VULNERABILITY ASSESSMENT AND ADAPTIVE STRATEGIES OF GRAIN FARMERS TO CLIMATE CHANGE IN SHINKAFI LOCAL GOVERNMENT AREA, ZAMFARA STATE, NIGERIA

BY

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A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE DECREE IN GEOGRAPHY,
DEPARTMENT OF GEOGRAPHY, FACULTY OF SCIENCE, AHMADU BELLO UNIVERSITY, ZARIA

FEBRUARY 2014

DECLARATION

I hereby declare that the work in this thesis titled ***Vulnerability Assessment and Adaptive Strategies of Grain Farmers to Climate Change in Shinkafi Local Government Area, Zamfara State, Nigeria*** was performed by me in the Department of Geography, Ahmadu Bello University-Zaria under the supervision of Dr. B. A. Sawa and Prof. E. O. Oladipo. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this work has been presented for another degree or diploma at any institution.

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10th March, 2014.
Date

CERTIFICATION

This thesis titled: ***Vulnerability Assessment and Adaptive Strategies of Grain Farmers to Climate Change in Shinkafi Local Government Area, Zamfara State, Nigeria*** carried out by Solomon Uduma NNACHI; M.Sc/SCIEN/5278/2009-2010 meets the regulations governing the award of the degree of Masters of Science in Geography, Faculty of Science, Ahmadu Bello University- Zaria, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

I dedicate this thesis work to God Almighty, maker of heaven and earth. He is my all in all - My inspiration and Helper. The Ancient of days from yonder who makes men ponder at my wonder! *I ascribe all the Glory to Him!*

ACKNOWLEDGEMENT

I am eternally grateful to God, My Father and to His Son, My Lord and Saviour, Jesus Christ, and to the Holy Ghost, My Comforter; for the gift of life and protection throughout my years of studying M.Sc. Geography in this prestigious university. *To God be the Glory!*

No research is done through the effort of one person alone and this study is no exception. I therefore wish to express my profound gratitude to my major and minor supervisors: Dr. B.A. Sawa and Prof. E. O. Oladipo who sacrificed their time to read through my bulky manuscripts untiringly and made sure it resulted in a work of scholarship, worthy of being accepted. Special thanks also go to all the other lecturers and staff of Geography Department for enlarging my academic horizons and setting my prospects aright including the former Head of Department, Prof. O. F. Ati and the former PG Coordinator - Dr. J. O. Folorunsho for their moral supports.

The efforts of the officials of Sokoto and Zamfara States Agricultural and Rural Development Authority are unreservedly appreciated. For providing me with annual rainfall and grain yield data, assisting me in my questionnaire administration including all the basic hints I needed on the agro-climatic situation of Shinkafi Local Government Area. *I say thank you!*

I am also grateful to my loving parents; Mr. and Mrs. E.U. Nnachi, for their joint support and sponsorship, my wonderful siblings; Mr. Benjamin Nnachi, Mrs. Comfort C. Umoh and Joseph (Jnr) Nnachi - for their patience, endurance, moral and spiritual support during my study period.

Mention must also be made of the membership of Deeper Life Bible Church, Zaria Region for their spiritual support and prayers. Finally, to my friends and well-wishers who have been very helpful as regards academics - to Mrs. E. O. Igbadun (Christ College Principal), Bro Kish Pius, Bro Adedayo Simon Folorunsho, Bro Elisha Ikpe, Dele Jacksolomon Mejabi, Grace Michael, Esther David Onoja; and others so numerous to mention; *God bless everyone*!

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GLOSSARY

C3 – Carbon three

C4 – Carbon four

DAC – Division of Agricultural College, ABU-Zaria

FASCO – Zamfara State Agricultural Supply Ltd

FBN – First Bank of Nigeria

IAR – Institute for Agricultural Research, ABU-Zaria

IPCC – Intergovernmental Panel of Climate Change

NACRBD – Nigerian Agricultural Cooperative and Rural Development Bank

NAERLS – National Agricultural and Educational Research Liaison Services

NIMET – Nigerian Meteorological Agency

NRI – Normalized Rainfall Index

NSPFS – National Special Programme for Food Security

SARDA – Sokoto State Agricultural and Rural Development Authority

UBA – United Bank of Africa

ZADP – Zamfara State Agricultural Development Project

ZARDA - Zamfara state Agicultural and Rural Development Authority

ABSTRACT

This study assessed the biophysical and socioeconomic vulnerabilities of climate change on grain farming and the adaptive strategies employed in combating the scourge in Shinkafi Local Government Area of Zamfara State. The results of the various statistical tests showed that the coefficients of Skewness and Kurtosis for the rainfall series from 1971-2010 was normally distributed at 95% confidence level. There was no significant trend in annual rainfall totals as against the years at the same confidence limit using the Mann Kendall's test. The five-year and ten-year running means, the 10-year non-overlapping and 20-year overlapping sub-periodic means of annual rainfall all showed lengthy dry periods below the long term mean from 1971-2001 with steady increases above the mean from the early millennium to the end of the period. The Pearson's Product Moment Correlation was also used to relate annual rainfall amounts with each of the state's prominent grain crops namely; Millet, Sorghum and Maize from 1996-2010 and this showed an imperfect but positive correlation. Biophysically, comparisons between the trends in the annual rainfall totals and pattern of grain crops; sub-periodic rainfall means and rainfall requirements for each crop and the Normalized Rainfall Index (NRI) generally revealed that climatic stress affected the outcome of grain production especially within the severe drought years of 1971 to the late 90's, in which only Millet and Sorghum gained more economic significance and wider patronage in the state due to their "drought tolerant" abilities; while Maize came into economic limelight from 2002 to 2007 due to increases in the annual rainfall tending towards flooding occurrences with great effects on yield. Furthermore, in assessing the socioeconomic vulnerability of farmers to climate change in the Study area, only a total of 169 farming respondents (due to unusable data in some of the questionnaires administered) from three systematically selected wards namely; Badarawa, Jangeru and Shinkafi were randomly selected and analyzed based on Summer (2009) school district method. In-depth interview sessions and focus group discussions with experts from the Zamfara State Agricultural and Rural Development Authority (ZARDA) were also conducted. Generally, about 50% of respondents in Shinkafi ward, 31% from Badarawa and 27% from Jangeru were unable to meet up with high food prices due to low income capacity, large family size and high poverty rates resulting to severe repercussions on their means of livelihood. Grain farmers' in the study area with the help of ZARDA have adopted traditional means of combating climatic stress such as mulching, shifting cultivation, good storage facilities, irrigation practices, use of insecticides and organic manure. However, the findings of this study recommends several modem adaptive strategies: - planting the best short duration-seed variety of grains in periods of drought, delaying the early planting of millet and sorghum in cases of accelerated rainfall increases, application of fertilizers for maize in cases of drought, crop rotation to reduce pests attack, improving rainfall data and continuous data monitoring as well as employing the best fiscal support and government policies favouring sustainable grain production.

