demand placed on water supply by human-used systems (Loukas and Vasiliades, 2004). Based on the nature of the water deficit, four types of drought are defined: The meteorological drought is defined by a precipitation deficiency over a pre-determined period of time. The agricultural drought is defined as a period when soil moisture is inadequate to meet the demands for crops to initiate and sustain plant growth. The hydrological drought is normally defined by deficiencies in surface and sub-surface water supplies relative to average conditions at various points through the seasons. The socio-economic drought

occurs when the demand for an economic good exceeds supply as a result of a weather-related shortfall in water supply. (Wilhite, 2000; Loukas and Vasiliades, 2004 and UN/ISDR, 2007).

Drought is caused by a number of factors which results in failure of effective precipitation. The underlying cause of most droughts can be related to changing weather patterns manifested through the excessive build up of heat on the earth surface, meteorological changes which result in a reduction of rainfall and reduce cloud cover, all of which results in greater evaporation rates. Drought is exacerbated by activities such as poor cropping methods, which reduce water retention of the soil, and improper soil conservation techniques which lead to soil degradation (Economic Commission for Africa [ECA], 2007). Deforestation combined with the resultant erosion can also cause drought to begin because as soil is moved away from an area it is less able to absorb moisture when rainfalls (Briney, 2009).

Drought is one of the major threats among natural hazards to people's livelihoods, animals and socio-economic development than any other natural disaster (Loukas and Vasiliades, 2004). Drought tends to occur less frequently than any other hazards. However, when it does occur, it generally affects a broad region for seasons or years at a time. This can result in a larger proportion of the population being affected by drought than by other disasters. Some regions are more prone to drought disasters, and each country differs in its capacity to effectively prepare for and respond to the effects of drought. Therefore, the number of people affected by drought and the types of impacts experienced will vary by regions. For instance, in 2006, extreme drought affected several countries in the Horn of Africa. Especially the hard hit were people in the countries of Ethiopia, Somalia, Kenya, Eritrea

and Djibouti, where nearly 18 million people were estimated to be suffering from food shortages during the drought's peak in early 2006.UNICEF surveys revealed acute malnutrition rates of approximately 20 percent among children in many drought- affected communities (UN/ISDR, 2007).

Drought contributes to malnutrition, famine, loss of life, increase health risks, spread of infectious diseases, loss of civilization, emigration, decline in soil conditions, changing livelihood systems, and economic losses in developing countries (Okorie, 2003; Abaje, 2007a; Ishaya and Abaje, 2008).

Drought is not a recent phenomenon in Nigeria. Historical records indicate that droughts have occurred frequently in the past. Some of these droughts were severe and accompanied by famines arising from crop failure (Ayoade, 1988; 2005).

In the last few decades, several communities in the dry lands of Africa, which include the study area, have been facing drastic food shortages as a result of recurrent drought. Major droughts with deleterious consequences to food production occurred in 1968-73; 1982-85; 1990-1992 and 2003 with each drought circle, the occurrence of desertification increases. The reduced capacity for food production and desertification has put a population of over 100million in the dry lands on the brink of starvation (Darkoh, 1993 and FRN, 2003).

Many definitions of the term adaptation abound in literature. According to Inter-Governmental Panel on Climate Change (IPCC Report, 2001), adaptation are actions taken to help communities and ecosystems moderate, cope with, or take advantage of actual or expected changes in climatic conditions.

Adaptation is therefore a key factor in drought studies. Adaptation could be proactive also referred to as planned; this requires assessing the vulnerability of natural, man-made systems 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 of drought or take advantage of the opportunities presented (Omolola, 2009).

Drought represents a new challenge, and may require adaptation approaches to changes that are potentially larger and faster than those experienced with recorded natural climatic variability. Therefore, all climate sensitive systems of society and the natural environment, including agriculture, forestry, water resources, human health, coastal settlements, and natural ecosystems will need to adapt to drought or possibly face diminished productivity and functioning and health (EPA, 2008).

Adaptation is considered an important response option or strategy, along with mitigation (Frankhauser, 1996; Smith, 1996; Pielke, 1998; Kane and Shogren, 2000). Adaptation is imperative because droughts have occurred in the past and will continue to occur at rates unprecedented in recent human history (Scheraga and Grambsch, 1998). The risks associated with droughts are real but highly uncertain. Risks are apparent in every area which will affect development goals especially in developing nations. Therefore, while there is uncertainty about future droughts, failure to invest in adaptation may leave a nation poorly prepared to cope with the adverse changes and increase probability of severe consequences (Smith and Lanhart, 1996).

Small holder farmers in marginal environments and/or other areas of high rainfall variability such as the Katsina and its environs have characteristically adopted livelihood

strategies which have evolved to reduce the overall vulnerability to drought shocks (Adaptive strategies) and manage their impacts ex-post ("Coping strategies"). However, the distinction between adaptive and coping strategies is frequently blurred, as what looked like coping strategies in one period may become an adaptation for households or whole communities the following period (FAO, 2010).Thus, adaptation strategies are oriented towards longer-term lively-hood security while, coping strategies are short- term and immediate (Tiempo, 2010). Drought hazard affects agriculture and determine the adequacy of food supplies (Ayoade, 2004), hence, the need for adaptive and coping strategies.

1.2 Statement of the Problem

In spite of man's remarkable development in science and technology, his economy and social welfare is still dependent on climate and vitally affected by long-term and short-term fluctuation in climate (Dey, 1982).

The Sudano Sahelian Zone of Nigeria is generally characterized by short rainfall period and a long dry season (Otegbeye, 2004). Recent studies have indicated that the Sudano Sahelian Zone of Nigeria has suffered decrease in rainfall in the range of about 30-40% since the beginning of the nineteenth Century (FRN, 2003 and Sawa, 2010). The increasing temperature and decreasing rainfall in the semi- arid region of northern Nigeria-Sokoto, Katsina, Kano, Nguru, and Maiduguri may have resulted in the increasing evapotranspiration, drought and desertification in the region as reported by (Odjugo and Ikhuoria, 2003 and Adefolalu, 2007).

Evidence of climate change have been studied and reported persistent droughts, recurrent wet and dry spells, rainfall variability, rainfall intensity variations and ENSO

teleconnection and rainfall anomalies (Oladipo, 1993; Sawa, 2002; Olaniran, 2002; Adebayo, 1999; Ati, 2006).

Drought and desertification are presently reported to be affecting about eleven (11) states in northern Nigeria including Bauchi, Borno, Yobe, Jigawa, Kano, Katsina, Kebbi, Sokoto and Zamfara, representing large spatial extent and affecting about 27 million people in the area (NAPCD, 2010). Ibrahim, (2011) also observes that the gravity of desert encroachment erosion in villages and many cities in this part of the country is becoming a source of concern to the people. Since it was noticed by experts that over 154,725 people have lost their farmlands and over that figure were rendered homeless as a result of such disaster with seven years assessment in five states are indication of the fact that we are facing not only problem of environment in which our people are living in fear of any natural disaster. Akonga (2001) also shows that most of the refugees that emigrated as a result of drought and desertification usually move to nearby urban areas to beg for alms thereby compounding the already tensed urbanization problems.

According to Oladipo *et al* (1991) Katsina farmers suffered a 100 percent crop loss, due to drought and at the end of the 1987 harvest season, the new Nigerian reported that about 5 million metric tons of grains valued about ₦4.2 billion, had been lost.

The drought of early 1970s in Nigeria caused a lot of economic disruptions. For example, it was held responsible for the drastic fall in GDP of 18.4% in 1971-72 and of 7.3% in 1972-1973. It was also seen as causing the rapid rise in the price index for food stuff and relative decline in non-oil export (Federal Republic of Nigeria [FRN], 2000).

As vulnerable as this zone is, it contributes immensely to the agricultural production of Nigeria's grain crop and livestock (Federal Republic of Nigeria [FRN], 2000; Ati et al, 2007). However, failure in rainfall has triggered off famines in the study area with an inadequate food structure.

According to Ariyo (2002) nearly 70% of Nigerian cattle are concentrated in the Sudano Sahelian Zone of Nigeria. Based on that fact, investigation on how the cattle rearers adapt and cope with drought is therefore very important because it results in cattle losing weight and this affects revenue and household income.

Therefore, there is a need to harmonize the traditional strategies along with modern technology or technical government policies to make it more effective.

There are few studies on perception of communities and policy makers about drought and about actions to mitigate the same (Robert, 2009). In line with this, Abaje (2010) carried out a study on the occurrence of droughts in the Sudano-Sahelian Zone of Nigeria (1949-2008). The result revealed that 1980s is a decade of consecutive years of large scale drought that reached a peak in 1987.

A similar study was carried out by Gashua (1991) on an evaluation of indigenous techniques of coping with drought in Bade Local Government Area, Borno State. The result revealed that farming community of Bade perceives drought as its most serious ecological problem and measures for its mitigation have also been evolved to reduce its effects.

From the foregoing, it is obvious that not much have been done on adaptation and coping strategies to drought in Katsina and its environs. Previous studies appeared to be essentially centered on the indigenous techniques of coping with drought which does not involve the

adaptation strategies. It is in view of the above facts that this research seeks to assess Farmers adaptation strategies to drought in Katsina and its environs. The research questions that this study seeks to address include:

i. What are the characteristics of rainfall in the study area?
ii. How do farmers in the study area perceive drought?
iii. What do the farmers think cause drought and what are the associated effects?
iv. What are the various adaptations strategies the farmers employ in adapting to drought in the study area?

1.3 **Aim and Objectives of the Study**

The aim of the research is to examine Farmers adaptation strategies to drought in Katsina and its environs. The specific objectives are to:

i. characterize rainfall trend of the study area.
ii. determine the intensity and years of occurrence of drought in the study area.
iii. assess the awareness of farmers on drought issues.
iv. examine the socio economic effects of drought in the study area.
v. identify the farmers adaptation strategies within the farming system of Katsina and its environs.

1.4 **Scope and Limitation of the Study**

The spatial scope of this study covers Katsina and its environs, comprising of Katsina, Kaita and Jibiya Local Government Areas. The scope of the study in terms of content is to assess the farmers' adaptation strategies to drought in Katsina, Kaita and Jibiya Local Government Areas. The targeted populations are the farming community members in

Katsina LGA. More so, Jibiya and Kaita LGAs were also included for the survey because of their proximity to the desert area. The study has covered the period of 40 years from 1971 to 2010.

1.5 **Significance of the Study**

Katsina and its environs falls within the area referred to as Disaster Zone due to the impact of drought on farming and livestock husbandry activities. In this zone, rains could be very erratic and scarce. Thus, an area having this background, yet able to provide a substantial quantity of food, is therefore an appropriate case for such as a study. Thus, this research is expected to come up with policies and planning that will raise awareness on the drought hazards and the necessary preparedness to curtail same. Similarly, the findings of this research work are expected to constitute an invaluable source of data for future references. This research will also assist in identifying local drought adaptation techniques which would help in developing practical drought adaptation plans for sustainable productive agricultural activities in the study area and in similar drought- prone areas of Nigeria.

CHAPTER TWO: LITERATURE REVIEW

2.1 Rainfall Characteristics

The rainfall characteristics in Nigeria have been examined for secular change i.e. dominant trend notably by Olaniran (1990, 1992) and by Olaniran and Sumner (1989a,b &1990). The result of Olaniran shows that there has been a progressive early retreat of rainfall over the whole country spanning up to a half a century now and consistent with this pattern there has also been a significant decline of rainfall frequency i.e. the number of rain days in September and October which, respectively, coincide with the end of the rainy season in the northern and southern parts of the country. Furthermore, the combined effect of these declines was found to lead to a significant decrease in annual rain days over the whole country. In effect, except farmers change to early maturing crop varieties, streamline their farming calendars with the changing rainfall regime or have access to irrigation water, the secular changes in rainfall frequency reported above for the country pose serious threat to the maturity of annual crops and consequently to food security for the nation. However, recent trends of annual rainfall have been that of high intensity from the year 2000 to date Abaje, *et al.* (2012b)

A number of studies have been carried out for various parts of Nigeria and the world in general on the characteristics of rainfall. This is due to the importance of rainfall to agriculture and water resources development.

Observations show that changes are occurring in the amount, intensity, frequency and types of precipitation. Pronounced long- term trends from 1900 to 2005 had been observed in precipitation amount in some places: significantly- wetter in eastern North and South America, northern Europe and northern and central Asia but drier in the Sahel, southern

Africa, the Mediterranean and southern Asia. Wide spread increases in heavy precipitation event have been observed, even in places where total amount have decreased. These changes are associated with increased water vapour in the atmosphere arisen from the warming of the world oceans especially, at lower latitudes (Trenberth *et al*, 2007).

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 *et al,* 1990). 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).

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, et al, 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 *et al,* 2001) the rainy season start mostly in May and ends during the month(s) of August or September and is associated with squall lines that move westward across the southern fringes of the Sahara during the monsoon season (Prince *et al,* 1990).

Eldredge *et al,* (1987) investigated the changing patterns of rainfall in western Sudan using annual and monthly rainfall series observed that relative dry conditions have persisted in the region since 1966 due mainly to a decline in rainfall during July, August and September, the critical months for the annual agricultural cycle. It was recommended that agricultural planning and government practice be based on recent meteorological patterns. Similarly, Hulme (1990) examined the changing nature of rainfall supply in Sudan during the 20th Century using historical annual, monthly and daily data back to 1900. The result revealed that rainfall has been most severe in semi-arid central Sudan where between 1921 to 1950 and 1956 to 1985 annual rainfall has declined by 15 percent, the length of the growing season has contracted by three weeks and rainfall zones have migrated south-wards by between 50km and 100km. the depletion has been due more to a reduction in the frequency of rain event rather than to reduce rainfall yield per rain event. It was concluded that rainfall in Sudan is a renewable resource and effective management of the rainfall resource requires accurate, useful and timely information about its supply.

The West African region has experienced a marked declined in rainfall from 15 to 30 percent depending on the area (Niasse, 2005). The trend was abruptly interrupted by a return of adequate rainfall conditions in 1994. This was considered the wettest year of the past 30 and was thought to perhaps indicate the end of the drought. However, by the

standard of the whole century, rainfall in 1994 barely exceeded the long- term mean. Unfortunately, dry condition returns after 1994 (McCarthy *et al,* 2001).

Balagun (1972) examined the variability of rainfall over Nigeria by a measure called coefficient of variability. The result revealed that the distribution of these values indicates that areas of high rainfall have low coefficient of variation and vice-versa. It was concluded that the low variability values for the south indicates a measure of reliability of the annual rainfall, and the high values to the north indicates low rainfall values as well as it unreliability. Therefore, it became clear that the major problem to agricultural production in the northern part of Nigeria is the unreliability of the rains.

Oladipo and Salahu (1993) analyzed the spatial and temporal variations of rainy days and mean daily rainfall intensity for northern Nigeria. The results showed that there is a general northward decrease in the mean number of the rainy days from between 80 and 100days in the south to between 40 and 60 days in the extreme north. This general latitudinal decrease is interrupted by the central highlands where rainy days of between 100 and 120 are observed. Therefore, the decreasing trend in seasonal rainfall over northern Nigeria is due to decreasing frequency in the number of rainy days.

In the Sudano-Sahelian zone of Nigeria, the average annual rainfall in this zone varies from less than 500mm in the extreme north-eastern part to 1000mm in the southern sub—regions (FRN, 2000). The rainfall intensity is high between the months of July and August (Ati *et al,* 2007). 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). As a result of the larger inter-annual variability of rainfall, it often results in climate hazard, especially floods and severe and wide spread droughts with their

devastating effects on food production and associated calamities and sufferings (Oladipo, 1993a, Okorie, 2003).

Ati (2006) investigated the rainfall characteristics in drought prone areas in Nigeria and the result indicates that the annual rainfall totals over the region started decreasing in the 1960s but the last decade especially the late 1990s had been witnessing increasing annual rainfall totals. The results further reveals that the number of wet days is on the decrease while the number of dry days is on the increase. Increase rainfall with decreasing number of rain days means higher rainfall amount per storm and hence higher intensity. This would result in flooding and soil erosion with its attendant loss of farmland and property.

The above reviews have pointed the importance of rainfall to agriculture and water resource development in Katsina and its environs and the needs for continuing monitoring of its characteristics from time to time.

2.2 Drought

Drought is a natural part of climate, although many people erroneously consider it a rare and random event. It occurs in virtually all climatic zones, but its characteristics vary significantly from one region to another. Drought is a temporary aberration; it differs from aridity, which is restricted to low rainfall region sand is a permanent feature of climate (Okorie, 2003; NDMC, 2006a and UN/ISDR, 2007). It is the unavoidable result of our climate's variability-variability that sometimes leaves areas far short of their average water supplies for months or years. Drought is more than just a moisture deficit, however, it is the result of a complex interplay between natural precipitation deficiencies on varying time and space scales and can be exacerbated by human water demand and inefficiencies in water distribution and usage (American Meteorological Society [AMS], 2004). Despite all

the problems drought has caused in the past, and its frequent occurrence, drought has been difficult to define (Felch, 1978; Angel, 2008).

Critchfield (1983) and Ayoade (2004, 2005) classified drought into four types. These are permanent, seasonal, contingent, and invisible droughts. Permanent drought is found in arid areas where in no season is precipitation enough to satisfy the water needs of plants. In such areas, agriculture is impossible without irrigation through the whole crop season. Seasonal drought occurs in areas with well-defined wet and dry seasons as in most parts of the tropics. The drought can be expected every year owing to seasonal change in atmospheric circulation patterns. Agriculture is possible during rainy season while it's impossible without irrigation during dry season. Contingent drought is characteristics of sub- humid and humid areas and occurs when over a period of time the rains fail to fall. It is unpredictable and therefore, constitutes a hazard to agriculture. Invisible drought occurs any time the daily supply of moisture from the soil or falling precipitation fails to equal the daily water needs of plants. A slow drying of the soil results and crops fail to grow at their optimum rates. The needs for supplemental irrigation to combat invisible drought is rather difficult to establish since the crops do not wilt.

Of the four types of droughts, only contingent and invisible droughts are due to precipitation variability. They constitute a hazard to agriculture because they are unexpected and their occurrences are very difficult to predict. These two types of droughts constitute both the popular and scientific notions of drought (Ayoade, 2004; 2005).

There is no universally accepted definition of drought because drought means different things to different people, depending on their specific interest or areas of specialization.

One person's drought is another's fair weather (AMS, 2004). A broad definition of drought is a deficiency of precipitation over an extended period of time, usually a season or more, which results in a water shortage for some activity, group, or environmental sectors (UN/ISDR, 2007). Many authorities such as Palmer (1965), Riefler (1978), Oladipo (1985, 1988) Motimore (1989), Shuaibu and Oladipo (1993), Ayoade (1988, 2004), Odihi (1996), AMS (1997, 2004), Okories (2003), NDMC (2006a), Moneo and Iglesias (2006), ECA (2007), UN/ISDR (2007), Treberth *et al* (2007) and Abaje (2010) amongst others inclusively defined drought based on meteorological, agricultural, hydrological, and socioeconomic considerations.

2.2.1 Meteorological Drought: Occurs when the reduction in rainfall for a specified period (day, month, season or year) is below a specified amount – usually defined as some proportion of the long-term average. It is usually an expression of precipitation's departure from normal over some period of time. These definitions are region specific and presumably based on a thorough understanding of regional climatology FAO, (2007). Definitions of meteorological drought must be considered as region specific since the atmospheric conditions that result in deficiencies of precipitation are highly variable from region to region. For example, some definitions of meteorological drought identify periods of drought on the basis of number of days with precipitation less than some specified threshold. This measure is only appropriate for regions characterized by a year-round precipitation regime such as a tropical rainforest, humid subtropical climate, or humid mid-latitude climate (NDMC, 2006a; Moneo and Iglesias, 2006). Locations such as Manaus, Brazil; New Orleans, louisiana (U.S.A); and London, are examples. Other climatic regimes are characterized by a seasonal rainfall pattern, such as the central United States, northeast

Brazil, West Africa, and northern Australia. Extended periods without rainfall are common in Omaha, Nebraska (U.S.A); Fortaleza, Ceara (Brazil); and Darwin, Northwest Territory (Australia), and a definition based on the number of days with precipitation less than some specified threshold is unrealistic in these cases. Other definitions may relate actual precipitation departures to average amounts on monthly, seasonal, or annual time scales Abaje (2010).