CHAPTER ONE

INTRODUCTION

1.1 General Background to the Study

Global Climate has been envisaged and reiterated by several experts in the field of Meteorology and Climatology as constantly changing (Oladipo, 1989; Ati *et al.*, 2002; Ayoade, 2003; Sawa, 2010). Most unfortunate and alarming however, is the fact that despite all proposals and efforts made at alleviating its implications at the 17th United Nations Framework Convention on Climate change in 2011 by world leaders, the effects and impacts of this biting issue still lingers on in most parts of the globe. More so, since its advent in the nineteenth century, the climate change saga has continued to witness a growing worldwide awareness with large populated areas in most developing nations left vulnerable to the extremities and anomalies caused by these changes (Federal Ministry of Environment, 2003; *Guardian* Newspaper, September 26, 2011). Ayoade (1995) affirmed that these climatic extremes in form of floods, drought, famine and heat waves in many areas have resulted to devastating effects on human existence, crop productivity and food security, with many households affected by low economic status.

The Intergovernmental Panel for climate change (IPCC, 2007) in the Fourth Assessment Report gave the most acceptable definition of climate change, when it stated that, "climate change is a change in the state of the climate such as can be identified (e.g. using statistical tests) by the changes in the mean of temperature, precipitation and wind pattern, and that persists for an extended period typically decades or longer." Put differently, Climate Change is a long-term change in the statistical distribution of weather patterns over time that range from decades to millions of years. The change could be limited to a specific region or may occur across the globe.

The IPCC (2001) report in Deressa, *et al.*, (2008), defined vulnerability to climate change as the degree to which a system is susceptible, or unable to cope with adverse effects of climate change,

including climate variability and extremes. Vulnerability is majorly a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.

Adaptive capacity is the ability of a system to adjust or cope with actual or expected climate stresses. Sensitivity is the degree to which a system is either adversely affected or beneficial by climate change stimuli, whereas Exposure is the nature and degree to which a system is exposed to climate variations (IPCC 2001). Conceptual approaches to analyzing vulnerability to climate change include the biophysical vulnerability approach (or impact assessment) which assesses the level of damage that a given climatic stress exerts on both social and biological systems (such as farm or crop productivity). More so, the socioeconomic vulnerability approach focuses on the socioeconomic and political status of individuals such as education, gender, wealth, income etc., and their influence responses to changes in crop productivity, with price changes and shifts in comparative advantage (Adger, 1999; Füssel 2007). The integrated vulnerability assessment approach combines both socioeconomic and biophysical approaches to determine vulnerability (Cutter *et al.*, 2000).

The most crucial aspect of the concept of climate change is not only the periods involved but also the degree of climatic variability that the change is subjected to as well as the duration and the impact of the vulnerability of such variability on man and the ecosystem. Climate variability occurs on many time scales. Weather events occur at daily time scale and are associated with many agricultural, water resources and health impacts (e.g., heat waves and floods). Climate change is the long-term change in the average weather conditions for a particular location. It will become apparent as a change in annual, seasonal, or monthly means. Thus, incremental climate change will be superimposed upon the natural variability of climate in time and space (Odjugo, 2010).

The causes of global climate change are both natural and anthropogenic. Most often, these changes have been attributed to natural causes such as the earth's orbital cycle, ocean variability, solar

radiation and other physical occurrences like earthquakes, plate tectonics, volcanic eruptions, landslides, heat waves e.t.c. (IPCC, 2001; Ayoade, 2003). Nevertheless, several researchers (DeWeerdt, 2007; Odjugo, 2007) have recently shown that for the past few decades, anthropogenic factors like urbanization, deforestation, population explosion, industrialization and the release of greenhouse gases (i.e. carbon dioxide, chlorofluorocarbon, aerosols, methane etc) into the atmosphere; are the major contributing factors to the depletion of the ozone layer and its associated global warming and climate change.

The growing awareness that the earth's climate is changing is at an alarming rate and the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007) affirms that climate change is no longer in doubt but is now unequivocally apparent based on evidence from scientific observations of increases in global average air and ocean temperatures. Although extreme violent weather has occurred throughout history, recent upsurge in climate related hazards is confirming the argument for global warming and climate change (McGuire *et al.*, 2002; Odjugo and Ikhuoria, 2003; Nwafor, 2006). The evolving climate change coupled with increasing temperature has been observed to plunge some localities into experiencing extreme weather conditions (Olaniran, 2002; Ayoade, 2003; Odjugo, 2005). The on-going climate change and its associated global warming are expected to cause distinctive climate patterns in different climatic zones, which will impact negatively on the ecosystem (Hengeveld *et al.*, 2005; Ayuba, *et al.*, 2007). That is why Ojo (1991) and Clerk (2002) advised that weather and climate should not be taken for granted in the pursuit of technological development, exploration and processing of environmental resources.

Available evidences show that although climate change is global, likewise its impacts, the biting effects will be felt more by the developing countries especially those in Africa due to their low level of technology and coping capabilities making these areas vulnerable (Jagtap, 2007; Nwafor, 2007). By 2020, between 75 and 250 million people in the 'Black continent' are projected to be

exposed to increased water stress; crop yields from rain-fed agriculture could be reduced by up to 50 percent in some regions by 2020; agricultural production, including access to food, may be severely compromised (IPCC, 2007). More so, Houghton (1997) maintained that climate change would continue to increase the disparities in cereal production between developed and developing countries. In his model, production in the developed world tended to benefit from climate change (possible increase of about 5 percent) whereas production in the developing nations declined (by about 10 percent) as a result of climate change. Adaptation at the farm level does little to reduce these disparities. He stressed that cereal prices and thus the population at risk of hunger in developing countries are likely to increase despite adaptation.