2.2.2 Agricultural Drought: Is defined more commonly by the lack of availability of soil water to support crop and forage growth than by the departure of normal precipitation over some specified period of time. The relationship between precipitation and infiltration of precipitation into the soil is often not direct. Infiltration rates vary depending on antecedent moisture conditions, slope, soil type, and the intensity of the precipitation event. Soil characteristics also differ. For example, some soils have a higher water-holding capacity, which makes them less vulnerable to drought UN/ISDR, (2007).

Agricultural drought occurs when there isn't enough soil moisture to meet the needs of a particular crop at a particular time. Agricultural drought happens after meteorological drought but before hydrological drought. Agriculture is usually the first economic sector to be affected by drought FAO, (2007.) It links the various characteristics of meteorological (or hydrological) drought to agricultural impacts, focusing on precipitation shortages, differences between actual and potential evapotranspiration, soil moisture deficits, reduced ground water or reservoir levels, and so forth. Plant water demand depends on prevailing weather conditions, biological characteristics of the specific plant and its stage of growth, as well as physical and biological properties of the soil. Deficient topsoil moisture at planting may hinder germination, leading to low plant populations per hectare and a

reduction of final yield. However, if top soil moisture is sufficient for early growth requirements, deficiencies in sub soil at this early stage may not affect final yield if sub soil moisture is replenished as the growing season progresses or if rainfall meets plant needs (Palmer, 1965; Oladipo, 1985, 1988; AMS, 1997; Okorie, 2003; AMS, 2004; NDMC, 2006a; Moneo and Iglesias, 2006; Trenberth *et al*, 2007; Abaje, 2010).

It is important to mention that the effects of droughts are different in irrigated and non irrigated agriculture. In regions which rely on irrigation, the impacts of short lived agricultural drought s are usually lower than in regions where crops are not irrigated. Irrigated agriculture relies on stocks of water so if it does not rain, these crops still get the water they need (until the reservoir run dry).in non irrigated agriculture crops depend directly on the rain as their water source. If it does not rain, the crops don't get the water they need to survive (Moneo and Igesias, 2006).

2.2.3 Hydrological Drought: Is normally defined by deficiencies in surface and subsurface water supplies relative to average conditions at various points in time through the seasons. Like agricultural drought, there is no direct relationship between precipitation amounts and the status of surface and subsurface water supplies in lakes, reservoirs, aquifers, and streams because these hydrological system components are used for multiple and competing purposes, such as irrigation, recreation, tourism, flood control, transportation, hydroelectric power production, domestic water supply, protection of endangered species, and environmental and ecosystem management and preservation. There is also a considerable time lag between departures of precipitation and the point at which these deficiencies become evident in surface and subsurface components of the hydrologic system. UN/ISDR, (2007).

The frequency and severity of hydrological drought is often defined on a watershed or river basin scale. Although all droughts originate with a deficiency of precipitation, hydrologists are more concerned with how this deficiency plays out through the hydrologic system.

2.2.4 Socio-economic Drought: This refers to the situation that occurs when physical water shortage begins to affect people. Socioeconomic definitions of drought associate the supply and demand of some economic good with elements of meteorological, hydrological, and agricultural drought Abaje, (2010). It differs markedly from the other types of drought because it reflects the relationship between the supply and demand for some commodity or economic good (such as water, forage, or hydroelectric power) that is dependent on precipitation. Supply varies annually as a function of precipitation or water availability. Demand also fluctuates and is often associated with a positive trend as a result of increasing population, development, and other factors UN/ISDR, (2007)

Socioeconomic drought occurs when the demand for an economic good exceeds supply as a result of weather- related short fall in water supply. For example, in Uruguay in 1988-89, drought resulted in significantly reduced hydrologic power production because power plants were dependant on stream flow rather than storage for power generation. Reducing hydrologic power production required the government to convert to more expensive (imported) petroleum and stringent energy conservation measures to meet the nation's power needs (AMS, 1997; Okorie, 2003; AMS, 2004; NDMC, 2006a).

The relationship between these types of drought is obvious (Fig. 2.1). Agricultural, hydrological, and socio-economic drought occur less frequently than meteorological drought because impacts in these sectors are related to the availability of surface and

subsurface water supplies. It usually takes several weeks before precipitation deficiencies begin to produce soil moisture deficiencies leading to stress on crops, pastures, and rangeland. Continued dry conditions for several months at a time bring about a decline in stream flow and reduced reservoir and lake levels and, potentially, a lowering of the groundwater table. When drought conditions persist for a period of time, agricultural, hydrological, and socio-economic drought occur, producing associated impacts. During drought, not only are inflows to recharge surface and subsurface supplies reduced, but demand for these resources increases dramatically as well. The direct linkage between the main types of drought and precipitation deficiencies is reduced over time because water availability in surface and subsurface systems is affected by how these systems are managed. Changes in the management of these water supplies can either reduce or aggravate the effects of drought. For example, the adoption of appropriate tillage practices and planting more drought-resistant crop varieties can diminish the effect of drought significantly by conserving soil water and reducing transpiration. Therefore, the effects of drought are a product of both the physical nature of the hazard and our ability to manage risk UN/ISDR, (2007).

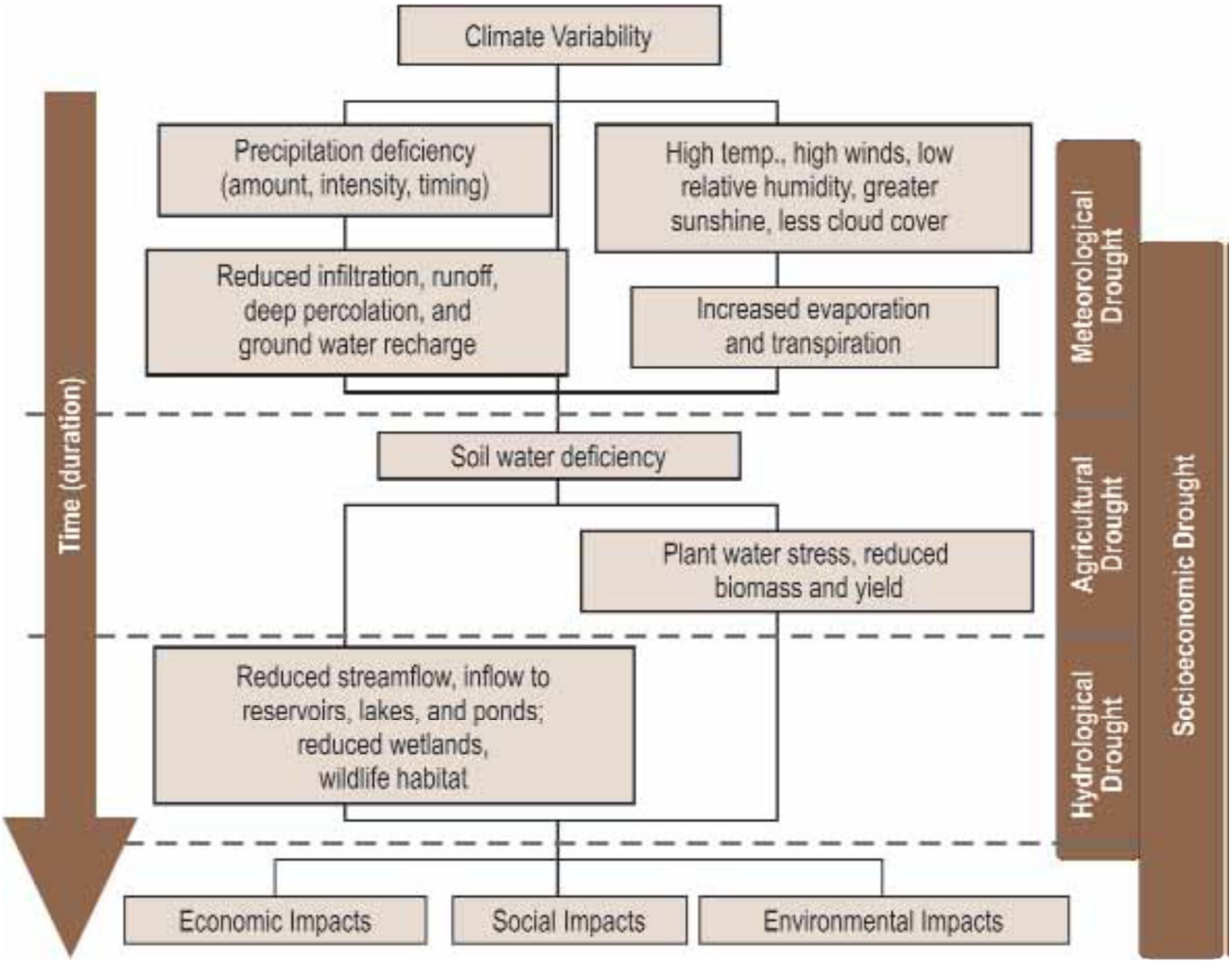


Fig: 2.1 Relationship between Meteorological, Agricultural, Hydrological, and Socio-economic Drought.
Source: (UN/ISDR, 2007).

Similar to meteorological drought are climatological and atmospheric droughts. Climatological drought occur when the amount of rainfall received is markedly below the long-term mean rainfall for the area or location concern (Oladipo, 1988; Ayoade , 2004; 2005). Atmospheric drought according to Oladipo (1988) involves not only precipitation but possible temperature, humidity or wind speed and is used to indicate the dryness of the air.

The above definitions illustrate the diversity of views about what constitute a drought. Drought is frequently defined according to disciplinary perspectives. Although agricultural and meteorological droughts may coincide in the short terms, the two are not necessarily synonymous. A drought may exist in the agricultural sense before it is evident to the meteorologist or hydrologist. Conversely, an agricultural drought may be ended, at least temporary, by rainfall that replenishes soil moisture, but which is not heavy to contribute ground water stream-flow. An agricultural drought may also exist because of poor temporal distribution of precipitation for the growing season even though the year (season) would be statistically speaking normal or above normal without any meteorological drought in evidence (Oladipo, 1985, 1988).

2.3 Causes of Drought

A drought occurs when not enough rain falls to the ground. However, water vapour condenses only if air rises into the colder regions of the atmosphere. If the air does not rise, then no rain will form (OEF, 2000). The dynamic process of adiabatic cooling is, therefore, very important for clouds formation and precipitation.

Causes of drought in Katsina and its environs are related to climate variability and non-availability of surface water resources. The immediate cause of a rainfall shortage may be due to one or more factors including absence of moisture in the atmosphere or large-scale downward movement of air within the atmosphere which suppresses rainfall. Changes in such factors involve changes, regional and global weather and climate. While it may be possible to indicate the immediate cause of a drought in a particular location, it often is not possible to identify an underlying cause.

The underlying cause of most droughts can be related to changing weather patterns manifested through the excessive build up of heat on the earth's surface, meteorological changes which result in a reduction of rainfall, and reduced cloud cover, all of which results in greater evaporation rates. The resultant effects of drought are exacerbated by human activities such as deforestation, overgrazing and poor cropping methods, which reduce water retention of the soil, and improper soil conservation techniques, which lead to soil degradation. Between 1950 and 2006, the Nigerian livestock population grew from 6 million to 66 million, a 11-fold increase. The forage needs of livestock exceed the carrying capacity of its grasslands. It is reported that overgrazing and over-cultivating are converting 351,000 hectares of land into desert each year. The rates of land degradation are particularly acute when such farming practices are extended into agriculture on marginal lands such as arid and semi rid lands, hilly and mountainous areas and wetlands (Yamusa, *et al* 2011).

When there is high air pressure, air falls instead of rising. With the air pressing down in a high pressure zone, no current of water vapour are carried upward. As a result, no condensation occurs, and little rain falls to the earth. In addition, high-pressure areas push clouds and currents downward and away, resulting in sunny, cloudless weather. It is normal for a high pressure system to pass over an area and move on, being replaced by a low pressure system. However, when a high pressure system is stalled, the sunny weather can drag on for days. If it keeps on going, the result is a drought (OEF, 2000). High pressure systems can be stalled by jet streams, wide bands of fast- moving air (up to 539 kilometers per hour) in the upper atmosphere. Masses of air that usually move from place to place can be locked in one area by jet streams. Usual currents of cold and warm water in the ocean

can also stall a high-pressure system. In the pacific, a warm water current known as El Nino brings low-pressure systems that cause hurricanes and other violent storms to North America, while a cold water current known as La Nina bring drought. In Asia, the opposite occurs, with El Nino bringing drought and la Nina stormy weather (OEF, 2000). The southern oscillation, a seesaw of atmospheric pressure between the eastern equatorial pacific and Indo-Austalian areas, is closely linked with El Nino. During an ENSO event, the Southern Oscillation is reversed. Generally, when pressure is high over Pacific Ocean, it tends to be low in the eastern Indian Ocean, and vice vasa.

Drought can occur virtually anywhere in the world during ENSO events, though researchers have found the strongest connections between ENSO and intense drought in Australia, India, Indonesia, Phillippines, Brazil, parts of east and south Africa, the western pacific basin islands (including Hawaii), central America, and various parts of the United States. Drought occurs in each of the above regions at different times (seasons) during an event and in varying degrees magnitude (NDMC, 2006a). In a study conducted by Kpripalani (1997) recognized that the ENSO phenomenon is a single most important cause of year to year climatic variability. According to them, a majority of the warm extremes (El Nino events) cause below–normal rainfall over Indonesia, while cold extremes (La Nina events) cause above normal rainfall over India. The most satisfactory explanation for the recent dry episode in the African Sahel according to Brooks (2004) involves changes in atmospheric circulation driven by a warming of the southern hemisphere oceans, and in particular the Indian ocean.

In northern Nigeria, Katsina and its environs in particular, drought can be attributed to failure of the rain- bearing monsoon winds from the Atlantic Ocean to penetrate enough

into the region (Oladipo, 1993b). This is supported by the work of Yamusa (2001) who observed that stations north of latitude 12^0 N in Nigeria have shown no significant correlation between rainfall and southern oscillation index.

Recently, it has been discovered that drought can be caused by a phenomenon known as the Indian Ocean Dipole (IOD). The IOD involved a periodic oscillation of sea- surface temperatures, between 'positive' and 'negative' phases. A positive phase sees greater than-average sea -surface temperatures and greater precipitation in the western Indian Ocean region, with a corresponding cooling of waters in the eastern Indian Ocean which tend to cause drought in the adjacent land areas of Indonesia and Australia. The negative phase of the OID brings about opposite condition, with warmer water and greater precipitation in the eastern Indian Ocean, and cooler and drier conditions in the west. The OID phenomenon was first identified by climate researchers in 1999. Yet evidence from fossil coral reefs demonstrates that the OID has functioned since at least the middle of the Holocene period, 6500years ago (Wikipedia, 2008).

Empirical studies conducted over the past century have never showed that drought is exclusively the result of a single cause. It typically results from a synergistic interaction between regional and remote influences (AMS, 1997).Studies on the causes of drought according to Oladipo (1993b) falls into four main categories. First are the studies which regard droughts as local manifestations of anomalies in the large- scale atmospheric circulation. Second are studies that have elaborated on the dynamical teleconnections between the dominant drought time scales and those of global sea- surface temperatures (SST) and other tropical phenomena such as the ENSO. Others have attributed droughts to land surface feed- back process and increase in green house gases resulting largely from

human activities. Finally, droughts have been explained as naturally occurring non- linear interactions in the atmosphere. Similarly, Barry and Chorley (2003) stated that the causes of drought conditions to include: a) increase in the size and persistence of the sub- tropical high pressure cells; b) changes in the summer monsoon circulation; c) lower ocean surface temperatures produced by changes currents or increased upwelling of cold waters; and d) displacement of mid-latitude storm tracks.

2.4 Impacts of Drought

When drought occurs, it produces a complex web of impacts that spans many sectors of the economy and reaches well beyond the area experiencing physical drought. This complexity exists because water is integral to society's ability to produce goods and provide services (ONRG, 2004a; NDMC, 2006c). We need water for everything from human, wild life and plants health; to washing dishes; river rafting and fishing; to growing food; cooling engines and producing electricity. When we don't have enough water for these activities, there will most often be a negative impact (NDMC, 2005). Drought affects more people than any other natural disaster. Lessons from developed and developing countries demonstrate that drought results in significant impact regardless of the level of development, although the character of this impact will differ profoundly (Wilhite, 2001).

Impacts are commonly referred to as direct and indirect. This is because drought impacts can cause a chain reaction of events that lead to additional drought impacts. Direct impact includes reduced crops, range land, and forest productivity, increased fire hazard, reduce water levels, increase livestock and wildlife mortality rates, and damage to wildlife and fish habitat. The consequences of these direct impacts illustrate indirect impacts. For example, a direct impact of drought may be that a farmer loses his wheat crop. An indirect effect is that

a farmer may then not have as much money and cannot buy a new tractor, reducing the income of the machinery dealership. If no one can afford to buy machinery, the dealership may eventually have to lay off employees or shutdown the business, resulting in even more indirect impacts. This chain reaction of drought impacts is often called the *ripple effects* (ONRG, 2004a; NDMC, 2005; NDMC, 2006c).

The impacts from drought tend to follow predictable progressions that vary as a function of societal wealth and socio-economic activities. In less developed regions of the world, the primary impacts are crop failures followed by food shortages, clean drinking water shortages and eventual related health problems, famine, energy shortages mass migrations, and political unrest (AMS, 2004). Clean drinking water shortages is always associated with multiple adverse health outcomes, including diseases associated with water contaminated with faecal and other hazardous substances. In accessibility to clean drinking water is therefore the major controlling factor of the various water borne diseases in drought prone environment (Abaje *et al*, 2009).

In the developed nations of the world, the impact of drought are more economic related such as crop production losses, higher food cost, higher cost of transportation and energy as well as reduced recreational opportunities and domestic and industrial water restrictions (AMS, 2004).

Drought impacts are often group as environmental and socio-economic (AMS, 2004; ONRG, 2004a; NDMC, 2005; NDMC, 2006c; Wikipedia, 2009).

2.4.1 Environmental Impacts: Environmental losses are the result of damages to plant and animals species, wild life habitat and air and water quality; forest and range fires;

degradation of landscape quality, loss of bio-diversity and soil erosion some of these effects are short-term and conditions quickly return to normal following the end of the drought. Other environmental effects linger for some time and may even become permanent. Wild life habitat for example, may be degraded through the loss of wet lands, lakes and vegetation. However, many species will eventually recover from this temporary aberration. The degradation of landscape quality including increased soil erosion may lead to a more permanent loss of biological productivity of the landscape (ONRG, 2004a; NDMC, 2006c; Wikipedia, 2009).

2.4.2 Socio-economic Impacts: Social impacts mainly involve public safety, health conflicts between water users; reduce quality of life and inequities in the distribution of impacts and disaster relief. Many of the impacts specified as economic and environmental have social components as well. Population out-migration is a significant problem in many countries, often stimulated by greater availability of food and water elsewhere. Migration is usually to urban areas within the stressed area or regions outside the drought area. Migration may even be to adjacent countries, creating refugee problem. However, when drought has abated, these migrants seldom return home, depriving rural areas of valuable human resources necessary for economic development. For the urban area to which they have immigrated, they increasing pressure on the social infrastructure, leading to greater poverty and social unrest. For example, the drought- prone north region of Brazil had a net loss of nearly 5.5milion people between 1950 and1980. Although not this entire population shift was directly attributable to drought, it was a primary factor for many in their decision to relocate. This continues to be a significant problem in Brazil and many other drought-prone countries (ONRG, 2004a; NDMC, 2006c).

When we talk of economic impacts, we mean those impacts of drought that cost people (or businesses) money. Many economic impacts occur in agriculture, livestock and related sectors, including forestry and fisheries, because of the reliance of these sectors on surface and sub surface water supplies (ONRG, 2004a) for example, the drought that occur between 1972 and 1973 in northern Nigeria resulted in the death of over 300,000 animals representing about 13% of the total livestock population of the northeastern part of Nigeria (Oladipo,1993a,1993b; Jaiyeoba, 2002; Ati, 2006),while crop yield dropped by about 60% (Okorie, 2003; Alatise, and Ikomawoyi,2007). Similarly, drought is associated with increase in insect infestations, plant diseases, and wind erosion especially in humid and sub-humid tropics (ONRG, 2004a; Ayaode, 2005). In Nigeria crop loss due to insects pests have been estimated to be of order of 50 to 60% of total crop production (Ayaode, 2005).

Income loss is another indicator used in assessing the impact of drought because so many sectors are affected. Reduced income for farmers has ripple effects. Retailers and others who provide good and services to farmers face reduced business. This leads to unemployment, increase credit risk for financial institutions, capital shortfalls, and eventual loss of tax revenue for local, state, and federal government. Prices for food, energy, and other products increase as supplies are reduced. In some cases, local shortages of certain goods results in the need to import these goods from outside the drought-stricken region. Reduced water supply impairs the navigability of rivers and results in increased transportation costs because products must be transported by alternative means such as rail or truck. Hydropower production may also be significantly affected Abaje, 2010.

According to NDMC (2006c) drought represents one of the most important natural triggers for malnutrition and famine, a significant and widespread problem in many parts of Africa

and in other countries of the world as well. Deaths resulting from famine are sometimes mistakenly attributed to drought rather than to underlying causes such as war civil strife.

The 2005 drought in the Amazon was particularly severe in the western and southern part of the basin where many rivers and lakes had lowest water levels in years. The drought had large impact on transportation, agriculture, fires and health in the region (Zeng *et al*, 2008). Doy (March 5, 2009) reported that the drought killed trees and release more greenhouse gas than the annual emissions of Europe and Japan. According to the report, rainforest from Africa to Latin America may speed up global warming if the climate becomes drier this century.

There have been numerous occurrences of drought in the past in Malaysia, but the most significant was the 1997/98 El Nino related drought which caused extensive impact to environment and social activities across the whole nation. Many parts of the nation including Selangor, Sarawak and Sabah were threatened by extensive wild forest fire due to prolong dry weather condition. The local situation coupled with that happened in the neighboring country had resulted in months of hazy atmosphere that threatened the health of every citizen (Shaaban and Sing, 2003). Chad, the largest country in the Sahel region, typifies the tragedy of the 1970s. It was estimated that more than 900,000 people were severely affected by drought. The important shortfall in crop production and massive death of livestock had overwhelming economic implications. In 1973, the gross domestic product (GDP) of Chad had a negative growth of 9%. The loss in real economic growth was a devastating setback for the country since per capita growth national product (GDP) dropped to 120 US$ by1975, ranking Chad as one of the lowest income countries in the world

Abaje, (2010). The 1984 drought had similar impacts on Mali and Niger, who saw their GDP fall by 9 and 18% respectively in the aftermath of the drought (Kandji *et al*, 2006).

In Nigeria, drought has severe impacts on food security, livelihood, economic, social and cultural activities of the affected people. This has aggravated the food situation in the area resulting in low food security index. The drought of the early 1970s in Nigeria caused a lot of economic disruptions. For example, it was held responsible for the drastic fall in GDP of 18.4% in 1971-72 and 7.3% in 1972-73. It was also seen as the rapid rise in price index for foodstuff and relative decline in non-oil exports (FRN, 2000).

In northern Nigeria, people ate the leaves of trees and herbs; whole villages appeared abandoned as whole as families went to the towns to beg, especially those of pastoral people whose starving herds had died. The mighty Nigerian economy, growing rich on proceeds of oil, seemed powerless to help the 20 million or more people of its vast Sudano-Sahelian region (Mortimore and Adams, 2001).

2.5 Characteristics of Drought

The beginning and ending times of drought are often rather vague, particularly the onset of a drought which often cannot be dated within two months (Felch, 1978). Drought is a recurring and worldwide phenomenon having spatial and temporal characteristics that vary significantly from one region to another (Vanlanen *et al,* 2007). The characteristics of drought are expressed in terms of drought index, drought intensity, duration and frequency (ONRG, 2004b). History shows us that each drought is unique, but common characteristics of the most severe droughts include long duration and large moisture deficits with a large areal extent, particularly during a climatologically wet season. These are the droughts with

the most far- reaching human and ecological impacts (AMS, 2004). The temporal and spatial characteristics of droughts were investigated in the Conchos River Basin in Mexico to provide a frame work for sustainable water resources management. Using the Palmer Drought Severity Index (PDSI) as an indicator of drought severity, the characteristics of droughts were examined. The analysis of the PDSI suggests that the Conchos River Basin had a severe drought in the 1990s, which the basin has not experienced before. Based on this analysis, the recent drought that occurs in the 1990s has an associated return period of about 80-100years over the basin (Kim and Valdes, 2002).

Shetty *et al*, (2006) have studied drought characteristics in the Ojos Negros region, in Baja California, Mexico in terms of intensity, duration and frequency. A conceptual model developed by Ponce *et al* (2000) was used in the characterization. The results revealed that drought intensity (per event) varied from 0.61 to 1.53 with an average of 0.83 duration range from 2 to 3 years, with an average of 2.46 years, frequency range from 3.33 to 4.83 years, with an average of 3.96 years. Based on the characterization, the study region is classified as arid according to drought duration (2 to 4years) and frequency (3 – 4years). Similarly, Oladipo (1993a) studied the spatial characteristics of drought in northern Nigeria and the result revealed that the mean probabilities of moderate drought for the Sahel, the mid land and the guinea savanna zones were 0.31, 0.26, and 0.24 respectively, with a recurrent interval of between 3 and 4 years. The occurrence of drought is, therefore, one of the conditions that also speed up the desertification process in the Sudano-Sahelian zone of Nigeria.

A long period data set (1875-1978) of monthly growing season (April - September) rainfall totals for over 400 stations in the interior plains of North America was used to derive a Bhalme and Mooley-type drought index. Based on the analysis, there were 4 patterns of moisture anomaly with distinct different between the eastern, western, southern and the extreme northern part of the study region. In general, large scale droughts do not frequently cover the region as a whole. It was concluded that drought in the interior plains of north America is predominantly a non- continental phenomenon (Oladipo, 1986). In the same continent, Khandekar (2004) found out that the Canadian Prairie provinces together with the American prairie region are the most drought prone regions of North America, were droughts of varying intensity and duration have occurred for many centuries, well before instrumental records became available. The analysis reveals that some of the severest droughts occurred during the 1920s and 1930s, a period commonly referred to as the dust bowl years. The recent drought of the 1980s and 1990s were comparable to some of the droughts of the dust bowl years in northern Nigeria, the 1980s witnessed the persistence of drought in the region beginning in 1982 (Oladipo, 1993a).

In Nigeria, Iwegbu (1993) investigated the areal extent of drought for the whole of Nigeria for the period 1921 – 1987. It was revealed that drought does not cover the entire country and no particular areas were persistently affected by drought until 1970s and 1980s; since the beginning of the 1970s areas affected by drought have increased in extent with a consequence decrease in near normal and wet conditions particularly in the Sahelian and midland zone. Drought incidence is not new in the sub-Saharan regions in Nigeria considering the fact that the entire sahel region is susceptible to climatic anomalies (Okorie, 2003). Oladipo (1993a) examines some aspects of spatial characteristics of drought in

northern Nigeria using a long period instrumental data set (1916-1987) of monthly growing season (April-October) rainfall totals for 34 stations in order to quantify drought. It was established that there were remarkable seasonal changes in the pattern of wetness and dryness over the regions with no consistent recurrent patterns in the moisture anomalies. The length and severity of drought varies from sub-area to sub-area with very low inter annual persistence. Similarly, Tarhule and Woo, (1997) analysed both historical information on sub-Saharan drought/famines and measured rainfall data from northern Nigeria. It was found that drought duration was related to magnitude, that is, the maximum cumulative rainfall deficit. This relationship confirms that longer drought recorded in the chronicles were more severe than the shorter ones. Both chronicles and rainfall records shows that drought of short duration less (<3years) tend to be less severe, more frequent and spatially more viable than long droughts. Droughts lasting over 3 years were regional in extent and were separated by long intervals between occurrences.

An in- depth study of drought, which covers 30 years period (1970-1999), was conducted in the sub-Saharan region of Nigeria using precipitation and satellite remote sensing data with emphasis on metrological drought vis-à-vis agricultural drought. According to the findings based on the ground truth (precipitation) data, many years of drought episodes were recorded in all the 14 states covered in the study. On the other hand, while the vegetation health index (VHI) data of July, 1985-1999 detects many years of drought condition in the region, the vegetation index (VI) data of 1982-1999 shows correlation with the rainfall data. However, 'drought' threatened the regions for many years within the period of the study, but there was climatic decline towards the end of the last decade, 1990-1999 (Okorie, 2003).

The Sudano-sahelian zone of Nigeria is an area of marginal rainfall. Rainfall data of 50 years (1953-2002) for four stations (Samaru, Potiskum, Sokoto and Katsina) in the zone were tested for trend analysis using the 5 years and 10 years running mean. The whole period was divided into decades and the decadal means compared with the long- term mean. Results indicate a decrease in annual rainfall in the zone from the mid 1960s up to the mid 1990s. Recent trends, however, show increase in annual rainfall from the mid 1990s. It means, therefore, that we are experiencing wetter condition in the Sudano-sahelian zone of Nigeria (Ati *et al*, 2007).

2.6 Agricultural Adaptation

Agricultural production remains the main source of livelihoods for most rural communities in developing countries and around the Saharan Africa in particular. In these Countries agriculture provides a source of employment for more than 60 percent of the population and contributes about 30 percent of Gross Domestic Product (GDP) (IFPRI 2007). Agriculture is inherently sensitive to Climate conditions, and is among the most vulnerable sectors to the risks and impacts of global climate change (Parry and Carter 1989).

Adaptation is certainly an important component of any policy response to climate change in this sector. Studies show that without adaptation, climate change is generally problematic for agricultural production and for agricultural economies and communities; but with adaptation, vulnerability can be reduced and there are numerous opportunities to be realized (Easterling *et al*. 1993; Fankhauser 1996).

Adaptations are adjustments or interventions, which take place in order to manage the losses or take advantage of the opportunities presented by a changing climate (IPCC, 2001).

Adaptation is the process of improving society's ability to cope with changes in climatic conditions across time scales, from short- term (e.g. seasonal to annual) to the long- term (e.g. decades to centuries). Adaptation methods are those strategies that enable the individual or the community to cope with or adjust to the impacts of the climate in the local areas. Such strategies will include the adoption of efficient environmental resources management practices such as the planting of early maturing crops, adoption of hardy varieties of crops and selective keeping of livestock in areas where rainfall declined. They also include the use of technological products that enable the individual to function in the ''new'' condition. Obviously, adaptation strategies are expected to be many, and their combinations in various ways will be required in any given location Nyong, *et al* (2007). The IPCC (2001) defines adaptive capacity as the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

The goal of an adaptation measure should be to increase the capacity of a system to survive external shocks or change. The assessment of farmers' adaptation strategies is important to provide information that can be used to formulate policies that enhance adaptation as a tool for managing a variety of risks associated with drought in agriculture.

While adaptation is often considered as a government policy response in agriculture, it also involves decision-making by agri-business and producers at the farm-level (Adger and Kelly, 1999). Adaptations in agriculture vary with respect to the climatic stimuli to which adjustments are made (i.e. various attributes of climate change, including variability and extreme events) and according to the differing farm types and locations, and the economic,

political and institutional circumstances in which the climatic stimuli are experienced and management decisions are made (Chiotti and Johnston, 1995; Bryant *et al*. 2000).

Many potential agricultural adaptation options have been suggested, representing measures or practices that might be adopted to alleviate expected adverse impacts. They encompass a wide range of forms (technical, financial, managerial), scales (global, regional, and local) and participants (governments, industries, farmers) (Skinner, *et al.* 2001). Most of these represent possible potential or adaptation measures, rather than ones actually adopted. Climate change impact analyses often assume certain adaptations, although the adaptation process itself remains unclear (Fankhauser and Tol, 1997). Evidences from several works (Mortimore, 1989 and Gashua, 1991) indicate that farmers in Nigeria's dry lands adopt several effective strategies to counter or adopt to climate variability through (a) Burying of seeds early enough (b) Burying of manure at lower soil layers to improve subsurface moisture storage. (c) Delayed planting of seeds. (d) Planting of cover crops to enhance moisture storage. There is a need to understand what types and forms of adaptation are possible, feasible and likely; who would be involved in their implementation; and what is required to facilitate or encourage their development or adoption.

Adaptation has the potential to significantly contribute to reductions in negative impacts from changes in climatic conditions as well as other changing socioeconomic conditions, such as volatile short-term changes in local and international markets (IFPRI, 2007). Therefore, an analysis of adaptation options and constraints to adaptation is important for the agricultural communities in the northern parts of Katsina state. The area, highly dependent on agriculture for economic survival and at the same time highly prone to climate variability that has adverse effects on agriculture. A better understanding of farmer

Ideas regarding long-term climatic changes current adaptation measures and their determinants will be important to inform policy for future successful adaptation of the agricultural sector. This is significantly explicit in achieving the MDGs Number one and seven goals (seven points agenda), which concern eradicating extreme poverty and hunger, and ensuring environmental sustainability.

2.6.1 Indigenous Knowledge in Drought Adaptation

Indigenous knowledge has been defined as institutionalized local knowledge that has been built upon and passed on from one generation to the other by word of mouth (Osunade, 1994; Warren, 1992). It is the basis for local-level decision-making in many rural communities. Indigenous knowledge has value not only for the culture in which it evolves, but also for scientists and planners striving to improve conditions in rural localities (Mundy and Compton, 1991). The knowledge set is influenced by the previous generations' observations and experiment and provides an inherent connection to one's surroundings and environment. Therefore, Indigenous Knowledge is not transferable but provides relationships that connect people directly to their environments and the changes that occur within it, including climate change (Woodley, 1991).

In the area of adaptation, indigenous knowledge systems have been applied in weather forecasting, vulnerability assessment and implementation of adaptation strategies. Considering that agriculture and land use changes are identified as the two main sources of green house gases (GHG) in Africa, we will review indigenous knowledge systems that have been applied adaptation within these two sectors.

Local farmers in the Sahel have been known to conserve C in soils through the use of zero tilling practices in cultivation, mulching and other soil management techniques (Schafer 1989; Osunade, 1994). Natural mulches moderate soil temperatures and extremes, suppress diseases and harmful pests, and conserve soil moisture. Before the advent of chemical fertilizers, local farmers largely depended on organic farming, which also is capable of reducing green house gases (GHG) emissions.

It is widely recognized that forests play an important role in the global carbon cycle by sequestration (Karjalainen *et al.* 1994; Stainback and Alavalapati, 2002). Local farmers are known to have practiced the fallow system of cultivation, which encouraged the development of forests. It may be argued that with the growth in population, lengths of fallow have been reduced to the extent that the practice no longer exists in certain areas. However, one must not forget that the importance of forests have been recognized by traditional institutions to the extent that communal forest reserves were very common in traditional societies. Besides the fact that these well managed food and timber resources to the community, they also served as C sinks. It is recognition of the role of forests in climate change that has influenced participants of the Kyoto Protocol to allow countries to include carbon sequestered in forests in a country's emission requirements.

Agro forestry is another practice that has been very effective in carbon sequestration. Agro forestry is a rational land-use planning system that tries to find some balance in the raising of food crops and forests (Adesina *et al.* 1999; Floyd, 1969). A practice similar to this has been described in a part of south western part of Nigeria to raise shade tolerant crops such as Dioscorea spp and cocoyam in essentially a permanent forest setting (Adesina, 1988). In addition to the fact that agro forestry techniques can be perfected to cope with the new

conditions that are anticipated under a drier condition and a higher population density, they lead to an increase in the amount of organic matter in the soil thereby improving agricultural productivity and reducing the pressure exerted on forests. Traditional knowledge of plants is very useful in agro forestry projects. Scientists have tended to limit plants' trials for forestry and agro forestry to known species that have performed well in other parts of the world. In the drier parts of the Sahel, the significance of the baobab (Adansonia digitata) and acacia (Acacia) trees is just being realized by researchers as a valuable tree especially during the hot and dry parts of the year. Local people certainly know other trees that perform well under different ecological conditions. The integration of such candidates into the pool of suitable agro forestry trees will provide opportunities for the farmers to make choices.

Local knowledge is vital for preserving bio-diversity, which is considered a very successful adaptation strategy. Through the World Bank, gene banks have been established to preserve genetic information of local varieties or indigenous species. Genetic traits of these species and the knowledge of cultivators may prove instrumental in future breeding programs to introduce resistance against pests or diseases or endurance for harsh climatic conditions. A major criticism of this initiative is that preserving genetic traits without preserving the knowledge of their husbandry may prove futile as the seeds and clones stored in seed banks do not carry the instructions on how to grow them (Warren, 1991). Hence, these gene banks should cooperate with farmers and communities who still cultivate local varieties to preserve such essential knowledge and skills in situ.

In the Sahel, local farmers have developed several adaptation measures that have enabled them to reduce their vulnerability to drought shock. One important step in reducing the

vulnerability of a climatic hazard is the development of an early warning system for the prediction or forecast of the event (Ajibade and Shokemi, 2003). There is a wealth of local knowledge based on predicting drought. A study of weather knowledge in various parts of the Sahel reveals the wealth of knowledge that farmers possess. These farmers have developed intricate systems of gathering, prediction, and decision-making in relation to drought. To a very great extent, these systems of climate forecasts have been very helpful to the farmers in managing their vulnerability. Farmers are known to make decisions on cropping patterns based on local predictions of drought, and decisions on planting dates based on complex cultural models of weather.

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

2.6.2 Farmers' Adaptation Strategies to Drought

Agricultural extension system in Nigeria needs to concentrate on appropriate local techniques that is, "agricultural adaptation". These are the practices evolved over the years by the local drought managers based on rationality and security. The adaptation strategies

that can be adopted in addressing crop failures can be identified, broadly divided into two: on-farm and off-farm adaptive strategies Gashua, (1991).

2.6.2.1On-Farm Drought Adaptation Strategy:

i. **Dry planting (Binne in Hausa)** - this is a technique popularly used by farmers in northern Nigeria. Seeds usually of millet, are planted on dry upland farms prior to the first rain of the season. The aim is to derive maximum utility from the highly unpredictable arrival of the first planting rain. (*Ruwan* shuka in Hausa).

   The risk is that insects may eat up the buried seeds or the first rain may not be sufficient for proper germination to occur, thus, making replanting necessary. On the other hand, if the first rain is plentiful and insects do not eat or destroy the seeds the venture may prove worthwhile (Gashua, 1991).

ii. **Mixed Cropping:** Farmers in drought-prone areas of Nigeria usually grow their crops in a carefully designed complex (mix) on the same plot. Millet, sorghum and cowpea are a popular mix. The rational is to ensure security because, even if a hazard like drought or pest strikes, the crop tolerant to the hazard will still survive.

   Millet for instance is noted for drought tolerance while sorghum is avoided by grasshopper, and cowpea is able to use late rains and residual moisture for growth. The proportion of land under mixed cropping usually increases with the probability of drought occurrence to ensure greater risk spread (Gashua, 1991).

iii. Irrigation

Irrigation accounts for the largest consumption of water in the country. Unfortunately, most of the water, an estimated 60% is wasted due to poor irrigation practices FAO, (2010). Irrigation agriculture though known in some parts of northern Nigeria for long became popular in other only after the 1972-1973 drought periods. Its transformation from a usually part-time activity into a full- time one is attributable in part to the same reason. Irrigation activities along the fadama lands of the study area are now an important drought adaptation measure (Gashua, 1991).

iv. Variation in Cropping Pattern:

Cropping has been altered in northern part of Nigeria since the 1972/73 drought. Cassava became popular in northern part of Katsina state, quick maturing cowpea (*dan arba'in* in Hausa) is now popular in Hadejia area of Kano state. Groundnut which is very susceptible to moisture stress is getting less attention even in Kano area where it dominated in the 1960s. Millet and cowpea seems to be getting more land due to their drought tolerance. These changes tempted speculations that the farming system of the northern sudan zone may be substituting some of its elements for those of the Sahel in line with reduced rainfall (Gashua, 1991).

v. Adopting New Tools:

Drought occurrence also results in the movement of some tools formally found deep in the Sahel into southern locations. For examples, the long- handle hoe (called *Ashasha* in Hausa) with its crescent -shaped blade that works as is pushed forward and backward by a working person. The blade is moved just beneath ground level

thus cutting weed roots. This tool was introduced into some part of Borno, Katsina and Kano from Niger republic. The tool is only workable in very sandy soil. The tool was introduced by migrant workers from Niger in 1972/73 period when a large number of oxens for ox-ploughs died (Mortimore, 1989; Gashua, 1991).

vi. Adopting Drought Resistant Crop Varieties:

Crop strains noted for moisture stress tolerance or those able to grow on residual moisture are increasingly getting adopted by farmers in the drought prone areas of Nigeria including the Katsina and its environs.