Nigeria is one of such developing countries already being plagued with agricultural problems. Higher temperatures, longer droughts, and increasingly frequent and violent storms are predicted to exacerbate the current challenge faced by agricultural production systems in Nigeria. Already, climate change rate is gradually exceeding the adaptive capacity of a broad range of crops and tree population used in Nigeria ten years earlier than the prediction of the IPCC's climate model prediction of 2020 (IPCC, 2007). Although Nigeria is blessed with a vast landmass totaling about 98.3 million hectares with about 74 million hectares arable, coupled with agriculture's contribution to the nation's Gross Domestic Product of about 41.5 percent, yet it is a net importer of food and the output of food per capita from Nigeria is among the least in South Saharan Africa. The share of Nigeria's agricultural products in total exports plummeted from over 70 percent in the 1960s to less than 2 percent in 2010 (Akoroda, 2010). In Nigeria, post harvest losses are 20 to 40% because harvesting, processing and storage techniques are inefficient and supply is unstable (*Guardian* Newspaper, October 16, 2011).

Food production and access to food, in many dry parts of the country is becoming more expensive and in some cases scarce, severely compromised, exacerbating food security problems, malnutrition, poverty, hunger, diseases and communal conflicts resulting from the loss of 92,000

hectares of land to drought and desertification (Commission for Sustainable Development, 2008). This is coupled with the scramble and partition of limited fertile lands. Researchers have linked these problems to climate change which invariably affects crop production in Sub-Saharan Africa (Odjugo and Ikhuoria, 2003; NEST, 2003; Chindu and Nyelong, 2005; Odjugo, 2005; Adefolalu *et al.*, 2007; Ikhile, 2007). For instance, Nigeria consumes over 14 million metric tonnes of maize but produces 7.7 million tonnes annually (Niger State Agricultural Development Project, 2010). It has been predicted that the majority of Nigeria will have novel climates over at least half of their current crop year by 2050 (IPCC, 2007). The manifestations of this biting climatic effect in Nigeria are mostly evident in the northern areas where the incidences of desert encroachment, drought and flooding (as of late) have crippled crop productivity (Awosika *et al.,* 1992; Sawa, 2010). The *Weekly Trust* Article (2012) also reported that drought and desertification are responsible for the loss of about 351,000 square kilometers of the nation's landmass. It is advancing southwards at a rate of about 0.4 to 0.6 kilometers per year, especially along the Niger Republic and Nigeria border.

Zamfara State's climate is inclined towards the arid, Sudano-Sahelian region of the savanna where the above-mentioned cases are seriously experienced. However, in a state where farming is pride, there are still great potentials for agro-economic development if active measures and strategies proposed by this research are strictly implemented to mitigate the adverse effects of climate change and facilitate grain crop production even in the driest regions of the state.

1.2 Statement of the Research Problem

Several studies have been carried out especially in the semi-arid tropics to assess the biophysical or impact vulnerability of climate change on grain farming. Graef and Haigis (2001) revealed that the semi-arid tropics are areas physically characterized by low and highly variable rainfall coupled with harsh temperature over space and time thereby limiting potential crop yields in these areas. Sawa (2010) opined that semi-arid areas especially the Sudan-Sahel zone of northern

Nigeria have suffered from interannual climatic variability, droughts and desertification since the 1960s, worsened by the expected decrease in rainfall within the range of 30-40% per decade. Awosika *et al.,* (1992) stressed that one undisputable cause of famine in the Guinea and Sudan Savannah of Nigeria is the failure of crops resulting from insufficient or untimely rainfall. Either a deficiency or a surplus of rain can cause crop failure and in turn affects crop yields, as has been the case during the drought of 1968-1973 and 1973-1983 in northern Nigeria. Maurya *et al.,* (1995) also affirmed that the low, erratic rainfall and high rate of evapotranspiration for the period of 1984-1991 in Sokoto state increased the duration of water deficit period in the year, which severely affected agricultural production.

Many scholars have also appraised the adaptive potentials of certain cereal crops to changes in climate in the Sudano-Sahelian zone. Awoyemi, *et al.,* (1986), Sowunmi and Akintola (2011) estimated that grain crops such as millet, sorghum and maize accounts for over 60-70 percent of the cereal production in most semi-arid areas of Nigeria, but they depend almost entirely on rainfall for moisture supply, which is most at times irregular and unpredictable. However, during the lengthy dry season, millet and sorghum are more tolerant to drought than any other cereal crop. For instance, Millet is widely grown in the Sudan Savannah as a 'hunger crop' because it is the earliest crop to be harvested when the food reserve is at its lowest level, while the other crops take two to three months to mature (Saleh, 2011).

Ashley (1993) reiterated that millet and sorghum are better adapted to semi-arid conditions like that of the Sudan Savannah ecological zone of Nigeria because they have more mechanisms of 'drought tolerance' than any other cereal crops. He defined 'Drought tolerance' as the ability of certain crops not just to survive but also to produce acceptable yield when subjected to periodic moisture stress. Jones *et al.,* (1981) further categorized the mechanisms of drought tolerant crops into

three: The drought escape, drought tolerance with high tissue water and drought tolerance with low tissue water potential.

However, the Federal Ministry of Environment (2003) survey group developed a contrary view when it envisaged a significant effect of climate change on Nigeria's crop production. This is majorly due to increased levels of carbon dioxide (CO_2) reflected in the production of both *C3 crops* (such as cassava, yam, cowpeas, wheat, soybeans, rice and potatoes), and *C4 crops* (such as millet, sorghum, sugar cane, and maize). In general, higher increases in productivity can be expected with the *C3 crops* compared with *C4 crops*. Thus, the *C4 crops*, which are more common in Nigeria, would be generally adversely affected as many of them are already functioning below-optimal conditions with today's relative increase in CO_2 levels. *C3 weeds* will grow more rapidly and hence compete more severely with a number of *C4 crops*. Similarly, expected changes in crop development and phenology due to climate change extremities can cause shortening or lengthening of crop cycle that could lead to decreases or increases in productivity. Structural changes, especially in the carbohydrate status of plants can also occur. This may affect the nutritional value, taste and storage quality of the crops. Increases in CO_2 can also lower crop water requirements by reducing transpiration per unit leaf area.

On the socioeconomic impacts of climate change on livelihood, Awosika *et al.*, (1992) explained that the aggregate impact of drought on the economy of Nigeria in 1992 caused a drop in the nation's Gross Domestic Product (GDP) between 4 and 6 percent thereby limiting food production and enhancing food importation. FAO (2005) survey team of northern states in Nigeria later observed that the number of farmers unable to afford food increased between 2003 and 2005 due to rising food prices in millet, rice and maize. As at 2005, average rate of food affordability was below 37 percent and the average spending per household rose indiscriminately and did not keep pace with food prices, forcing families to sell or lease their farmlands for survival. Ikuomola (2008) further revealed through his research that agriculture was becoming less lucrative in some selected northern Nigerian states.