Local millet varieties with tolerance of up to twenty five days are known to exist while growing of mellon species (*Guna* in Hausa) is of economic significance on the residual moisture of farms in Kano, Borno and Katsina (Mortimore, 1989; Gashua, 1991).

vii. Adjusting to Labour Demand:

The need to 'make the best' out of the usually unpredictable first rain is very familiar to farmers operating in the drought- prone areas. Planting, if not done at the dry planting stage, has to be quickly done. Replanting may also be necessary at times. Early first weeding and thinning are also very desirable farm management practices in the drought- prone farming. The urgency of these operations forces labour demand up and peasants with limited non- farm income sources and limited home labour availability are forced to reduce farm size or used tools like "*Ashasha*" hoe which work faster than the usual "*Fartanya*" (Hausa) hoe (Mortimore, 1989; Gashua, 1991)

viii. **Soil Management:**

Soil character like fertility and moisture retention capacity are very important to farmers in drought-prone areas. Use of chemical fertilizer and even manure if during dry spell, may have negative effects (Mortimore, 1989; Gashua, 1991).

2.6.2.2 Off-farm Drought Adaptation Strategy:

i. **Sale of Assets:**

Farmers when faced with the danger of food shortage may resort to sale off their assets to get money for the purchase of food. Livestock are popular items assets use for this purpose (Gashua, 1991).

ii. **Trade and Craft:**

Both men and women in drought- prone areas including the study area get involved in trading or craft to supplement farm based income especially in drought periods. Rope and mat making from dum palm, leather-works, blacksmithing and fish trading are some activities used. The activities usually depend on locally available resources (Mortimore, 1989; Gashua, 1991).

iii. **Depending on Others:**

Another adaption strategy centres on the use of assistance from other people. it may be help from relatives or friends so that poverty is 'shared' by all. Borrowing from others like money lenders can also be used (Gashua, 1991).

iv. **Sale of labour:**

It is popularly known as "*Kwadago*" in Hausa land, the sale of labour by persons affected by drought is used as an adaptation strategy to cope with

drought impact. Family head or members may go to nearby towns and work on construction sites, homes etc., on casual basis for cash that is used in buying food (Gashua, 1991).

v. **Migration:**

Temporary or permanent migration is also a usual sequence of drought in Nigeria. The practice of seasonal migration ("*Cin rani*" in Hausa) is usually compounded by drought incidence. Home remittance from family members who have migrated to cities from rural parts of the drought- prone areas in Nigeria such as Katsina and its environs is known to help in mitigating the impact of drought (Gashua, 1991).

vi. **Harvest from the Wild, Hunting and Fishing:**

Harvest of wild fruits, nuts etc, fishing and hunting are all known ways of supplementing food supplies during droughts (Gashua, 1991).

From the above review, agricultural development planning for drought- prone areas of Nigeria need to have the capacity of improving, where necessary and integrating the strategies evolved by the pleasance farmers in adapting with a menace he knows best. His regard for security should for the framework of such undertaking. More so, a better understanding of precipitation anomalies is essential to develop tools for prediction or forecasting of drought initiation and ending so that this occurrence may be clearly recognize for better adaptation options.

CHAPTER THREE: STUDY AREA AND METHODOLOGY

3.1 **Study Area**

3.1.1 **Location**

The study area (Katsina, Kaita, and Jibia LGAs) is bounded by Niger Republic to the north, Zamfara State to the West, Batsari, Batagarawa and Rimi LGAs to the South and Mashi LGA to the East. It is located between latitude $12^0\ 59^1$ North and longitude $7^0 36^1$East. It has a total land mass of 142 km^2. Below is Katsina state showing study area and the study area showing some selected wards (see Fig 3.1 and 3.2).

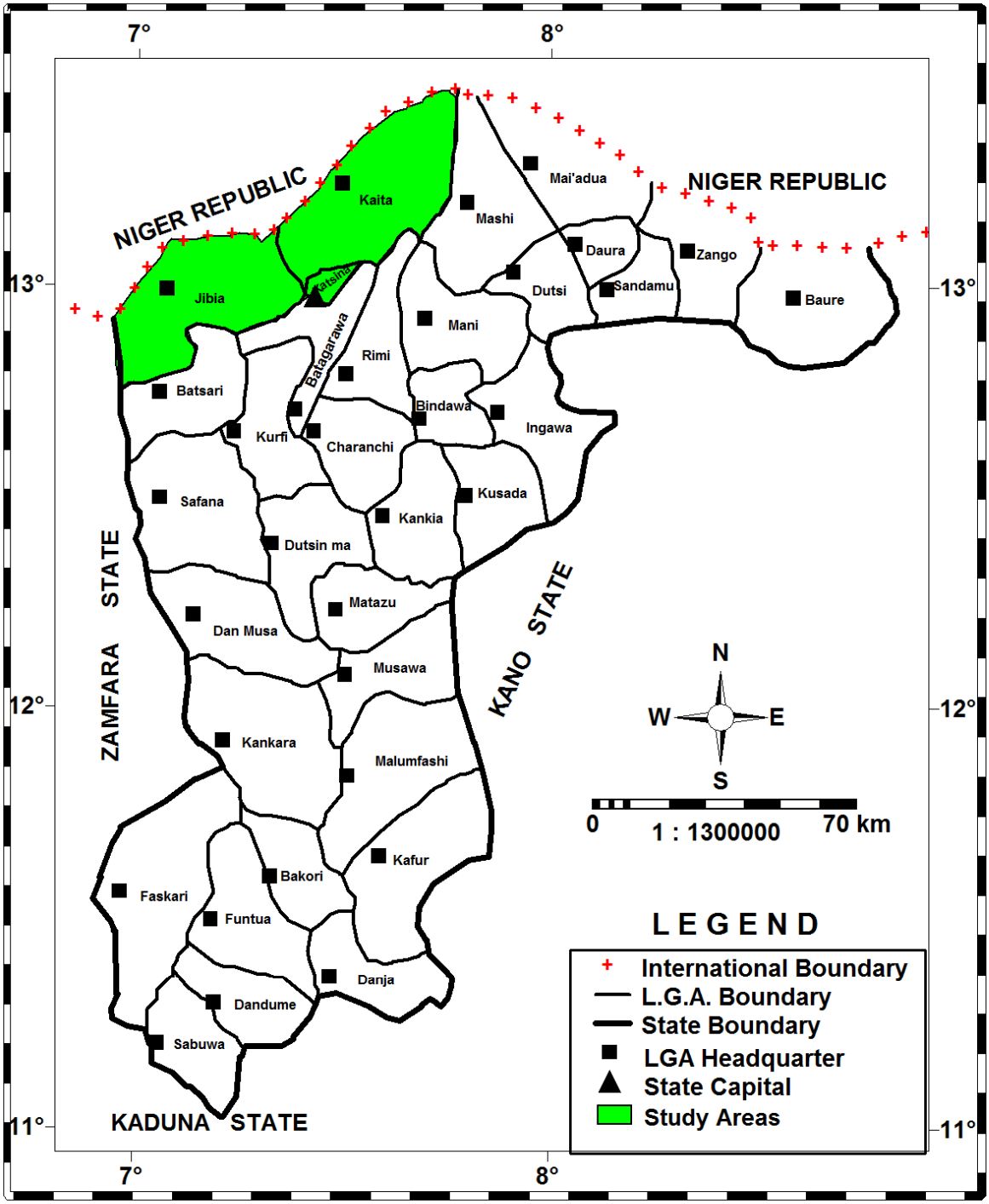


Fig 3.1: Katsina State Showing Study Area.
Source: Adapted and Modified from Katsina State Map, 2012.

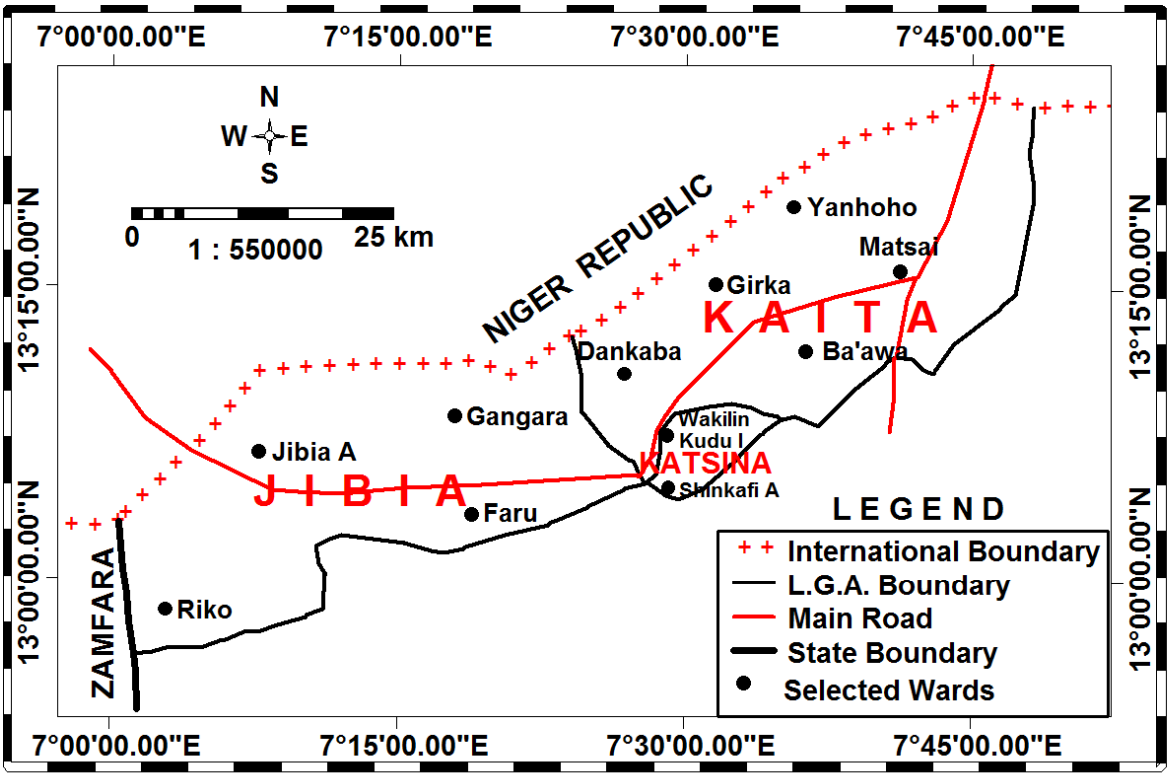


Fig 3.2: Study Area Showing Some Selected Wards.
Source: Adapted and Modified from Katsina State Map, 2012.

3.1.2 **Climate**

Katsina state can be classified into zones climatically: the tropical continental and semi-continental. The north of Katsina state (from around Kankiya to the extreme North-East has total rainfall figure ranging from 600 – 700mm per annum. Generally, rainfalls vary considerably according to months and seasons. There are: Cool dry (Hamattan) season from December to February, a hot dry season from March to May, a warm wet season from June to September, a less marked season after rains during the months of October to November characterized by decreasing rainfall and gradual lowering temperature (O.N, 2003).

For successful agricultural activity which is the mainstay of the economy of the area, rainfall is the most critical climatic factor and a strong direct correlation between rainfall and drought occurrence is deeply entrenched. The variability of climatic elements such as rainfall and temperature are an important factor in determining crop yield and food production. Rainfall and temperature detect seed germination and healthy plant growth that result in bumper harvest. The area like all other places experiences temperature and rainfall variability as a result of global warming that brings about change in global climate conditions Rafindadi, (2011).

3.1.3 **Geology and Relief:**

Katsina and its environs form part of the extensive plains known as the high plains of Hausa land. It is composed of undulating plains which generally lies gently from 360m in the North-East, to 600m around Funtua in the South-West. But, the northern part cretaceous sediments overlap the crystalline rocks.

Katsina-Daura plain lies at a lower base level than any other parts of the state, around Funtua and Dutsinma. There are many Quartzatic and Granitic hills which rise above 6200m above the surrounding plains; these hills are probably the result of intrusion of older granites into basement complex which have undergone long period of denudation. Over much of the area, solid granite rock is covered by thick weathered materials which accumulated during drier climatic conditions (Udo, 1970; Effeh, 2000 & O.N, 2003).

3.1.4 **Drainage**

Katsina and its environs are drained by many rivers. Major rivers originate in or traverse the state include: the Koza, Sabke, Tagwai and Gada systems in the northern half of the state (all the following either north or North-West ward). However, all these rivers contain water in their channels only during the raining season and have little or no water in the dry season. Among them river Gada, Karaduwa and Sabke have been dammed. Mainly for irrigation purpose and the dams are known as Jibiya, Zobe and Daberam respectively (O.N, 2003).

3.1.5 **Soil**

Katsina and its environs, underlying rocks are overlain by sandy 'drift' deposits lain down during the last arid phase about twelve thousand years ago. In the north, the drift deposits are coarse, resulting in light sandy soils of buff or reddish colours of low medium fertility. These soils are easily worked and well suited to crops such as millet and groundnut which are less demanding in their water requirement than cotton, maize and guinea corn. (O.N, 2003).

3.1.6 **Vegetation**

Katsina and its environs, belong to the Sudan Savannah Zone in the northern half of the state. While, the southern half belongs to the northern guinea savannah zone. The northern district consists of trees that grow long tap roots and thick barks that make it possible to withstand the long dry season and bush fires. The fine-leaved species of thorny trees with continuous short and feathery grass cover. The grass cover here too has durable roots which remain underground after stalk are burnt away or` wilted in the dry season only to germinate with the first rains (O.N, 2003).

3.1.7 **Economic Activities**

Agriculture is the backbone of the states' economy as 75% of its people are farmers. Katsina state is blessed with abundant agricultural land and wide range of crops is grown. This includes: guinea corn, millet, maize, cowpea, cotton, groundnut etc.

Local trade in Katsina and its environs is primarily in sorghum, millet, onion, peanut (groundnut), cotton, hides and skins, cattle, sheep, goats, horses, donkeys, poultry are kept by its Hausa-Fulani inhabitants. Cotton weaving and peanut collecting (for export) are significant economic activities (O.N, 2003).

Exploitation of the vegetation has been largely for fuel wood, wild fruit, pasture for livestock, herbs for treatment of diseases, cultivation, grazing, and for hunting.

3.2. Methodology of the Study

3.2.1 **Reconnaissance Survey**

The researcher carried out a reconnaissance survey from 10 to 17 of May 2012 in order to be well acquainted with the study area. During the survey, the researcher was opportuned to

meet all the relevant people such as head of village farmers (Sarkin noma) that would, in any way, assist in identifying farmers that have the experience of drought.

3.2.2 **Types of Data:**

In order to achieve the stated aim and objectives, the following data were collected:

(i) Data on rainfall for 1971-2010. The rainfall data were used to determine the years of occurrence of drought in the study area.

(ii) Farmer's perception and adaptation strategies to drought. This helped to assess the sensitivity of farmers to the hazards of drought and how they adapt to it.

3.2.3 **Source of Data**

The rainfall record for the stated period was obtained from the Nigerian Meteorological Agency (NIMET) Katsina, Station No.1307.4, located between latitude 13:0[1] N and longitude 07:41 (Umaru Musa Yar'aduwa Air Port, Katsina). The station was chosen to represent the entire study area because of the following reasons:

i. It's the only synoptic station in the study area.

ii. Nigerian Meteorological Services Department, Oshodi had confirmed that the station data are reliable for researches of this type.

iii. The station has no significant missing records during the period of study

iv. The station has not been relocated since its establishment in 1941.

Data on Farmers' perception, adaptation strategies were gathered through the field survey using closed and open ended questions to elicit the following information.

(i) Respondent's personal data (e.g. Age, Gender, Marital status, Educational qualification etc).

(ii) The farmers' perception of drought and its causes.

(iii) The farmers' evaluation of the effects of drought on farming and livestock husbandry activities.

(iv) How decision on response to drought is arrived at by the farmers and how they are adapting with it.

(v) The farmers' ability to recall the frequency and intensity of occurrence of hazards and predict the same.

3.3 Sampling Design:

According to NPC (2006) Katsina Local Government Area has a population of 318,459, Jibiya has a population of 169,748 and Kaita has a population of 184, 401. The study area, therefore, has a total population of 672,608.

Each of the selected LGAs has a number of wards under it. These were arranged alphabetically and all the even numbered wards were systematically selected to ensure a good geographical spread across the study area. This is because the study area is quite large.

These are shown in table 3.1

Table 3.1 Local Government Areas, Wards, Selected Wards and Sample Size

LGAs	Number of Wards	Selected Wards	Sample Size Administered	Sample Size Retrieved
Katsina LGA	Kangiwa			
	Shinkafi A	Shinkafi A	24	24
	Shinkafi B			
	Wakilin Arewa A	Wakilin Arewa A	24	24
	Wakilin Arewa B			
	Wakilin Gabas I	Wakilin Gabas I	24	22
	Wakilin Gabas II			
	Wakilin Kudu I	Wakilin Kudu I	24	23
	Wakilin Kudu II			
	Wakilin Kudu III	Wakilin Kudu III	24	24
	Wakilin Yamma I			
	Wakilin Yamma II	Wakilin Yamma II	24	23
Jibiya LGA	Bugaje			
	Faru	Faru	24	19
	Farfaru			
	Gangara	Gangara	24	21
	G/ Baure/ Mallamawa			
	Jibiya A	Jibiya A	24	23
	Jibiya B			
	Kusa	Kusa	24	22
	Mazanya/ Magama			
	Riko	Riko	24	23
	Yangaiya			
Kaita LGA	Abdallawa			
	Ba awa	Ba awa	24	22
	Dankama			
	Dankaba	Dankaba	24	23
	Gafiya			
	Girka	Girka	24	24
	Kaita			
	Matsai	Matsai	24	20
	Yandaki			
	Yanhoho	Yanhoho	24	24
	Total 33	**Total 16**	**Total 385**	**Total 361**

Source: NPC, 2006

The respondents for the questionnaire were the farmers in the sixteen (16) selected wards in Katsina and its environs. The number of questionnaires used was based on the population of the study area. To determine the sample size for this research, Krejcie and Morgan (1970) method of determining sample size was adopted which state that for an area with a population between 75,000 –999,999 the sample size would be 382. Since, the population of the study area is 672,608, which falls within this range; the sample size to be used for this research is 382. However, 385 respondents were used to have equal representation in each ward.

Purposive sampling technique was adopted with the help of village heads helping in identifying farmers who have a lot of experience with drought incidence and traditional coping methods to administer the questionnaire among the sixteen wards of the study area. Purposive sampling, according to Bernard (2002) "is the deliberate choice of an informant due to the quality the informant possesses." The three hundred and eighty five (385) questionnaire was shared proportional to the population of each ward, but due to the non availability of population figures for each ward from the 1991 and 2006 census results, the questionnaire was distributed uniformly among the sixteen (16) selected wards, with twenty four (24) questionnaires in each ward. For the purpose of administering the questionnaire, farmers above thirty (30) years of age and who must have lived at least, twenty (20) years within the study area were identified and issued a questionnaire. This was achieved by asking the farmers of their age and how long they have lived in the area. The reason for this decision is that those within the age bracket will have the information needed about drought adaptation and indigenous coping methods.

3.4 **Analytical Techniques:**

Analysis and presentation of data from the questionnaire was done by means of descriptive and inferential statistics.

- To characterize rainfall trend of the study area, the monthly and annual rainfall for the station was plotted using trend analysis for easy identification of its temporal variability.
- To determine the intensity and years of occurrence of drought, Normalize Rainfall Index (NRI)) was used to discuss drought situation in the area.
- To present the farmers awareness of drought issues and the various agricultural adaptive strategies used by the farmers to cope with drought, percentage analysis was used. The data were summarized and presented in tables, percentages, graphs, etc.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Rainfall Characteristics and Trends for Monthly and Annual Rainfall

The study area has the long- term mean annual totals of 557.39 mm for the entire period of study (1971 to 2010). For agricultural purposes, the months of June to September (the growing season) are considered to be the most important in drought study. This is because they are said to be the months when more than 95% of the annual rainfall total is received in the study area (Anyadike, 1993).