They include Borno, Kano, Sokoto and Zamfara because of the low farming yields of food coupled with the high prices and scarcity of cash crops like millet, sorghum, sugarcane, rice and beans. This invariably translates to over 63 percent poverty level among populace, low income capacity in the sales of crops, low economic power of inhabitants in the states, poor financing and irregularities in the supply of fertilizers, insecticides and pesticides by government agencies as at when due. Even governmental programmes on climate change earlier proposed by some states were said to be non-existent and limited to only compensation due to high rates in poverty level and illiteracy.

Maurya *et al.,* (1995) in trying to appraise techniques employed by grain farmers in addressing climate change issues in Sokoto state, observed that most farmers encountered problems in adapting to these changes. Even with the widespread adoption of new technologies and practices in Sokoto state from 1984-1991, there was still considerable difference between the average potential and expected crop yield due to the high level of illiteracy on the part of farmers leading to severe decline in wheat, rice and maize yields. They further advised that farmers should be properly trained on the use of modern machineries and employing appropriate soil conservation practices and other farming techniques to reduce the adverse effects of climate change. Houghton (1997) also advised that where these changes occur rapidly, rapid and possibly costly adaptation to a new climate will be required by the affected community such as migration to a region where less adaptation would be needed – a solution which has become increasingly difficult or in some cases impossible in many crowded areas.

From the foregoing, grain production in the study area needs to be assessed for its vulnerability, especially since it is heavily dependent on the characteristics of rainfall - a situation that makes the area socioeconomically and biophysically or climatologically vulnerable to climate change. This work thus, seeks to address these issues by asking the following important questions:

i. What is the pattern of rainfall in the state?

ii. What is the current trend of Millet, Sorghum and Maize yields in the study area?

iii. What is the extent of the climate change problem, socioeconomically and biophysically?

iv. What strategies have farmers in the area adopted in coping with the effects of climate change on these grain crops?

v. How can government assist in mitigating the impact of climate change on farming systems in the study area?

1.3 Aim and Objectives

The aim of this research is to assess the vulnerability and adaptive strategies of grain farmers to climate change in Shinkafi Local Government Area of Zamfara State for 40 years (1971 to 2010). To achieve the aim of this study, the specific objectives are to;

i. determine trends of rainfall characteristics in Zamfara State using the Gusau station as an example;

ii. examine changes in the yield pattern of Millet, Sorghum and Maize (percentage of kilograms per hectare) for the time of data availability in the state;

iii. determine any significant relationship between rainfall variability and the yields of Millet, Sorghum and Maize over the period;

iv. assess the Vulnerability indices for Zamfara State through the mean periodic rainfall amounts, Normalized Rainfall Index (NRI) and grain farmers' socioeconomic status;

v. use the findings of (i) to (iv) to determine the adaptive strategies in a bid to address biophysical and socioeconomic vulnerability to climate change with particular reference to Shinkafi LGA.

1.4 Significance of Study

Preliminary findings from the annual agricultural performance survey conducted by the National Agricultural and Educational Research Liaison Services (NAERLS) in 2011– ABU Zaria in Kaduna State showed that in northern Nigeria, though more lands were put under cultivation, the increase in production is marginal; attributed to poverty, low use of improved seeds, pests and diseases

attacks and the incidences of floods and dry spells across the northern parts of the country. Generally, Maize production increased slightly from 9 million tons in 2010 to 9.4 million tons in 2011 while Sorghum production declined from 7.02 million tons to 6.89 million ton over the same period. Millet production was impacted by the prolonged dry spells in the extreme north and declined from 1.38 million tons in 2010 to 1.27 million tons in 2011. Total production for Millet, Sorghum, Maize and Rice; the most important cereal crops in the north were estimated to be about 22.1 million tons in 2011, slightly higher than 21.96 million tons as recorded in 2010 showing declining signs in production (FEWS NET Nigeria, Abuja).

It is therefore imperative to elicit if and how climate change has affected grain production in the study area over time and how grain farmers have adapted to the changes. Thus, investigating the present vulnerability of grain producers over the study area helps in proffering new stringent adaptive strategies to mitigate the changes and minimize future vulnerability.

1.5 Scope and Delimitation of the Study

This study is restricted to three communities in the study area namely; Badarawa, Jangeru and Shinkafi. Shinkafi LGA was chosen based on its geographical location in the semi-arid tropics as well as its prominence in grain production for commercial purposes. The grain crops that were considered in this study include; Millet, Sorghum (Guinea corn) and Maize. The period of study is between 1971 and 2010.

1.6 Organization of the Study

Chapter 1 of this research is the Introduction, which contains the General background to the study; Statement of research problem; Aim and objectives, the Significance of the study; the Scope and delimitation of the study and the Study area.

Chapter 2 is a general review of some related literatures on the research topic. Referential works will centre on the characteristics and attributes of the rainy season in the Sudano-Sahelian region; Conceptual approaches to Vulnerability; Vulnerability assessments to climate change; Statistical analysis of rainfall variability impacts on crop productivity and the Status of crop production technology-adoption to climate change in the Sudano-Sahelian region.

Chapter 3 is the Research Methodology comprising of types and sources of data, sample size and sampling techniques, methods of determining rainfall attributes and crop yield and methods of data analysis.

Chapter 4 is the Presentation and discussion of the results obtained and;

Chapter 5 gives the Summary, Conclusion and Recommendations of the study.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Introduction

This chapter sets out to review the literature that is related to this study. Busha and Harter (1980) observed that "Literature search and subsequent review can be of value to researchers by helping them regard their studies as contributions to a large topic of which the enquiry at hand is only a part rather than an isolated or esoteric collection of facts".

This review has thus enabled the researcher to assess previous works on the concepts and approaches to assessing vulnerability to climate change particularly rainfall variability in the Sudano-Sahelian region of Nigeria and adaptive strategies employed by grain farmers in addressing this issue. The interest here is to justify the conceptual framework and methodological approach adopted for this study. This chapter is thus organized into the following broad sub-headings:

2.2 The Characteristics and Attributes of the Rainy Season in the Sudano-Sahelian Zone

Oladipo (1993a) stated that rainfall stands out as perhaps the single and most unique element such that its total amount, intensity, duration, variability, reliability and its spatial and temporal distribution influences phenomena especially in the tropical regions of the world where the prevailing economic activity is simply agro-based. Odumodu (1982) also observed that although unique, rainfall is undoubtedly the most limiting factor in the tropics and subtropics because it is highly variable in time and space especially where at present because crop production is obtained from dry land farming. Scholars like Ayoade (1973), Ogallo (1979) and Nicholson (1981) have similarly identified year-to-year fluctuations in rainfall trends and periodicities in West African regions paving way to gross variation in food production resulting to human impoverishment.