4.1.1 Trend in June Rainfall Value in Katsina and its Environs for 40 Years (1971-2010)

The trend in June rainfall for the study area is shown in fig.4.1.1

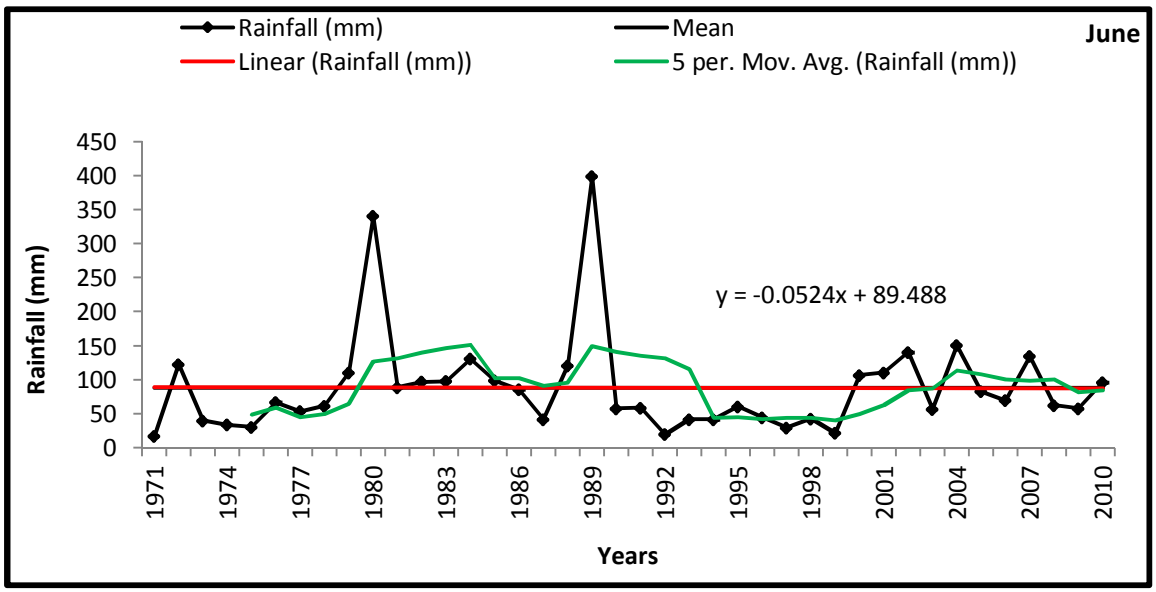


Fig.4.1.1 Rainfall Trend for June

The June rainfall value in Katsina and its environs from 1971-2010 are normally distributed at 95% confidence level. Linear trend line indicates a decrease in rainfall of approximately 2.00mm at the rate of 0.05mm year^{-1} which is about 0.06% year^{-1}. Thus, linear trend line did not indicate any significant decrease, rather, the line passess through the long –term

mean. The five year running mean indicates values below the long-term mean from the beginning to the end of the first decade with a sharp increase between 1980- 1984.The values decline between 1985-1988 with sudden increase between 1989- 1993. The value declined below the long- term mean between 1994 -2003 with slight increase from 2004 till end of that decade.

4.1.2 Trend in July Rainfall Value in Katsina and its Environs for 40 Years (1971-2010)

The trend in July rainfall for the study area is shown in fig.4.1.2

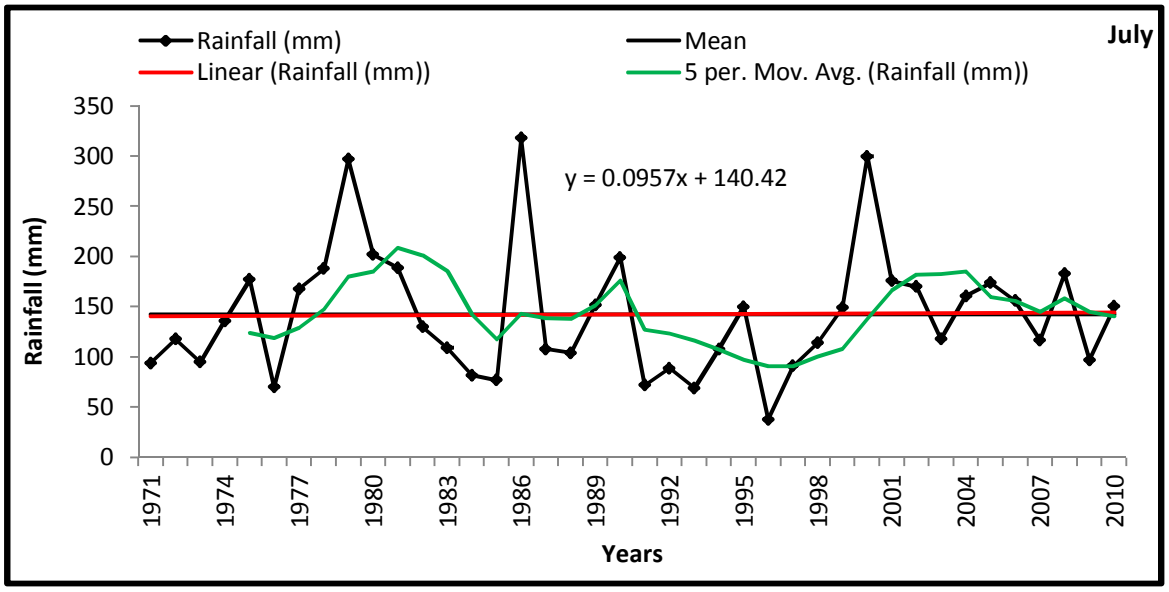


Fig.4.1.2 Rainfall Trend for July

The July rainfall value in Katsina and its environs from 1971-2010 are normally distributed at 95% confidence level. Linear trend line indicates an increase of 4.00mm at the rate of 0.10mm year^{-1} which is about 0.03% year^{-1} in July. Thus, linear trend line did not indicate any significant increase, rather, the line passess through the long –term mean. The five year running mean indicates values below the long-term mean from the beginning with sharp increase between 1978- 1985. The value remained below the long- term mean until

1999. From then the value increased above the long- term mean until years of the last decade.

4.1.3 Trend in August Rainfall Value in Katsina and its Environs for 40 Years (1971-2010)

The trend in August rainfall for the study area is shown in fig.4.1.3

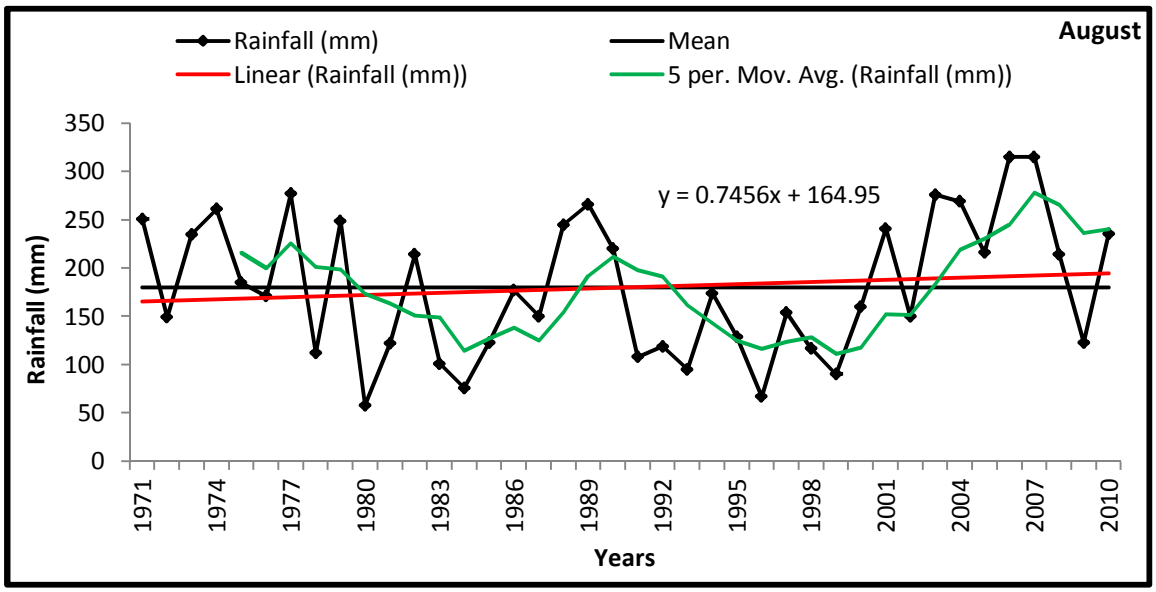


Fig.4.1.3 Rainfall Trend for August

The August rainfall value in Katsina and its environs from 1971-2010 are normally distributed at 95% confidence level. Linear trend line indicates an increase of approximately 30.00mm at the rate of 0.75mm year^{-1} which is about 0.42% year^{-1} in August. The five year running mean indicates values above long term mean in the beginning to the end of the first decade. The value declined between 1980- 1989 with a sudden increase in between 1990-1992. Then the value decline until the beginning of 2000.The value then increase above the long -term mean till the end of the last decade.

4.1.4 Trend in September Rainfall Value in Katsina and its Environs for 40 Years (1971-2010)

The trend in September rainfall for the study area is shown in fig.4.1.4

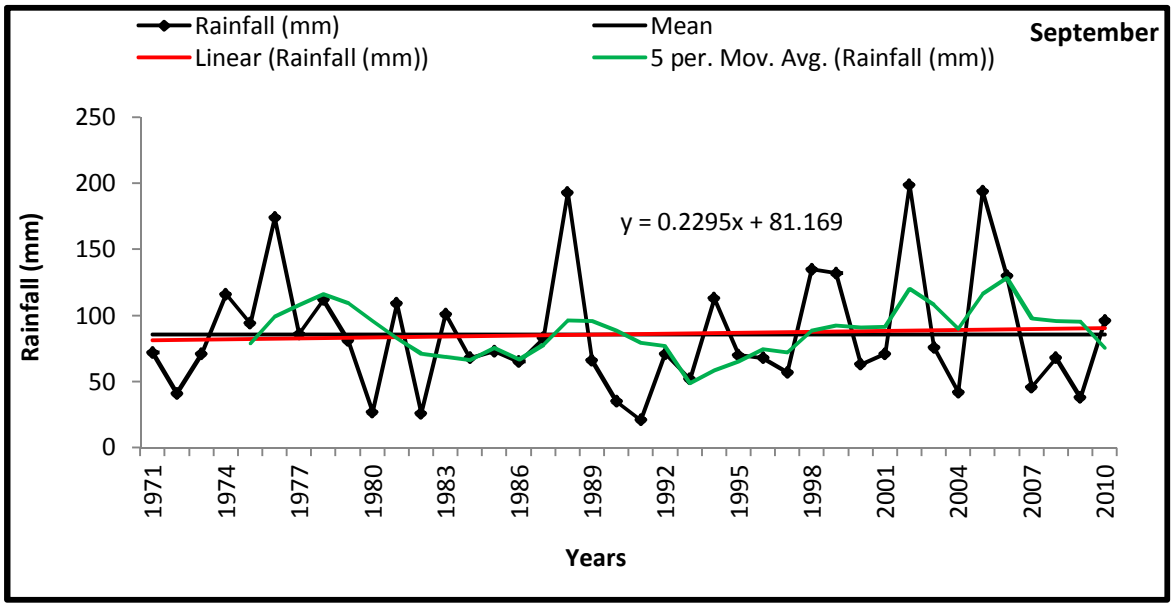


Fig.4.1.4 Rainfall Trend for September

The September rainfall value in Katsina and its environs from 1971-2010 are normally distributed at 95% confidence level. Linear trend line indicates an increase of approximately 9.20mm at the rate of 0.23mm year^{-1} which is about 0.27% year^{-1} in September. The five year running mean indicates values above long- term mean at the beginning to the end of the first decade. The value decline below the long- term mean from early 1980 to the mid -1980s with sudden increase from 1986- 1989. From then the value decline below the long- term mean till 1998. The value increased above the long- term mean until the end of the last decade.

4.1.5 Trend in Annual Rainfall in Katsina and its Environs for 40 Years (1971-2010)

The trend in annual rainfall for the study area is shown in fig.4.1.5

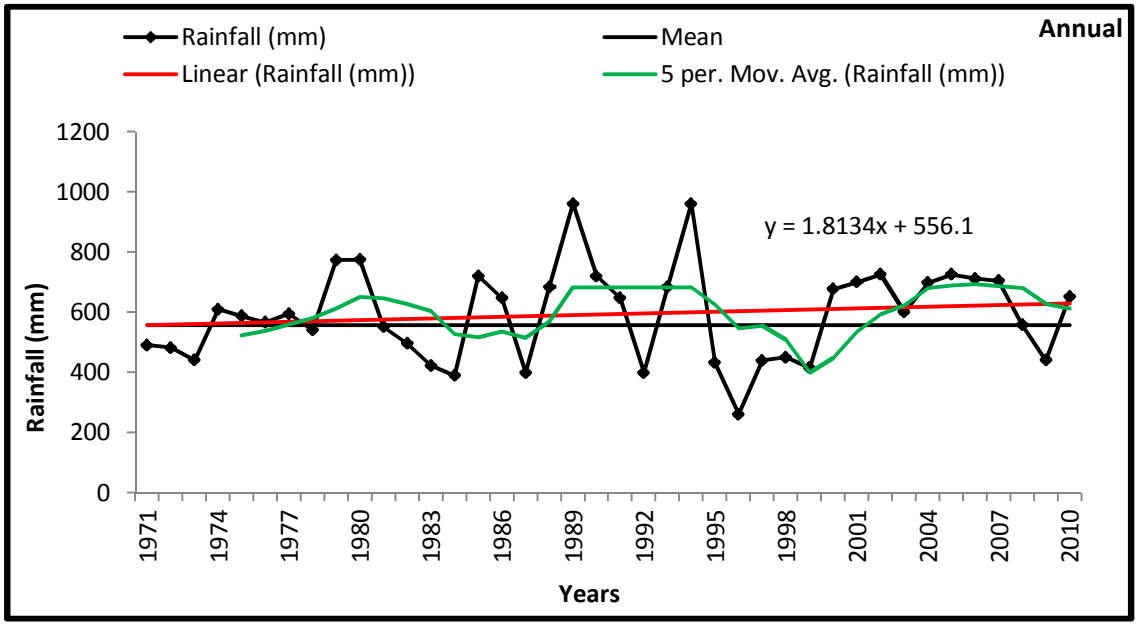


Fig.4.1.5 Rainfall Trend for Annual Total

The annual rainfall value in Katsina and its environs from 1971-2010 are normally distributed at 95% confidence level. Linear trend line indicates an increasing trend by approximately 72.40 mm at the rate of 1.81mm year^{-1}. Compared with the long-term average total, it means that the annual rainfall was increasing at a rate of 0.32% year^{-1}. The five year running mean indicates values below the long- term mean at the beginning with sudden increase towards the end of the first decade. Then the value decline below the long-term mean from 1982- 1987. From then the value increases above the long -term mean until mid- 1990. Then the value declined below the long- term mean until end 1990s. Since the beginning of the year 2000 the value increases above the long -term mean to the end of that decade.

The 5-year running mean, therefore, shows that below average rainfall was experienced from the early 1970s up to 2000. This coincides with the period of great droughts of the 1970s, 1980s and 1990s in the area as described by Oladipo (1993a) and Iwegbu (1993); Abaje, (2010). On the other hand, above average rainfall is being experienced from the year 2000 afterward (see Fig.4.1.5).

From the linear trend lines of the monthly and annual rainfall, there is a clear indication of an increase in rainfall amounts overtime. It is also clear from the results of the linear trend lines that the increase in the annual rainfall yield is predominantly as a result of the increase in August and September rainfall. This findings is in agreement with the observation made by Ati, Iguisi, and Afolayan (2007), Ati *et al.* (2008 & 2009), Odekunle, Andrew and Aremu (2008), Abaje, Ishaya and Usman (2010), Abaje (2010), and Abaje, Ati and Iguisi (2012a & b) that the Sudano-Sahelian Ecological Zone of Nigeria has been experiencing decreasing number of drought occurrences and consequently increasing wetness over the recent years.

4.2 Intensity and Years of Occurrence of Drought

The intensity and years of occurrence of drought for the study area is presented in fig. 4.2

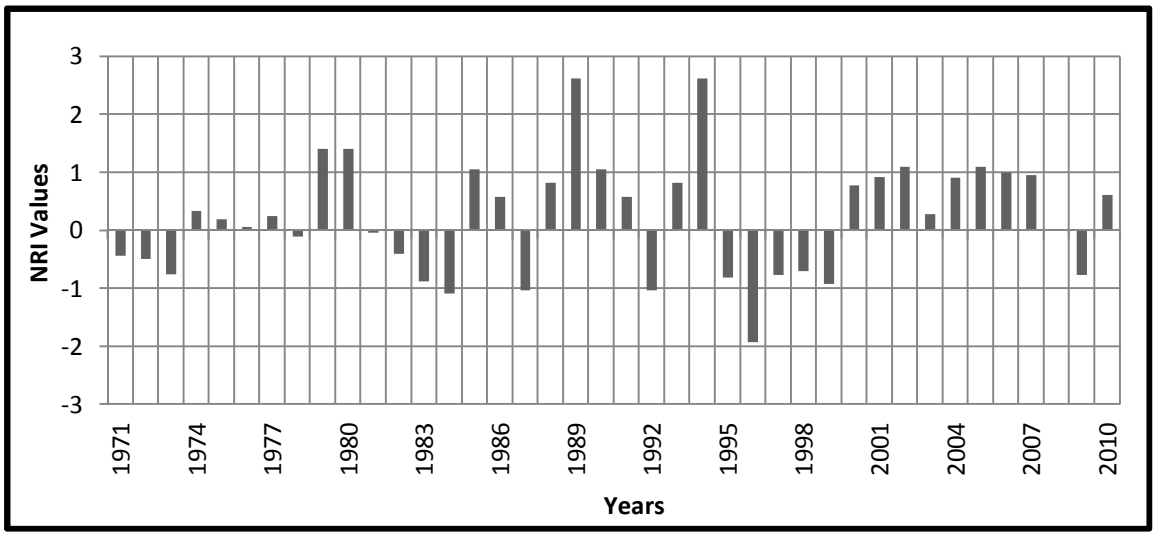


Fig. 4.2 Normalized Rainfall Index for Katsina and its Environs

From Fig. 4.2, Katsina and its environs suffered from mild to moderate drought in 1971. The drought persisted in 1972 attaining its peak level in 1973. There was a slight break in the intensity of drought in the1974- 1977 due to near normal wet condition. The negative effects of the 1970s droughts, which led to dramatic losses of human lives, death of animals and visited hunger and abject poverty on millions of Sahelians was exacerbated by the fact that the adaptive capacity of the rural populations was stretched to its limit and therefore, became inadequate to response to the 'crisis' (Hume, 2001; Abaje, 2010).

The 1980s was a decade characterized by more severe and more persistent droughts than the 1970s. Moderate to severe drought covered the area in 1981 to 1987. However, the drought of 1984 was the peak of the 1980s drought which was also more severe than the driest year of the 1970s. Yet, it made relatively less damage as the economics and the

societies of the Sahelian region had, by mid- 1980s, developed more appropriate adaptive mechanisms to tackle such extreme situations (Battebury, 2001).

The 1990s experienced moderate to severe droughts. Although, extreme northern part of the area study around Kaita and Jibia LGAs had near normal moisture condition in the first half of the 1990s. Contrarily, the same extreme northern part of the area experienced moderate drought in 1995, 1997, 1999 and severe drought in1992 and 1996.

The study area during the period 2000 to 2010 had experienced near normal to vary wet conditions except some isolated mild and moderate droughts.

Generally, Katsina and its environs were plagued by larger extent of moderate to severe drought since the beginning of 1970s to the end of 1990s. However, drought in 1980s became more severe than any other decade in the study period. The late 2000s on the other hand had witnessed decreasing number of drought episodes in the study area. The recent decrease in the frequency of drought occurrence in the area particularly, the last decade may be due to apparent increase of wet condition, increasing awareness to the causes and effects of drought; increase in farmers adaptive capacity and high level commitment from international governmental and nongovernmental organizations such as Intergovernmental Panel on Climate Change (IPCC); United Nations Environment Programme (UNEP); KTARDA ZONE 1 AJIWA, EEC, Katsina State etc.

Table 4.2.1 Drought Intensities, Years of Occurrence and Percentage in Katsina and Its Environs Using NRI

Drought Intensity	Drought Years	Frequency of Occurrence	Percentage of Total Occurrence
Mild drought	1971, 1972, 1982 and 2009	4 years	30.77
Moderate drought	1973, 1983, 1995, 1997, 1999	5 years	38.46
Severe drought	1984,1987, 1992 and1996	4 years	30.77
Total		**13years**	**100.00**

Source: Field survey, 2012

The most dominant drought intensity in this station was moderate drought with 5 years occurrences representing 38.46% of total drought occurrences during the period of the study. The least occurred intensities were mild and severe drought with years representing 30.77% each. The 13 years of all drought intensities occurrence represents about (32.50%) of study period (40 years) for this station.

4.3 Demographic Characteristics of Respondents

Farmers' characteristics play a vital role in their agricultural practices. Generally, farmers' characteristics such as age, gender of the farmers, level of education and years of farming experience are considered to have differential impacts on adaptation options and decisions. These are vividly discussed below.

Table 4.3.1 Age of the Respondents

Age	Number of Respondents	Percentage (%)
Less than 20 years	80	22.2
21-30 years	91	25.2
31-40 years	98	27.1
41-50 years	52	14.4
Above 50years	40	11.1
Total	**361**	**100**

Source: Field Survey, 2012.

The table 4.3.1 shows that 22.2 percent (80 farmers) are less than 20 years; 25.2 percent (91 farmers) are within the age range of 21-30 years; 27.1 percent (98 farmers) are within the age range of 31-40 years; 14.4 percent (52 farmers) are within the age range of 41-50 years; 11.1 percent (40 farmers) are above 50 years of age. This indicates that majority of the respondents that engage in farming are 'young group' who can evolve modern adaptive strategies. Thus, the time of the survey did not correspond with the time when the younger people migrate to the urban centers for alternative job.

Table 4.3.2 Gender of the Respondents

Gender	Number of Respondents	Percentage
Male	288	79.8
Female	73	20.2
Total	**361**	**100**

Source: Field Survey, 2012.

Table 4.3.2 shows that 79.8 percent (288 farmers) are Male while, 20.2 percent (73 farmers) are female. This indicates that majority of the respondents are male who have strength to farm. However, the predominance of the male farmers can also be attributed to cultural values of the community. The participation of women in decision- making regarding climate policy- mitigation and adaptation- and its implementation in instruments and measures is very low. Thus, in general it is men's perspective which is taken into account in planning processes Genanet (2007).

Table 4.3.3 Marital Status of the Respondents

Status	Number of Respondents	Percentage
Married	212	58.7
Single	130	36.0
Divorce	9	2.5
Widow	10	2.8
Total	**361**	**100**

Source: Field Survey, 2012

Table 4.3.3 shows that 58.7 percent (212 farmers) are married; 36.0 percent (130 farmers) are single; 2.5 percent (9 farmers) are divorce; 2.8 percent (10 farmers) are widow. This implies that majority of the respondents were married. Thus, the predominance of married couples amongst the respondents is because most of them were above 30 years of age. Meanwhile, the recent increase in wet condition and the consequent decrease in drought occurrence as reported by Ati *et al* (2008 & 2009) are the main factors that favour marital relationship to the extent that many monogamous couples have change to polygamous couples.

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Table 4.3.4 Educational Qualification of the Respondents

Qualification	Number of Respondents	Percentage
Primary	35	9.7
Secondary	136	37.8
Tertiary	105	29.1
Quranic	85	23.5
Total	**361**	**100**

Source: Field Survey, 2012

Table 4.3.4 shows that 9.7 percent (35 farmers) obtained Primary Education; 37.8 percent (136 farmers) have Secondary Education; 29.1 percent (105 farmers) have tertiary Education; 23.5percent (85 farmers) have Qur'anic Education; this implies that significant percentage of the respondents are educated.

Table 4.3.5 Duration of Residency in the Area

Duration	Number of Respondents	Percentage
1-5years	87	24.1
6-10years	74	20.5
11-15years	57	15.9
16-20years	53	14.7
Above 20years	90	24.9
Total	**361**	**100**

Source: Field Survey, 2012

Table 4.3.5 shows that 24.1 percent (87 farmers) have been in the area for 1-5years; 20.5 percent (74 farmers) have live in the area for 6-10 years; 15.9 percent (57 farmers) have live in the area for 11-15years; 14.7 percent (53 farmers) have live in the area for 16-20 years; 24.9 percent (90 farmers) have been in the area for above 20 years. Farmers who live in the area for above 20 years were sampled. The reason for this decision is that those within the age bracket have the information needed about drought. This is in agreement with the findings of Gashua (1991) that the greater the experience of a farmer the higher the chances of knowing the techniques used in adapting with drought.

Table 4.3.6 Duration of Farming

Duration	Number of Respondents	Percentage
1-5years	83	22.9
6-10years	85	23.5
11-15years	40	11.5
16-20years	44	12.2
Above 20years	109	30.2
Total	**361**	**100**

Source: Field Survey, 2012.

Table 4.3.6 shows that 22.9 percent (83 farmers) have been farming for 1-5 years; 23.5 percent (85 farmers) for 6-10 years; 11.5 percent (40 farmers) for 11-15 years; 12.2 percent (44 farmers) for 16-20 years; 30.2 percent (109 farmers) for above 20 years. This implies that majority of the respondents' falls within farming duration of 20 years and above. This is because those who spend many years in farming have more experience with drought incidence and the traditional adaptation methods.

4.4 Agricultural Practices

The practices or techniques used by the farmers contribute to the adaptation options and decisions in the area as presented below.

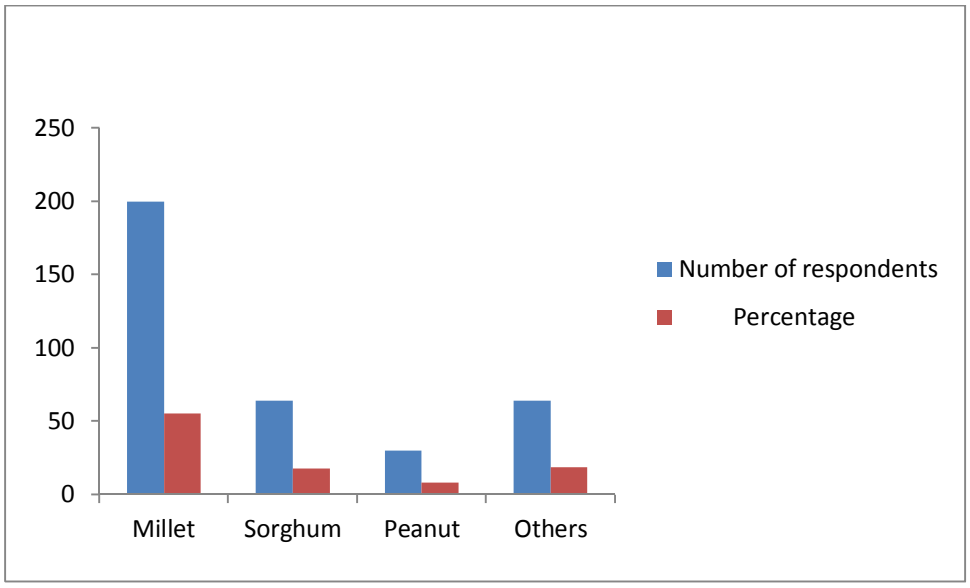


Figure 4.3 Types of Crops Cultivated
Source: Field Survey, 2012

Figure 4.3 shows that 55.4 percent (200 farmers) cultivate millet; 17 .7 percent (64 farmers) Sorghum; 8.3 percent (30 farmers) cultivates peanut; 18.6 percent (67 farmers) others. From the above, millet farmers have the highest population. This is because millet crop is strongly resistant to drought, it requires little effort and maintenance, with high yield compared to others. This result is in agreement with the findings of Yamusa *et al* (2011) that through the years, short duration (100-105 days) and drought tolerant local varieties of sorghum have been screened and adopted by farmers with the help of the ADPs, especially in Kano State.

Table 4.4.1 Type of Farmer

Type of Farmer	Number of Respondents	Percentage
Commercial	130	36.0
Subsistence	101	27.9
Both	130	36.0
Total	**361**	**100**

Source: Field Survey, 2012.

Table 4.4.1 shows that 36.0 percent (130 farmers) are commercial farmers; 27.9 percent (101 farmers) are subsistent farmers; 36.0 percent (130 farmers) are both commercial and subsistent farmers. This indicates that majority of the farmers in the area are both commercial and subsistent farmers. This could be attributed to increase adaptive capacity of the farmers in the area.

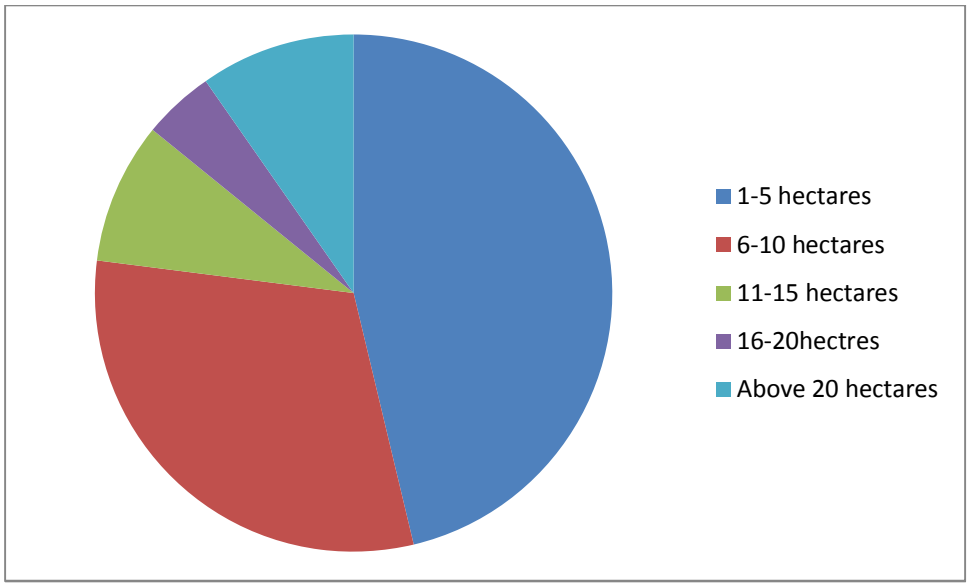


Fig. 4.4 Farm Size
Source: Field survey, 2012.

Fig.4.4 shows that 46.3 percent(167 farmers) cultivate 1-5 hectres; 30.7 percent (111 farmers) cultivate 6-10 hectres; 8.9 percent (32 farmers) cultivate 11-15 hectres; 4.4 percent (16 farmers) cultivate16-20 hectres; 9.7 percent (35 farmers) cultivate above 20 hectres. This implies that farm sizes increases. This may be due to socio economic status of the farmers.

Table 4.4.2 Is Annual Harvest Increasing or Decreasing?

Condition	Number of Respondents	Percentage
Increasing	182	50.4
Decreasing	179	49.6
Total	**361**	**100**

Source: Field Survey, 2012

Table 4.4.2 shows that 50.4 percent (182 farmers) stated that their annual harvest is increasing. While, 49.6 percent (179 farmers) stated that their annual harvest is decreasing. The respondents were able to give reasons for the increasing annual harvest, as shown in figure 4.5.

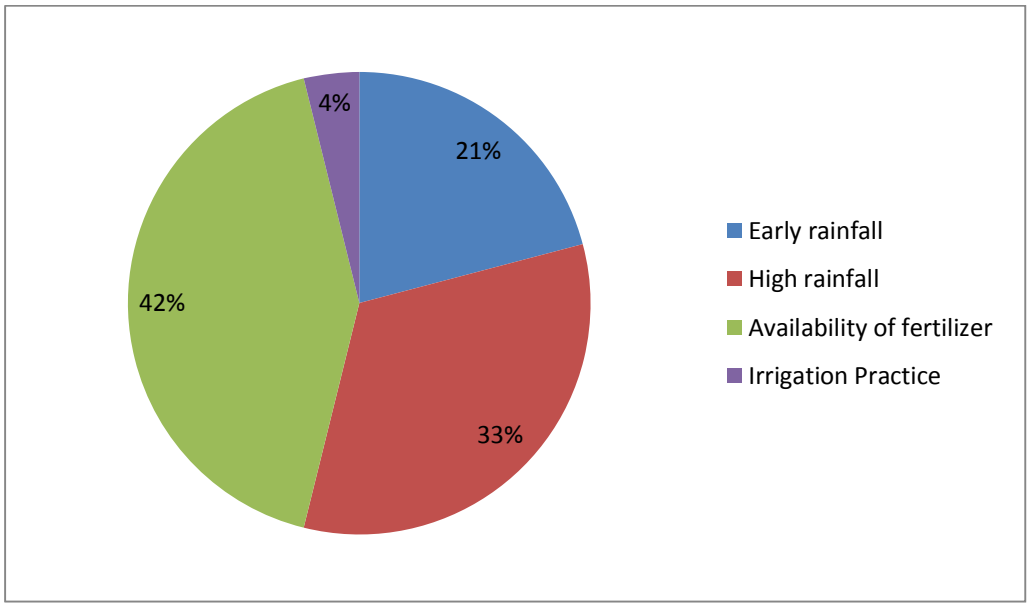


Fig.4.5 Reasons for Increasing Annual Harvest
Source: Field Survey, 2012.

From Fig.4.5, it can be observed that where 20.9 percent (38 farmers) attributed the increasing yield to early rainfall; 33 percent (60 farmers) attributed it to high rainfall; 42 percent (77 farmers) related the incidence to availability of fertilizer; 3.8 percent (7 farmers) attributed it to irrigation practices etc. Therefore, the increased agricultural productivity in the area can be attributed to increased rainfall and availability of fertilizer. This finding is in agreement with the observation made by Abaje, Ati and Iguisi (2012a&b) that the Sudano-Sahelian Ecological Zone of Nigeria has been experiencing decreasing number of drought occurrences and consequently increasing wetness over the recent years.

Table 4.4.3 Average Bag of Crops Harvested

Bags	Number of Respondents	Percentage
1-5 bags	88	24.4
6-10 bags	82	22.7
11-15 bags	49	13.5
16-20 bags	49	13.5
Above 20 bags	93	25.8
Total	**361**	**100**

Source: Field Survey, 2012.

Table 4.4.3 shows that 24.4 percent (88 farmers) harvest between 1-5 bags of grains annually on the same piece of land; 22.7 percent (82 farmers) harvest between 5-10 bags; 13.5 percent (49 farmers) harvest between 11-15 bags; 13.5 percent (49 farmers) harvest between 16-20 bags; 25.8 percent (93 farmers) harvest 20 bags and above annually. This indicates that average bags of crops harvest increases and this can be attributed to high rainfall, increase in farm size and availability of fertilizers.

4.5 Farmers Awareness of Drought

Adaptation to drought requires that farmers need to be fully aware of the causes and socio-economic effects of drought and committed to identifying and implementing useful adaptation options to help reduce farmers suffering. These were presented below.

Table 4.5.1 Awareness of Drought

Awareness	Number of Respondents	Percentage
Yes	286	79.2
No	75	20.8
Total	**361**	**100**

Source: Field Survey, 2012

Table 4.5.1 shows that 79.2 percent (286 farmers) stated that they are aware of drought incidence. While, 20.8 percent (75 farmers) stated that they are not aware of drought

episodes. As for those that are aware of drought incidence they were able to state sources of their information as indicated in Figure 4.6.

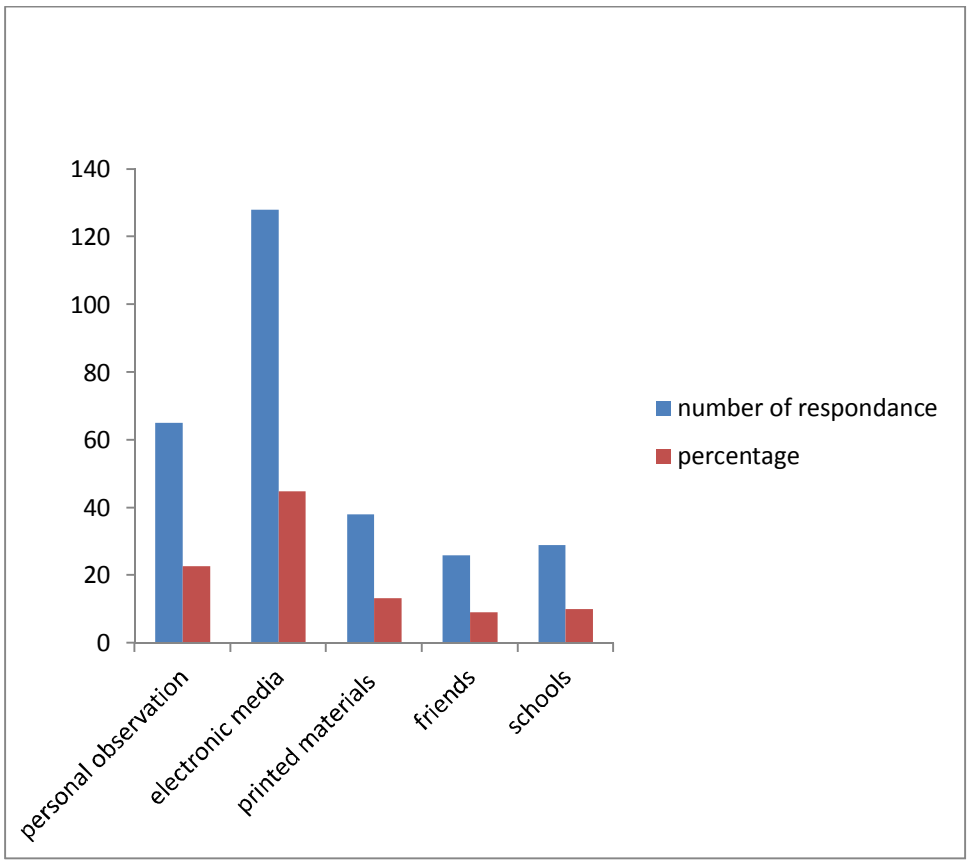


Fig. 4.6 Farmers Source of Information on Drought
Source: Field Survey, 2012.

From Fig. 4.6, it can be observed that 22.7 percent (65 farmers) stated that they obtained their information on drought episodes through personal observation; 44.8 percent (128 farmers) obtained their information through electronic media; 13.3 percent (38 farmers) through printed materials; 9.1 percent (26 farmers) through friends and 10.1 percent (29 farmers) through school.

The media plays an important role in improving the "disaster reduction consciousness" of the general population and disseminating early warnings. In many cases, the media is the

primary means of communication between policy makers, practitioners, and the public. In this regard, the media carries a great responsibility to serve the needs of their audiences, and policy makers and practitioners are tasked with improving ways to formulate messages that are "newsworthy" and attract the media UN/ISDR (2007)

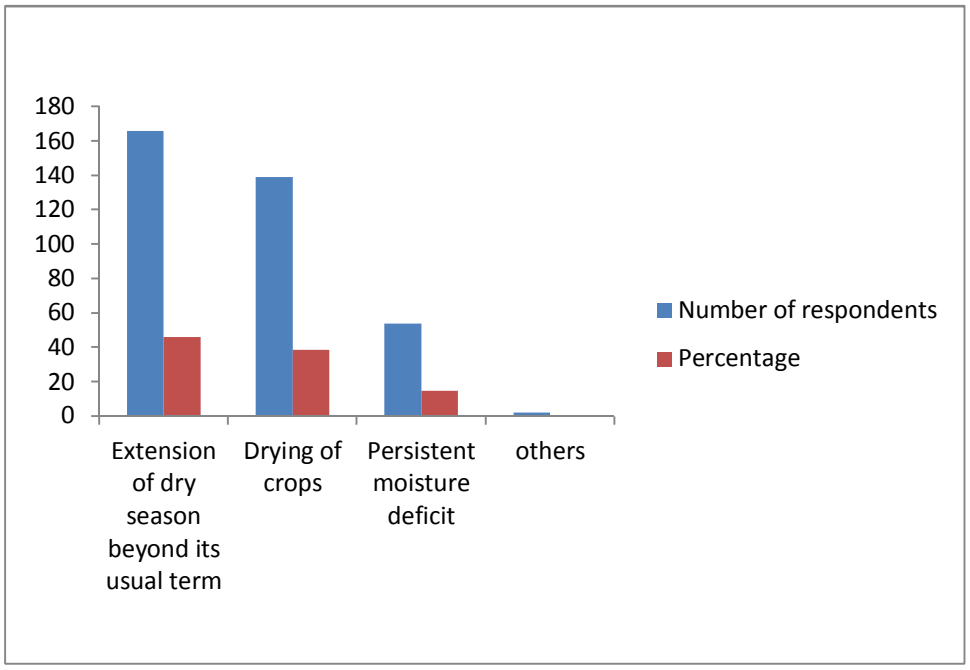


Fig.4.7 What do you consider as Drought?
Source: Field Survey, 2012.