The Sudano-Sahelian zone of Nigeria is generally characterized by short rainfall periods and a long dry season (Otegbeye, 2004). The annual precipitation in this area varies from less than 500mm

in the extreme northeastern part to about 1000mm in the southern part (FRN, 2000). Recent studies have indicated that the Sudano-Sahelian zone of Nigeria has suffered decrease in rainfall in the range of about 30-40 percent since the beginning of the nineteenth century (FRN, 2003). Oladipo (1989) established that since the 1969-1973 Sudano-Sahelian droughts, rainfall has been irregular and unpredictably low in the drought prone areas of northern Nigeria. Sawa (2002) also affirmed that even within the period of 1970-2000, the Sudano-Sahelian bio-climatic zone of northern Nigeria has been experiencing a general tendency towards a decreasing number of wet spells, and a drier than normal condition as from 1969/70, thus proving that there is an apparent and real increasing aridity in the region (Sawa and Adabayo, 2011).

Seasonal variations in rainfall in the Sudano-Sahelian region are directly influenced by the interactions of two air masses. The relative warm and moist tropical maritime ($_mT$) air mass, which originates from the Atlantic Ocean associated with Southwest winds in Nigeria; and the relatively cool, dry and stable tropical continental ($_cT$) air mass that originates from the Saharan desert. The tropical continental air mass is associated with the dry, cool and dusty Northeast trades known as the *Harmattan* (Ayoade, 1982b; Oguntoyinbo, 1982; Oladipo and Salahu, 1993; FRN, 2000; Sawa, 2002; Ayoade, 2004, Abaje, 2006; Abaje, 2007a; Ati *et al.*, 2007). The boundary zones between the two air streams have been given various names by tropical weather analysts. Such terms as the Inter-tropical front (ITF), Inter-tropical Convergence zone (ITCZ), Inter-tropical Confluence (ITC), Equatorial front and the Inter-tropical Discontinuity (ITD) have been used to describe this feature of tropical weather and climate (Ayoade, 2004).

The movement of the ITD northwards across the country between January and August and its retreat from the southern fringe of the Sahara desert, after August causes much of Nigeria to experience seasonal rainfall (Olaniran and Sumner, 1989a; Ati *et al.*, 2007; Olaniran, 2002). The ITD

assumes its northernmost position around latitude 20-22^{0}N in August. This marks the height of the rainy season to all areas south of its location. The ITD attains its southernmost position around latitude 6-7^{0}N in January/ February. This is the peak of the dry season to areas north of its location (FRN, 2000; Ayoade, 2004; Abaje, 2006). The position so far south reflects the general southward movement of wind and pressure systems of this time of the year. This southward migration is further assisted by the strengthening of the surface high-pressure cells over the Sahara desert, which is in turn related to the southward migration of the cyclones and anticyclones of the Mediterranean and northwest Europe (Ojo, 1977). The surface position of the ITD in the Sudano-Sahelian region exhibits not only seasonal but also day-to-day variations (Oladipo and Salahu, 1993). It tends to take a more southerly position when the pressure exceeds 1020mb and moves slightly northwards when the Saharan pressure weakens (Ojo, 1977). The movement of the ITD is very irregular, varying according to the season from 2^{0} to 5.6^{0} of latitude per month (Oladipo and Salahu, 1993), and the southward retreat of the ITD is faster than its northern advance. While the northward advance is at the rate of about 160km per month, that of the southward retreat is at about 320km per month. This accounts for the rather gentle onset of the rainy season in West Africa and its rather abrupt end (Ayoade, 2005).

Olofin (2008) and Danbazau (2008) exclusively identified four seasons in the Sudano-Sahelian regions of Nigeria based on the effect of climatic controls and temperature conditions namely;

i. The Dry and Cool season (*Kaka*): This season is known as the harmattan period and it lasts from mid-November to the end of February. This period is characterized by cool, dry and dusty weather conditions. The wind originates from the Faya Largeau Birma region near the Ahaggar and Tibesti massifs. The ITD lies south of the region during this period and prevailing winds are the Northeast Trades.

ii. The Dry and Hot season (*Bazara*); This is a very short season that follows the *harmattan* period. Its length in a particular year is determined by the onset of the rains. On the average, it lasts from March to April and may extend to mid-May at the northeastern extreme. This is the hottest period of the year and mid-day temperature often exceeds 40^0C in some cases. This period is characterized by the occurrence of sandstorms, which originates from the Sahara desert with local surplus of sand as the ITD begins to move northwards. The dominant winds are still the Northeast Trades. The sandstorm normally signifies the end of the dry season and the beginning of the rainy season.

iii. The Wet and Warm season (*Damina*): This is the period when the ITD runs through the region and moves southwards. The period begins around May and ends in September over 90% of the annual rainfall is recorded during this period and has the lowest diurnal and monthly ranges in temperature. The cessation of rains starts from the extreme north around mid-September moving southwards reaching the southern tips of the study area about the end of September in mid-October in the wet years.

iv. The Dry and Warm season (*Rani*): this period starts at the end of the rains and ends about mid-November with the onset of the harmattan. It is the second hottest period, winds are very variable and the season records the highest number of calms in the year.

In his work, Sawa (2002) further observed that the various aspects of rainfall in Nigeria have been studied on monthly and annual rainfall values. For instance, he stressed that Kowal and Knabe (1972), Ilesanmi (1972), Olaniran and Sumner (1989a) and Ati et al., (2002), have all investigated the onset, advance and retreat of rainfall. Rainfall distribution over the northern Nigerian region was the subject of a study by Adefolalu and Oguntoyinbo (1985). Anyadike (1992, 1993) also investigated regional variations, seasonal and annual fluctuations of rainfall. However, except for Oladipo and

Salahu (1993) and Sawa (2002), studies on the temporal variability in the occurrence of rainy days based on daily rainfall data in Nigeria in general and northern Nigeria in particular have almost been neglected. Stern *et al.*, (1982a) stressed that daily rainfall data was appropriate in determining rainfall characteristics because cumulative data on mere decadal, monthly or annual rainfall often give misleading climatological information notably on the onset and cessation of the rains, and , in many cases, information on wet and dry spells are lost. It is perhaps for this reason that Niewolt (1989) stated that the agricultural usefulness of rainfall is often determined more by its daily and distribution rather than by the monthly totals or mean annual values. Hence, Stern *et al.*, (1982a) suggested that the analysis of climatological data for agronomical purposes must start with the analysis of daily rainfall records.