Figure 4.7 shows that 45.9 percent (166 farmers) believe that drought is extension of dry season; 38.5 percent (139 farmers) believe that drought is drying of crops; 14.9 percent (54 farmers) stated that drought is drought is persistent moisture deficit; 0.6 percent (2 farmers) others. This indicates that majority of the respondents believed that drought is extension of dry season beyond its usual term. This may be as a result of the extension of dry condition beyond a period – a season, a year, or several years – of deficient rainfall relative to the long- term average rainfall for the area.

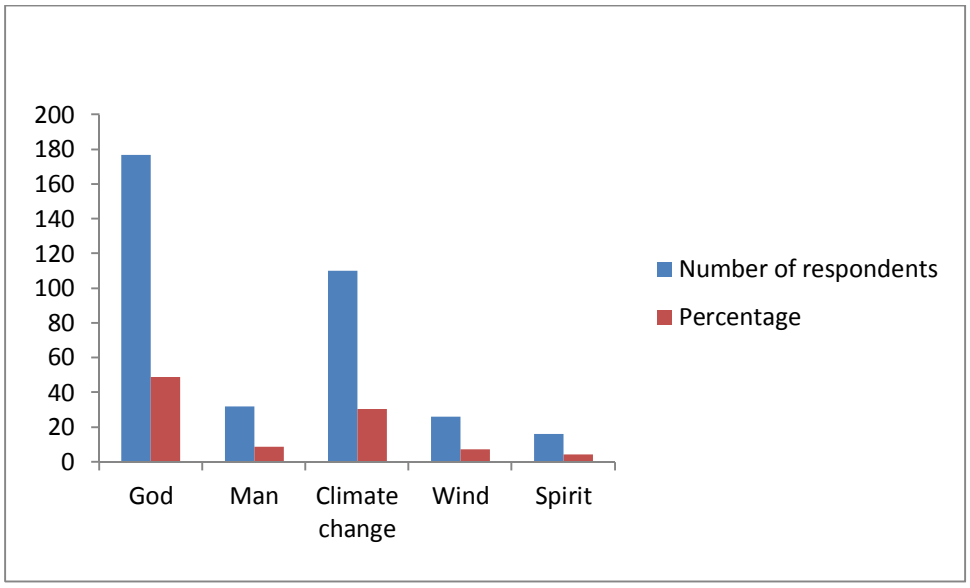


Fig. 4.8 Causes of Drought
Source: Field Survey, 2012.

Figure 4.8 shows that 49.0 percent (177 farmers) believed that drought is caused by God; 8.9 percent (32 farmers) stated that drought is caused by man; 30.5 percent (110 farmers) attested that its caused by climate change; 7.2 percent (26 farmers) attributed drought to winds blowing from Niger republic especially in June and July which 'blow-off' the rains. Therefore, it's the wind that disperses the clouds and rain. 4.4 percent (16 farmers) related drought to spirits. However, this implies that majority of the respondents are of the perception that drought is act of God. This is because Katsina farmers are predominantly religious one and therefore perceived occurrence of drought within the realm of divine power. This corresponds with the perception of Bade farmers in Borno state that occurrence of drought is to the will of God as reported by Gashua (1991).

Table 4.5.2 Drought Incidence

Materials	A	D	U	Total
Rainfall Onset and Ceasation is Abrupt.	153 (42%)	70 (19%)	138 (38%)	361(100%)
Number of Rainy Days/Months/Years is Reducing.	152 (42%)	78 (21%)	131(36%)	361(100%)
Rainfall Amount increases Compared to the Past Ten Years.	160 (44%)	97 (26%)	104(28%)	361(100%)

Source: Field Survey, 2012

Where:

A= Agreed

D=Disagreed

U= Undecided

Table 4.5.2 indicates that 42 percent (153 farmers) agreed that rainfall onset and ceasation is abrupt, 70 percent (19 farmers) disagreed and 138 percent (38 farmers) did not decide any more. This implies that majority of the farmers agreed that rainfall onset and ceasation is abrupt .This is in agreement with the findings of Oladipo *et al* (1991) that rains comes and cease abruptly as such Katsina farmers suffered from drought.

The result also indicates that 42 percent (152 farmers) believed that number of rainy days is decreasing, 21 percent (78 farmers) disagreed while, 36 percent (131 farmers) did not decide any more. This implies that most of the farmers believed that number of rainy days is decreasing. This result is in agreement with the findings of Ati (2006) that the number of wet days is on the decrease while the number of dry days is on the increase in the study area. This implies that Increase rainfall is decreasing number of rain day means higher rainfall amount per storm and hence higher intensity.

The result also indicates that 44 percent (160 farmers) agreed that rainfall amount increases compared to the past ten years, 26 percent (97 farmers) disagreed while 28 percent (104 farmers) did not decide any more. This implies that majority of the farmers agreed that rainfall amount increases compared to the past ten years. This result corresponds with the findings of Abaje *et al*. (2012b) that recent trends of annual rainfall have been that of high intensity from the year 2000 to date.

Table 4.5.3 Can you Predict Drought?

Drought Prediction	Number of Respondents	Percentage
Yes	58	16.1
No	303	83.9
Total	**361**	**100**

Source: Field Survey, 2012

Table 4.5.3 shows that 16.1 percent (58 farmers) stated that drought can be predicted while, 83.9 percent (303 farmers) stated that drought cannot be predicted. As for those who can predict drought 8.6 percent (5 farmers) stated that soil erosion signifies drought; 43.1 percent (25 farmers) believed that drying of crops signifies drought; 31.0 percent (18 farmers) said when there is decrease in the amount of rainfall; 5.2 percent (3 farmers) said when there is strong wind blow especially in June and July is a sign of droughty season; 12.1 percent (7 farmers) said when there is delay in rainfall onset. This implies that majority of the respondents can predict drought whenever there is frequent drying of crops. This is similar to the views of Gubio, Mobbar and Kukawa LGAs farmers in Borno State that drying up of crops/plants signifies drought as reported by Jajere (2006).

Table 4.5.4 Occurrence of Drought goes through a Definite Circle

Drought occurrence	Number of respondents	Percentage
Yes	138	38.2
No	228	61.8
Total	**361**	**100**

Source: Field Survey, 2012.

Table 4.5.4 shows that 38.2 percent (138 farmers) believed that drought occurrence goes through a definite circle while, 61.8 percent (223 farmers) did not. As for those that attested, 50.7 percent (70 farmers) believed that drought repeats at the interval of two consecutive years. 6.5 percent (9 farmers) said at interval of 5 years; 39.1 percent (54 farmers) stated that after every 10 years; 3.6 percent (5 farmers) others. It can therefore be observed that majority of the respondents believed that drought circle repeats at decadal interval. This opinion corresponds with the findings of Abaje (2010) that 1970s, 1980s, and 1990s are decades of consecutive years of great droughts.

Table 4.5.5 If Warning were to be that Drought is Occurring what will you do?

Drought warning	Number of Respondents	Percentage
Stop farming	31	8.6
Prayer	21	5.8
Planting Drought resistant variety	39	10.8
Delay farming	37	10.2
Early farming	35	9.6
Irrigation Practice	21	5.8
Cross-ridging	21	5.8
Change occupation to trading	23	6.4
Store food	16	4.4
Others	87	24.1
Sell of asset	30	8.3
Total	**361**	**100**

Source: Field Survey, 2012.

From table 4.5.5 , it could be observed that 8.6 percent (31 farmers) stated that they will stop farming; 5.8 percent (21 farmers) said that they will observe prayer; 10.8 percent (39 farmers) attested that they will plant resistant variety of crops; 10.2 percent (37 farmers)

stated that they will delay farming; 9.6 percent (35 farmers) will adopt early farming; 5.8 percent (21 farmers) will embark on irrigation farming; 5.8 percent (21farmers) will make cross- ridging; 6.4 percent (23 farmers) said that they will change occupation to trading; 4.4 percent (16 farmers) attested that they will store food; 8.3 percent (30 farmers) will sell their assets; 24.1 percent (87 farmers) others. The implication of drought warning to the farmers is to enable the farmers adjust in many ways. This is in agreement with the findings of Oladipo (1991) that rural people respond in a variety of ways to the hazards of drought by liquidating accumulated assets such as livestock and personal assets; Finding alternative employment. For example, firewood selling, trading and weaving etc.

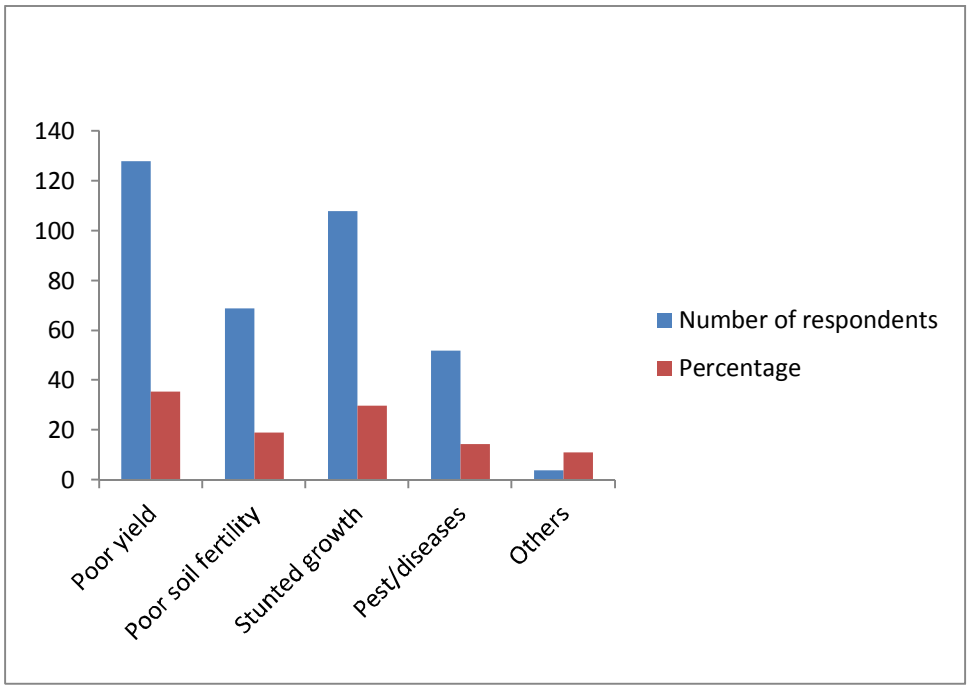


Fig. 4.9 Effects of Drought on Farming Activities
Source: Field survey, 2012.

Figure 4.9 shows that drought caused poor yield, 19.1 percent (69 farmers) mentioned that drought leads to poor soil fertility; 29.9 percent (108 farmers) observed that drought leads

to stunted growth; 14.4 percent (52 farmers) said that it brings pest/diseases; 11.1 percent (4 farmers) others. Therefore, significant percentage of the respondents mentioned that drought leads to stunted growth of the crops. This is because the inability of rainfall to meet the Evapo-transpiration demands of crops result in general water stress crop failures. This is in agreement with the findings of Yamusa *et al* (2011) that the poor crop yields or total crop failure due to drought result in mass poverty and starvation as agriculture is the mainstay of Nigeria's rural economy.

Table 4.5.6 Can drought influence your yearly income?

Effects of Drought	Number of respondents	Percentage
Yes	270	74.8
No	91	25.2
Total	**361**	**100**

Source: Field Survey, 2012

Table 4.5.6 shows that 74.8 percent (270 farmers) attested that drought influences their early income while, 25.2 percent (91 farmers) did not. As for those that attested for the socio-economic implications of drought, 26.3 percent (71 farmers) stated that drought leads to high rate of poverty; 64.1 percent (173 farmers) believed that it causes high food price; 9.6 percent (26 farmers) observed that it increases transport cost. However, this indicates that majority of the respondents attested that drought leads to high food price due to food shortages. This result is also in agreement with the findings of Yamusa *et al (*2011) that the poor households that are affected by drought and desertification do not have adequate resources to deal with food shortages leading to food insecurity and hunger that affects millions of people.

4.6 Adaptation Strategies to Drought

The basic understanding in the context of drought adaptation among Katsina farmers will include the adoption of efficient drought management practices as presented below.

Table 4.6.1 Is Drought Preventable?

Drought Prevention	Number of respondents	Percentage
Yes	203	56.2
No	158	43.8
Total	**361**	**100**

Source: Field Survey, 2012

Table 4.6.1 shows that 56.2 percent (203 farmers) attested that drought is preventable. While, 43.8 percent (158 farmers) believed that drought cannot be prevented. Similarly, 45.3 percent (92 farmers) stated that drought can be prevented by prayer; 17.7 percent (36 farmers) said by preventing sinful act; 36.9 percent (75 farmers) believed by growing more trees in the farm. This indicates that majority of the respondents are of the view that drought can only be prevented by observing prayers this is because sinful acts are so rampant these days thus inviting the wrath of God in the form of drought.

Table 4.6.2 Farmers Adaptation Strategies to Drought

Adaptive strategy	Number of respondents	Percentage
Yes	225	62.3
No	136	37.7
Total	**361**	**100**

Source: Field Survey, 2012.

Table 4.6.2 shows that 62.3 percent (225 farmers) attested that they were to able to adopt various adaptation strategy to drought, while, 37.7 percent (136 farmers) have not been able to adopt any strategy. As for those that could adopt strategies, 33.3 percent (75 farmers) stated that they plant drought resistant varieties and early maturing varieties of crops, 23.6 percent (53 farmers) mentioned that they perform cross-ridging, 27.6 percent (62 farmers)

adopt irrigation practices, 15.6 percent (35 farmers) delay farm clearance till mid of rainy season. This implies that majority of the respondents can curb drought by planting drought resistant variety and early maturing variety. This result is in agreement with the findings of Yamusa *et al* (2011) that predominant crops grown in the drought-prone region of Nigeria include cowpea, sorghum, millet, groundnut and lately maize in various mixtures. In drought areas which are characterized by erratic and unreliable rainfall in the beginning and towards the end of the season, the importance of drought tolerant crop varieties as well as early maturing varieties that could escape terminal drought cannot be overstated.

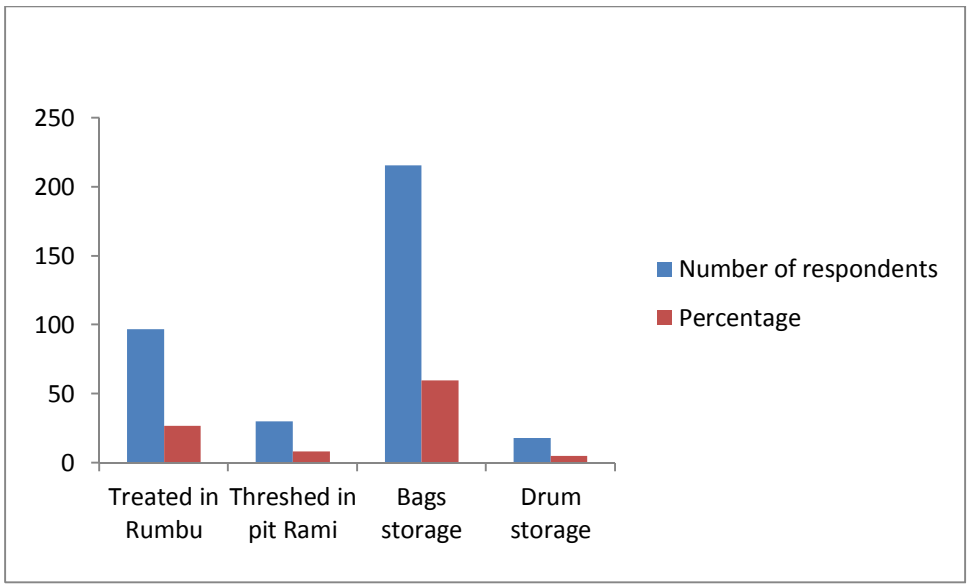


Fig.4.10 Storage of Harvest Crops
Source: Field Survey, 2013

Figure 4.10 shows that 26.9 percent (97 farmers) store harvest crops in treated Rumbu; 8.3 percent (30 farmers) threshed in pit Rami; 59.8 percent (216 farmers) use bag storage; 4.9 percent (18 farmers) drum storage. This implies that majority of the respondents store harvest crops by means of bags. This may be due to its availability and convenience. This is in agreement with the findings of IITA (2010) that in the survey carried out in 2010 in the

Jigawa, Kano, and Katsina States. Purdue Improved Cowpea Storage (i.e. PICS bags) was used. Survey results show that a relatively high number of farmers (both • demonstrators and non demonstrators) was reusing their PICS bags for cowpea storage (66.2%) in 2009, i.e., 90 out of the 136 respondents.

Tables 4.6.3 Visit by Extension Worker

Visit by extension worker	Number of respondents	Percentage
Yes	94	62.3
No	267	37.7
Total	**361**	**100**

Source: Field Survey, 2012

Table 4.6.3 above shows that 26.0 percent (94 farmers) attested that they were ever visited by extension worker, while, 73.9 percent (267 farmers) were not ever visited. As for those that were ever visited 6.4 percent (6 farmers) were visited by the agricultural extension club; 17.0 percent (16 farmers) were visited by young agricultural club organization; 6.4 percent (6 farmers) by the Agricultural Development project (ADP) ; 7.4 percent (7 farmers) by EEC Katsina State; 20.2 percent (19 farmers) by KTARDA ZONE I- AJIWA; 3.2 percent (3 farmers) by Fadama III; 15.9 percent (15 farmers) by Katsina State Farmers Association; 6.4 percent (6 farmers) by IFAD; 9.6 percent (9 farmers) by Katsina State extension workers; 7.4 percent (7 farmers) were visited by FARMA SUPPLY.

This implies that government of Nigeria and a number of civil organizations have embark upon development of Nigeria to minimize risk, improve local and national adaptive capacity and resilience, leverage new opportunities and facilitate collaboration with global community, all with a view to reducing Nigeria's vulnerability to the negative impact of drought BNRCC (2011).

Table 4.6.4 Discussion of Drought issues with Extension Workers

Discussion of Drought Issues	Number of respondents	Percentage
Yes	119	32.9
No	242	67.0
Total	**361**	**100**

Source: Field Survey, 2012.

Table 4.6.4 shows that 32.9 percent (119 farmers) confirmed that they have ever discussed drought issues with extension worker, while, 67.0 percent (242 farmers) have never discuss it with anyone. As for those that discussed it, 10.1 percent (12 farmers) were advised to use mixed-cropping method; 10.9 percent (13 farmers) were advised to delay farm clearance till mid of rainy season; 24.4 percent (29 farmers) were advised to plant more trees; 14.3 percent(17 farmers) were advised to adopt irrigation method; 19.3 percent (23 farmers) were advised to plant drought resistant variety of crops; 10.1 percent (12 farmers) were advised to grow early maturing seeds; 6.7 percent (18 farmers) were advised to use cross-ridging method; 4.2 percent (5 farmers) were advised to observe prayer. This implies that majority of the respondents that discussed drought issues with extension workers were advised to plant more trees in the farms. This enhances soil moisture and soil fertility, and reduces soil losses. This is in agreement with the findings of UNEP (2006) that the role of trees in improving microclimate, reducing soil erosion, generating income and enhancing soil fertility will be more important in the advent of drought.

Tables 4.6.5 Do you know any Drought Agency?

Drought agency	Number of respondents	Percentage
Yes	165	45.7
No	196	54.3
Total	**361**	**100**

Source: Field Survey, 2012.

Table 4.6.5 shows that 45.7 percent (165 farmers) attested that they know drought agencies while, 54.3 percent (196 farmers) did not know. As for those that know governmental drought agencies, 20 percent (33 farmers) stated that they did not get any assistance from them; 16.4 percent (27 farmers) said that they have enjoyed food relief; 48.5 percent (80 farmers) confirmed that they were given seeds for the next planting season; 15.2 percent (25 farmers) reported that they received credit from the government. Majority of the respondents indicates that they received variety of seeds from governmental drought agency to curb drought. Example of such agencies include: Agricultural Development Agency (ADP), EEC Katsina State, Permanent Inter-state Committee for Drought Control (CILLIS) and State Environmental Agencies (SEPAS).

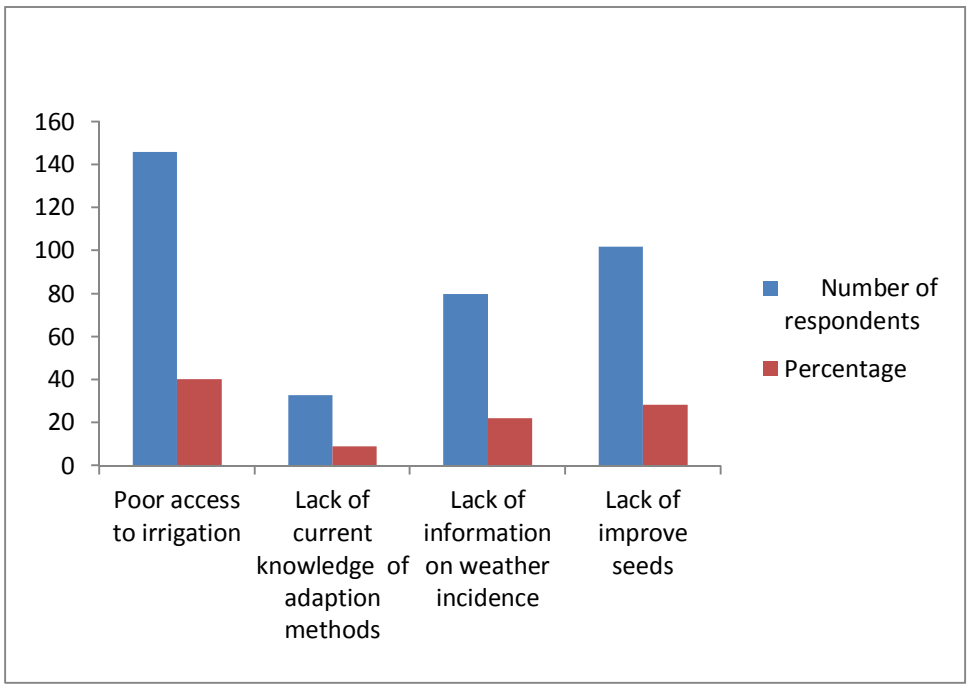


Fig.4.11 Barriers to Drought Adaptation

Source: Field Survey, 2012.

From Fig. 4.11, it can be observed that 40.4 percent (146 farmers) perceived lack of access to irrigation; 9.1 percent (33 farmers) did not know current adaptation methods; 22.2 percent (80 farmers) perceived ignorance of weather incidence; 28.3 percent (102 farmers) perceived lack improved seeds.

However, majority of the respondents indicates that poor access to irrigation has been the major barrier to drought adaptation in the area. this result is in agreement with the findings of Othman *et al* (2010) and Abubakar (2008) that the overall performance of the major public irrigation schemes in Northern Nigeria was reported to be generally poor due to lack of proper maintenance, unreliable water delivery as well as technical deficiency in the infrastructure. They reported that the major problems of irrigation in Nigeria to include poor operation and maintenance of infrastructure, problems of water logging and salinity, inadequate funding to irrigation, poor water management at farmers field and apathy to maintenance by some farmers, problem of energy to drive water pumps, Problems of pests, disease and weeds, water-borne and water-related diseases, lack of credit to farmers and insufficient external support such as markets and extension. These problems have to be addressed in order to effectively use irrigation to reduce risk of drought in Nigeria.

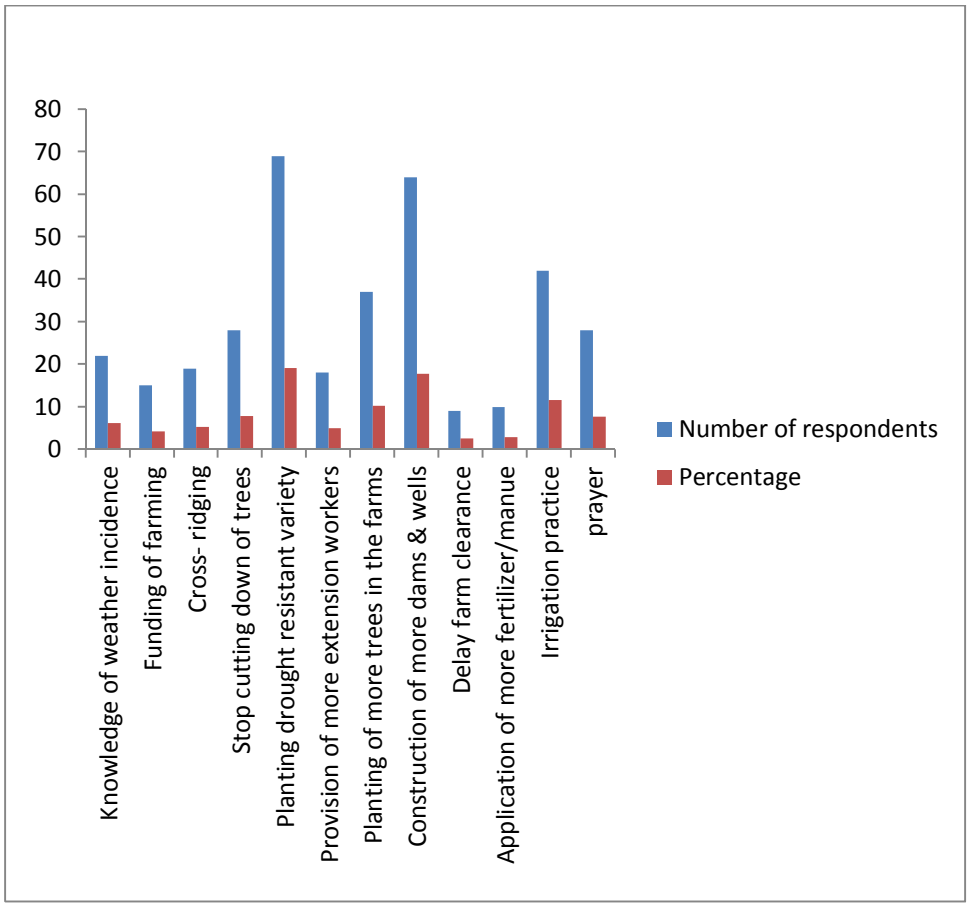


Fig.4.12 Adaptive Strategies Recommended by farmers to enhance fight against Drought
Source: Field Survey, 2012.

From Fig.4.12, 6.1 percent (22 farmers) suggested for knowledge of weather incidence; 4.2 percent (15 farmers) recommended funding of farming; 5.3percent (19 farmers) advised farmers to practice cross-ridging; 7.8 percent (28 farmers) observed that cutting down of trees should be stopped; 10.2 percent (37 farmers) recommended planting of more trees in the farms. 19.1 percent (69 farmers) recommended planting of drought resistant variety of crops; 4.9 percent (18 farmers) recommended provision of more extension workers; 10.2 percent (37 farmers) recommended planting of more trees; 17.7 percent (64 farmers) recommended construction of more dams and wells; 2.5 percent (9 farmers) recommended

delay farm clearance; 2.8 percent (10 farmers) recommended application of fertilizer/ manure. 11.6 percent (42 farmers) recommended provision of modern machines for irrigation practice. 7.6 percent (28 farmers) recommended prayers. This implies that majority of the farmers believed that planting of drought resistant variety of crops is the most important measure that will enhance the fight against drought in the area. This may be as a result of its strong resistance to drought and require little effort for maintenance.

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 **Summary**

Drought is a climatic anomaly. However, when it does occur, it generally affects a broad region for seasons or years at a time. This can result in a large proportion of the population being affected by drought than by other disasters. One of the sectors where immediate impact of drought is felt is agriculture. With the increase intensity or extended duration of drought prevalence, a significant fall in food production is often noticed especially in areas rain fed agriculture is the main stay of the rural economy. One of the most important climate-related disasters which climate change is set to exacerbate in Katsina and its environs is agricultural drought the phenomenon being attributed to occurrence of long-term rainless period.

The study focused on analyzing the farmers' adaptation strategies to drought in Katsina and its environs. In order to achieve this total of 385 open and close ended questionnaire were administered in the field survey to the respondents. The questionnaire also assessed farmers' awareness to drought, socio-economic implications and adaptation strategies to drought in the study area.

Rainfall data from 1971 to 2010 obtained from the Nigerian Meteorological Agency (NIMET) Katsina, was subjected to linear trend analysis for rainfall characteristics. The meteorological drought index (NRI) was used in depicting periods of different drought intensities in the study area. The 13 years of all drought intensities occurrence represents about (32.50%) of study period (40 years) for this station.

The result of monthly linear trend lines revealed that there is a significant decrease in rainfall amount in the month of June, little change in the month of July and substantial increase in the months of August and September. However, going by the rainfall characteristics of the area, the length of rainy season and the annual rainfall are consistent. Consequently, affecting crop yield by affecting the cultivation processes such as land preparation, clearing, planting weeding harvesting etc.

The result also revealed that, the annual rainfall indicates an increase of approximately 72.40 mm at the rate of 1.81mm $year^{-1}$. Compared with the long-term average total, the increase in the annual rainfall yield is predominantly as a result of the increase in August, and September, rainfall. Meanwhile, presently there is decrease in frequency of drought occurrence in the study area due to apparent increase in wet condition.

The five- year moving mean indicates that below average rainfall was experienced from early 1970s to 1990s. This implies that years with lowest rainfall amount in the station coincide with the periods of drought in the area.

Investigation revealed that moderate to severe drought was experienced in 1970s to 1990s with the peak in 1984. However, the last decade (2000s) has been witnessing decreasing number of drought occurrences due to apparent increase in wet condition and increasing farmers' adaptive capacity.

The result also revealed that farmers awareness of the causes and effects of drought, extension services along with increasing wet condition are the factors that enhance adaptive capacity to drought in the study area.

The fact that farmers are well aware of drought incidence majority has taken steps to adjust their farming activities. The main adaptation strategies which the farmers employ include: planting drought resistant variety of crops (e.g millet and sorghum); cross-ridging; irrigation practices; delay farm clearance; application of fertilizer/manure; planting of more trees in the farm. The result shows that planting of drought resistant variety is the most common among others.

The result also shows that poor access to irrigation; lack of current knowledge of adaptation methods; lack of information of weather incidence; lack of improve seeds etc are the major barriers to drought adaptation in the area. However, majority of the farmers observed that poor access to irrigation has been the strongest barrier to adaptation in the area.

5.2 Conclusion

Based on the result of the linear trend analysis of the rainfall characteristics it's possible to generalized that there has been a change towards wetter condition in the study area over the recent years. This results, therefore corresponds with the fact that the study area has been tilting towards decreasing number of drought occurrence due to increasing wetness over the recent years.

Its worthy of note that length of rainy season and the cropping season are consistent. Consequently, affecting crop yield by affecting the cultivation processes such as land preparation, clearing, planting weeding harvesting etc.

The Normalized Rainfall Index was found suitable in describing drought situation in the area because of its ability to depict all the previously identified drought periods. The area was characterized by moderate to severe drought from beginning of 1970s to 1990s. There

was mild to moderate drought in 1970s which attained the highest point in 1973.The 1980s drought was more severe than any other decade in the study period and attained its peak in 1984.the first half of the 1990s had normal moisture condition and moderate to severe drought in 1992 and 1996.

The process of drought which have prevailed in the area over the last few decades, are nothing more than the embodiment of a degenerative process that started several decades back. Thus, reduced and erratic rainfall has contributed to transform the study area thereby making agriculture and livestock farming highly unproductive. Drought threatens agricultural production on the marginal lands, exacerbating poverty and undermining economic development. The impact of drought and climatic variability in both economic and mortality terms is generally larger for relatively simple and predominantly agricultural economies. The drought of 1971-72 for example reduced Agricultural contribution to GDP in Nigeria from 18.4% in 1971-72 to 7.3% in 1972-1973. The poor crop yields or total crop failure due drought result in mass poverty and starvation as agriculture is the mainstay of Nigeria's rural economy.

Drought influences water availability, which is projected to be one of the greatest constraints to economic growth in the future. Reduced annual average rainfall and its run-off would worsen drought conditions. Most of the rivers and streams in the drought prone areas shrink. The rivers contribute in recharging several dams built for irrigation and domestic water supply. This means that the area will not have sufficient water resources to maintain their current level of per capita food production from irrigated agriculture - even at high levels of irrigation efficiency - and also to meet reasonable water needs for domestic, industrial, and environmental purposes.

One of the most important effects of drought is the depletion of biodiversity. Existing fauna and flora that are not resistant to drought are likely to go extinct. The dry areas of the world are the origin of a large number of globally important cereals and food legumes, such as millet, sorghum, barley, wheat, beans and many other important crops. Drought, land degradation and desertification have had serious impact on the richness and diversity of plants and animals. Plant biodiversity will change over time, unpalatable species will dominate, and total biomass production will be reduced.

Even if rainfall has come back to near-normal and food security improved in recent years, the study area remains an environmentally sensitive region and climate change is likely to exacerbate repetition of drought circle where the immediate impact is felt is agricultural sector.

5.3 Recommendations

It's indeed a bitter reality that climatic anomaly such as drought in Katsina and its environs cannot be overcome and man cannot effect measures to reduce the menace on various sectors like agriculture. Therefore, base on the findings the following recommendations are made:

i. Farmers should learn Water harvesting techniques by constructing ridges or tied ridges with a series of small basins is a useful technology for the collection and storage of rainwater in dry areas.

ii. Farmers should adopt simple technique of cross-ridging to concentrate water and increase yield especially in drought conditions.

iii. Promote dry planting in which seeds are planted while waiting for the rains in order to make maximum use of moisture from the very unpredictable, but usually heavy, first rains.

iv. Delayed farm clearance until the middle of rainy season in order to reduce soil erosion of the exposed soils by the often heavy showers of the first rains should be encouraged.

v. Farmers should adopt improved agricultural technologies. This include adoption of new technologies, planting drought resistant and early maturing varieties especially millet, sorghum and cowpea.

vi. Farmers should promote planting of more trees in the farms. This is because of the role of trees in improving microclimate, reducing soil erosion and generating income will be more important in the advent of drought.

vii. There is a need to accelerate the adoption of simple tools, such as the labour-saving long- handled hoe (Asha- sha) which is well adapted to the light sandy soils of the area is a measure by which farmers avoid ridging before planting to reduce the rate at which top soils are wind-eroded during drought.

viii. There is an urgent need to increase the land under irrigation in the study area. Focus should be on the boring of wells, boreholes, earth dams and stock ponds also can contribute to the development of horticulture.

ix. There is the need to improve information delivery and foster the use of climate information to inform decision making, using seasonal climate forecasts to inform farmers to avoid surprises, and take right decisions in case of impending drought.

x. There is the need to invest in soil and water conservation as well as pest and disease control in the area.

xi. There is the need to integrate farmers' indigenous techniques along with technical government policies or modern technology to make drought adaptation more effective.

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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 **Farmers Adaptation Strategies to Drought in Katsina and its Environs**. Please, help fill this questionnaire and be assured that all information provided will be treated in strict confidence and used only for academic purposes.

PERSONAL BIODATA:

Please tick ( ) where appropriate

1. Age(years): a. less than 20 years ( ) b. 20-30 ( ) c. 31-40 ( ) d. 41-50 ( )
   e. above 50 ( )
2. Gender: a. Male ( ) b. Female ( )
3. Marital status: a. Married ( ) b. single ( ) c. Divorce ( ) d. widow ( )
4. Educational qualification: a. primary ( ) b. secondary ( ) c. tertiary ( )
   d. Quranic ( )
5. For how long have you been in this area? a. 1-5years ( ) b. 6-10years ( ) c.11-15years ( ) d.16-20 years ( ) above 20 years ( )

AGRICULTURAL PRACTICES

6. For how long have you been farming? a. 1-5years ( ) b. 6-10years ( ) c. 11-15years ( ) d. 16-20years ( ) e. above 20years ( )
7. What type of crops do you cultivate? a. Millet ( ) b. Sorghum ( ) c. peanut ( ) d. others…….

8. What type of farmer are you? a. Commercial ( ) b. subsistent ( ) c. both ( )
9. What is your farm size? a. 1-5 hectares ( ) b. 6-10 hectares ( ) c. 11-15 hectares ( ) d. 16-20 hectares ( ) e. above 20 hectares ( ).
10. Is your annual harvest on the same piece of land, increasing or decreasing?
    a. Increasing ( ) b. decreasing ( )
11. If increasing why? a. early rainfall ( ) b. high rainfall ( ) c. Availability of fertilizers ( ) d. others, specify ……
12. If decreasing why? a. late rainfall ( ) b. small amount of rainfall ( ) c. inadequate fertilizers ( ) d. drought ( ) e. others, specify ……
13. What are the average bags of crops have you been harvesting since you started cultivating crops in this area? a. 1-5bags ( ) b. 6-10bags ( ) c. 11-15bags ( ) d. 16-20bags ( ) e. above 20bag ( )

FARMERS PERCEPTION TO DROUGHT

14. Are you aware of drought? a. Yes ( ) b. No ( )
15. What are your sources of information? a. from personal observation ( ) b. from electronic media e.g. radio and TV ( ) c. from printed materials e.g. news papers and magazines ( ) d. from my friends ( ) e. from the school ( )
16. In your opinion, what do you consider as drought? a. extension of dry season beyond its usual term ( ) b. drying of crops ( ) c. persistence of moisture deficits condition through a series of years ( ) d. others, specify …….
17. What in your opinion causes drought? a. God ( ) b. man ( ) c. climate change ( ) d. wind ( ) e. spirit ( )

18. Rainfall onset and cessation is abrupt? a. agreed ( ) b. disagreed ( )
c. undecided ( ).

19. Number of rainy days/months/years is reducing? a. agreed ( ) b. disagreed ( )
c. undecided ( ).

20. Rainfall amount compared to the past 10years is decreasing every year? a. agreed ( )
b. disagreed ( ) c. undecided ( ).

21. Can you predict drought? Yes ( ) b. No ( )

22. If yes, how do you predict its occurrence? .....

23. Do you think occurrence of drought goes through a definite time circle? a. Yes ( )
b. No ( )

24. If yes, what is the usual periods between two (serial) droughts a. 2years ( ) b.5years c.
10years ( ) d. others, specify……

25. If a warning from the government were to be given that a drought is occurring this year
what will you do? .....

26. Are droughts preventable? A. Yes ( ) b. No ( )

27. If yes, how do we prevent drought? a. By praying ( ) b. By preventing sinful acts in
the community ( ) c. by growing more trees in the forest ( ) d. others,
specify……..

EFFECTS OF DROUGHT

28. In what ways has drought affected your farming activity? a. poor yield ( ) b. poor soil fertility ( ) c. short/stunted growth ( ) d. pests/diseases ( ) e. others, specify ……...

29. Can you say that drought influences your yearly income generation?

    a. Yes ( ) b. No ( )

30. If yes, what are the socio-economic implications on you and your household? a. high rate of poverty ( ) b. high food prices ( ) c. increase transport cost ( ) d. high rate of crime e. others, specify ……..

FARMERS ADAPTATION STRATEGIES

31. Have you been able to adopt any adaptive strategy to curb drought in your area?

    a. Yes ( ) b. No ( ).

32. If yes, what strategies have you been able to adopt to curb drought problems in your crops? a. planting drought resistant crops variety ( ) b. cross-ridging ( ) c. adopting irrigation farming ( ) d. delay farm clearance until mid of rainy season ( ) e. others, specify ……..

33. How do you store your harvest crops? a. threshed/treated in Rumbu ( ) b. threshed untreated in pits (Rami) ( ) c. bags storage ( ) d. drum storage ( ) e. others, specify ……...

34. Where you ever visited by an extension worker? a. Yes ( ) b. No ( )

35. If yes, by which organization? …….…….

36. Did you ever discuss the issue of drought with such extension worker?

    a. Yes ( ) b. No ( )

37. If yes, what method did he suggest that could help you adapt to the drought? ……

……..……..

38. Do you know any governmental drought agency? a. Yes ( ) b. No ( )
39. If yes, how did government assist you? a. I did not get any help ( ) b. They sent us food relief ( ) c. They sent us seeds for the next planting season ( ) d. We get credit from government ( ) e. others, specify …….
40. In your own opinion, what are the impediments to the use of modern techniques in mitigating drought? a. lack of improve seeds ( ) b. lack of access to water for irrigation ( ) c. lack of current knowledge on adaptation methods ( ) d. lack of information on weather incidence ( ) e. others, specify …….
41. What do you recommend to be done that will enhance the fight against drought in your area, comment freely ……..……....

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