As an addendum to the foregoing, the Federal Ministry of Environment (2003) survey group also envisaged that the baseline period of climatic conditions between 1961 and 2099 in the Sudano-Sahelian region of Nigeria tends to indicate an effective rainy season for only four months long while six of the dry season months will be rainless. Although the onset of the season is in May in most years, the fields are not sufficiently wet for cropping until June. June in some years may not even receive as much rain as to make planting feasible. Peak rainfall comes in August, and the season terminates at the end of September. The projections made for the rest of the 21st century in Kano indicated significant increases in June. The rainfall of July, August and September were projected to remain as they were for the baseline period from 1961 to 1990. However, projections of rainfall for Maiduguri during the 21st Century indicated an increase in rainfall for June, July and August up to 2069 followed by a decrease during the final thirty years of the century. The significant increases in the rainfall of June will tend to bring that month more effectively into the planting season.

Rainfall characteristics therefore determines the zonal pattern of crops, the quality and quantity of crop yield available for subsistent and commercial consumption and the seasonal activities of farmers all due to the availability of annual or monthly rainfall data.

2.3 Conceptual Approaches to Vulnerability

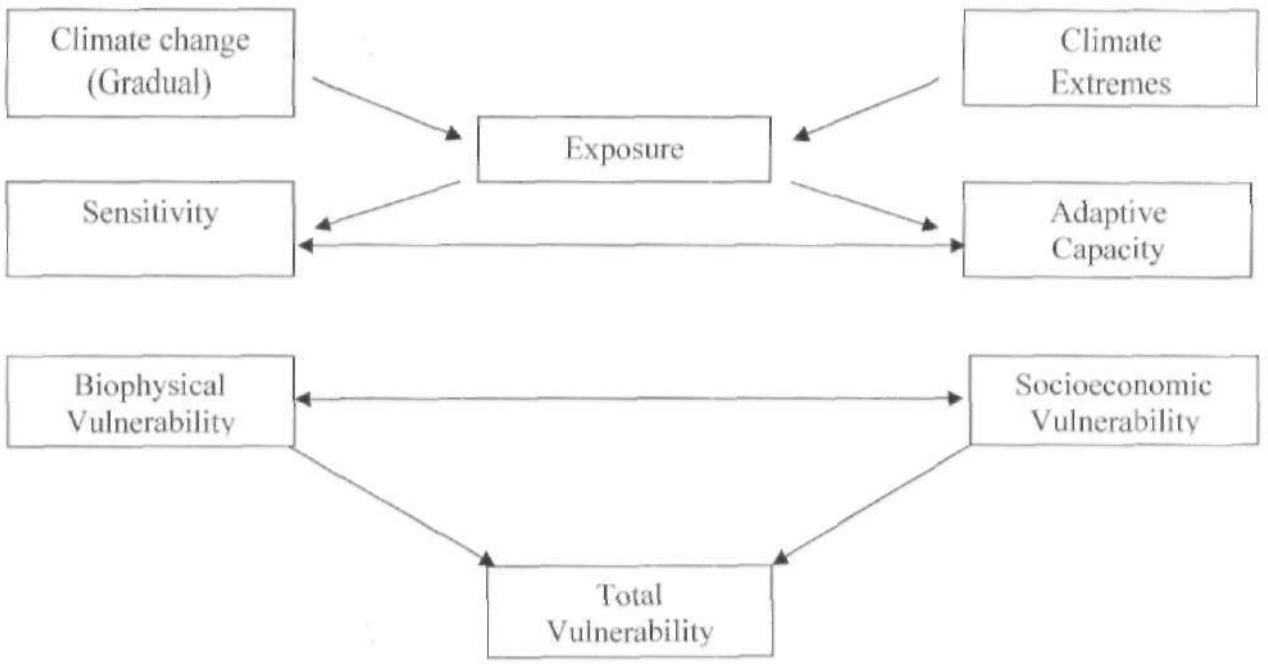
The availability of water via rainfall is the most important factor affecting food production and agriculture in general. The vulnerability of water supplies to climate change carries over into the vulnerability in the growing of crops and the production of food. Thus the arid and semi-arid areas, mostly in developing countries, are most at risk economically and physically. Based on this assumption, vulnerability is thus, defined as the net effect of adaptive capacity, sensitivity, and exposure. In this relationship as shown in Figure 1.1, higher net value indicates lesser vulnerability and vice versa (Deressa *et al.*, 2008).

There are three major conceptual approaches to analyzing vulnerability to climate change as were discussed by Deressa *et al.*, (2008). They include the socioeconomic, the biophysical (impact assessment), and the integrated assessment approaches.

2.3.1 Socioeconomic approach

The socioeconomic vulnerability assessment approach mainly focuses on the socioeconomic and political status of individuals or social groups (Adger 1999; Füssel 2007). Individuals in a community often vary in terms education, gender, wealth, health status, access to credit, access to information and technology, formal and informal (social) capital, political power, and so on. These variations are responsible for the variations in vulnerability levels. In this case, vulnerability is considered to be a *starting point* or a *state* (i.e., a variable describing the internal state of a system) that exists within a system before it encounters a hazard event (Allen, 2003; Kelly and Adger, 2000).

Figure 1.1: Conceptual Framework to Vulnerability Assessment



Thus, vulnerability is considered to be constructed by society as a result of institutional and economic changes (Adger and Kelly, 1999). In general, the socioeconomic approach focuses on identifying the adaptive capacity of individuals or communities based on their internal characteristics. A study by Adger and Kelly (1999) is an example of this approach. In that study, the environmental factor in a district to coastal lowlands of Vietnam was taken as given, and vulnerability was analyzed based only on variations in socioeconomic attributes of individuals and social groups.

The main limitation of the socioeconomic approach is that it focuses only on variations within society (i.e., differences among individuals or social groups). In reality, societies vary not only due to sociopolitical factors but also to environmental factors. Two social groups having similar socioeconomic characteristics but different environmental attributes can have different levels of vulnerability and vice versa. In general, this method overlooks - or takes as exogenous - the environment-based intensities, frequencies, and probabilities of environmental shocks, such as drought and flood. It also does not account for the availability of natural resource bases to potentially

counteract the negative impacts of these environmental shocks - for example, areas with easily accessible underground water can better cope with drought by utilizing this resource.

2.3.2 Biophysical, Climatic or Impact approach

The biophysical approach assesses the level of damage that a given environmental stress causes on both social and biological systems. For instance, the yield impacts of climate change can be analyzed by modelling the relationships between crop yields and climatic variables (Adams 1989). Other related impact assessment studies include the impact of climate change on human mortality and health terms (Martens *et al.*, 1999), on food and water availability (Food and Agriculture Organization [FAO] 2005), and on ecosystem damage (Forner, 2006). The damage is most often estimated by taking forecasts or estimates from climate prediction models (Kurukulasuriya and Mendelsohn, 2006) or by creating indicators of sensitivity by identifying potential or actual hazards and their frequency (Cutter *et al.*, 2000).

Füssel (2007) identified this approach as a *risk-hazard approach* and denoted the vulnerability relationship as a hazard-loss relationship in natural hazard research, a dose-response or exposure-effect relationship in epidemiology, and a damage function in macroeconomics. Kelly and Adger (2000) referred to the biophysical approach as an *end-point analysis* responding to research questions such as, "What is the extent of the climate change problem?" and "Do the costs of climate change exceed the costs of greenhouse gas mitigation?"

Although very informative, the biophysical approach has its limitations. The major limitation is that the approach focuses mainly on physical damages, such as yield, income, and so on. For example, a study on the impact of climate change on yield can show the reduction in yield due to simulated climatic variables, such as increased temperature or reduced precipitation. In other words, these simulations can provide the quantities of yield reduced due to climate change, but they do not show what that particular reduction means for different people. A 50 percent reduction in yield due to

climate change does not mean the same for poor farmers that it does for rich farmers. Poor farmers very often cannot cope with marginal changes in their yields or income, whereas richer farmers can buffer their loss (smoothen consumption, in technical terms) by depending on savings or sale of some of their assets. In general, the biophysical approach focuses on sensitivity (change in yield, income, health) to climate change and misses much of the adaptive capacity of individuals or social groups, which is more explained by their inherent or internal characteristics or by the architecture of entitlements, as suggested by Adger (1999).

2.3.3 The Integrated assessment approach

The integrated assessment approach combines both socioeconomic and biophysical approaches to determine vulnerability. The hazard-of-place model (Cutter *et al.,* 2000) is a good example of this approach, in which both biophysical and socioeconomic factors are systematically combined to determine vulnerability. The vulnerability mapping approach (O'Brien *et al.,* 2004) is the other related example, in which both socioeconomic and biophysical factors are combined to indicate the level of vulnerability through mapping.

Füssel (2007) argued that the IPCC (2001) definition, which conceptualizes vulnerability to climate as a function of adaptive capacity, sensitivity, and exposure, accommodates the integrated approach to vulnerability analysis. According to Füssel and Klein (2006), the risk-hazard framework (biophysical approach) corresponds most closely to sensitivity in the IPCC terminology. Adaptive capacity (broader social development) is largely consistent with the socioeconomic approach (Füssel, 2007). In the IPCC framework, exposure has an external dimension, whereas both sensitivity and adaptive capacity have internal dimension, which is implicitly assumed in the integrated vulnerability assessment framework (Füssel, 2007).

Even though the integrated assessment approach corrects the weaknesses of the other approaches, it has its limitations. The main limitation is that there is no standard method for combining

the biophysical and socioeconomic indicators. This approach uses different data sets, ranging from socioeconomic data sets (e.g., race and age structures of households) to biophysical factors (e.g., frequencies of earthquakes, drought and flooding occurrences); these data sets certainly have different and yet unknown weights. Cutter *et al.*, (2000) explained that because this analysis provides no common metric for determining the relative importance of the social and biophysical vulnerability, or for determining the relative importance of each individual variable, much care is required. The other weakness of this approach is that it does not account for the dynamism in vulnerability. Coping and adaptation measures are characterized by a continual change of strategies to take advantage of opportunities (Eriksen and Kelly, 2007); thus, this dynamism is missing under the integrated assessment approach. Despite its weaknesses, however, this approach has much to offer in terms of policy decisions. Therefore, this method was adopted to assess the vulnerability of grain farmers in a Sudano-Sahelian zone such as Zamfara state to climate change, and adopt stringent measures to minimize the stress.

2.4 Vulnerability Assessments to Climate Change

An assessment of a country's vulnerability in the context of Climate Change is an evaluation and analysis of the extent and severity of potential impacts of climate changes on the physical environment, main sectors of the national economy, human health and other socio-economic activities. In general, vulnerability assessment would allow for the identification of the types of problems that a country could face in the event of marked climate changes (Federal Ministry of Environment, 2003). Therefore, only the most common methods are employed in most vulnerability literature- namely, the econometric and indicator methods as discussed below.

2.4.1 Econometric method

The econometric method has its roots in the poverty and development literature. This method uses the household-level socioeconomic survey data to analyze the level of vulnerability of different

social groups. The method is divided into three categories: vulnerability as expected poverty (VEP), vulnerability as Low Expected Utility (VEU), and vulnerability as uninsured exposure to risk (VER) (Hoddinott and Quisumbing, 2003). All three share common characteristics in that they construct a measure of welfare loss attributed to shocks.

2.4.2 Indicator method

The indicator method of quantifying vulnerability is based on selecting some indicators from the whole set of potential indicators and then systematically combining the selected indicators to indicate the levels of vulnerability. These levels of vulnerability may be analyzed at local (Adger 1999), national (O'Brien *et al.*, 2004), regional (Leichenko *et al.*, 2004) and global (Brooks *et al.*, 2005) scales.

Two options are available for calculating the level of vulnerability using this method at any scale. The first is assuming that all indicators of vulnerability have equal importance and thus giving them equal weights (Cutter, *et al.*, 2000). The second method is assigning different weights to avoid the uncertainty of equal weighting given the diversity of indicators used. In line with the second method, many methodological approaches have been suggested to make up for the weight differences of indicators. Some of these approaches include use of expert judgment (Kaly and Pratt, 2000), principal component analysis (Cutter *et al.*, 2003), correlation with past disaster events (Brooks *et al.*, 2005), and use of fuzzy logic (Eakin and Tapia, 2008). Even though there are attempts in giving weights, their appropriateness is still dubious; because there is no standard-weighting method against which each method is tested for precision.

2.5 Statistical Analysis of Rainfall Variability Impacts on Food Productivity

Significant works have been done in Nigeria and other African countries on the long-term trends and periodicities in rainfall, which have also been well-documented (Ogallo, 1979; Adefolalu,

1986a). These studies dealt with rainfall amounts and their distributions in Nigeria, factors responsible for observed rainfall patterns, onset and length of the rainy season as well as long-term trends.

Studies have also been carried out on the analysis of rainfall variability of most African countries including Nigeria For instance, Gregory (1964) used standard deviation rather than the mean deviation to assess the variability of rainfall over a time period of 1936-1955 in Mozambique so that further characteristics of the data can be evaluated. Balogun (1972) examined the variability of rainfall over Nigeria by a measure called the coefficient of variability. The distribution of these values indicated that the areas of high rainfall have low coefficients of variation and vice versa. He concluded that the low variability value for the south indicates a measure of reliability of the annual rainfall and the high values to the north indicated low rainfall values as well as its unreliability. Thus, it becomes clear that the major problem to agricultural production in the northern part of the country is the unreliability of the rains.

Ayoade (1974) used the semi-average method and the linear regression analysis to demonstrate that over most parts of Nigeria, there appears to be no significant overall trend in the annual rainfall totals over the period of 1931-1960. However, when Ogallo (1979) examined trends and cycles in annual rainfall totals for 69 stations in Africa at different locations and specified lengths of time ranging from 40 to 109 years, it was realized that some of these series were too short to define a definite long-term trend or analyze the shape of the spectra in details. Oguntoyinbo (1983) also buttressed the fact that there were no climatological records of long durations in Nigeria and that the longest established weather station in the country is in Lagos where recording of rainfall amounts began in 1892. This lack of long-term instrumental records has not allowed for a closer study of long-term trends. However, there were oscillatory patterns of rainfall records between 60-80 years for some stations due to low rainfall periodicities when drought swept over most parts of West Africa.

Howbeit, Adefolalu (1986) in his study, compared moving averages of annual rainfall over 44 years rainfall series (1911-1950, 1921-1960, 1931-1970, 1941-1980) and showed that the 40 year moving average annual rainfall decreased by 50 to 100mm in the Sahel region of Nigeria. Nevertheless, there has been a decrease in the heaviest daily precipitation amounts, coincident with an overall decrease in annual rainfall. This pattern is apparent through out the Sudano-Sahelian zone (Nicholson, 1981). In the general analysis of rainfall patterns carried out in Southwestern Nigeria by Oyebande and Oguntoyinbo (1970), it was concluded that since there is a wide difference between individual mean monthly rainfall values from year-to-year, monthly mean values therefore are not reliable indicators for forecasting a particular month's rainfall without knowing the degree of variability in the rainfall series.

Ati (1996) observed that annual rainfall series can be considered normal for all practical purposes at 95% confidence level but when stringent conditions are set for a better fit, then a transformation of the series becomes necessary. Sawa (2002) also affirmed that during the rainfall series from 1911-2000, over 80 % of wet and dry spells in 15 synoptic stations north of latitude 10^0N in Nigeria were homogenous at 95% confidence level according to the Swed and Eisenharts (1943) and that 87% of the stations conformed to the Gaussian normal distribution at 95% significance level. Thus, since the deviation from the homogeneity and normality was slight, the data were not transformed. Owolabi (2004) used Skewness and Kurtosis to test for the normality of rainfall in the Northwestern zone of Nigeria and the rainfall series were found to be normally distributed. He further concluded that there is a trend towards decreasing rainfall totals in the study area. Other transformation models that can be used to normalize rainfall series where they are found to be non-normal include the Log transformation and Lambda transformations of Box and Cox (1964) and Square and Cube Root transformations of Stidd (1970).

Kowal and Knabe (1972) conducted studies of rainfall characteristics for northern Nigeria and produced different features of selected stations. They further concluded that when a region or country goes through a period of high rainfall peak, a period of low rainfall (below mean) should be anticipated to follow because of the unpredictable nature of the rainfall regime in the northern part of the country. Other scholars studied the duration of wet seasons and produced models for determining onset, duration and the ending of the rainy season. It thus showed that the length of rainy season in Nigeria might be determined from mean monthly values of rainfall from daily records to avoid false starts for undue planting seasons (Walter, 1967; Ati *et al.*, 2002).

Stern *et al.*, (1982a) have showed that for agricultural purposes, analysis of daily rainfall seems to be more relevant and from their analysis, they gave agronomical useful results. Also Nwafor *et al.*, (1982) noted that the most important factor in the creation of major crop zones is the relationship between the available water and water need. This shows therefore that the most important single factor or environmental influence on agriculture, which effectively determines that type and period of grain cultivation in Nigeria is rainfall. However, where the climate is greatly influenced by drought and desertification, the conditions of rainfall in relation to evapotranspiration and soil moisture content may help promote or hinder crop yield. Thus, the rate of evapotranspiration is subject to the availability of moisture at the evaporating surface and the ability of the atmosphere to vapourize the water and remove the vapour. This has great implication on crop production (Osagie, 2002).

Houghton (1995) analysed the effect of climate change on world food supply and concluded that potential changes in national grain crop yields were estimated for wheat, rice, maize (which between them accounts for about 85 per cent of world cereal exports) and soybean (which accounts for about two-thirds of the trade in protein cake equivalent). These national crop yield changes were extrapolated to provide yield change estimates for other countries and other crops.

2.6 Status of Crop Production Technology - Adoption to Climate Change in Certain Regions

Adaptation is concerned with adjustment in ecological, social or economic systems in response to actual or expected climatic stimuli, or their effects, that moderates harm or exploits beneficial opportunities. Thus, adaptation measures refer to all those responses to climate change that may be used to reduce vulnerability. In this regard, an assessment of a country's adaptation is an identification and evaluation of possible options or changes in policies, practices and technologies, as well as actions designed to adapt to or take advantage of new opportunities that may arise as a result of climate change. For instance, Olsen *et al.*, (2002) compared the scales of the Scandinavian climate and soil data in wheat production especially during the winter season. They observed that crop yields could be better enhanced with the introduction of modern technological heat-generating mechanisms to address the climatic issue in ice regions such as Denmark, which invariably affects soil condition during the winter.

Another example of adaptation to changing climate is the way in which farmers in Peru, South America adjust the crops they grow depending on the climate forecast for the year. Peru is a country whose climate is strongly influenced by the cycle of *El Nino* events. Two of the primary crops grown in Peru, rice and cotton, are very sensitive to the amount and the timing of rainfall. Rice requires large amounts of water; cotton has deeper roots and is capable yielding greater production during years of low rainfall. In 1983, following the 1982-83 *El Nino* event, agricultural production dropped by 14 per cent. However, by 1987, better awareness on the forecasts of the onset of *El Nino* events had become sufficiently good for Peruvian farmers to take into account in their planning and this led to an increase in production by 3 per cent (Houghton, 1995).

In the Sudano-Sahelian region of Nigeria, wide spread adoptions of new technologies and their practices has given the impression that farmers are sophisticated. Their ability to increase the net return is however, another matter. According to Maurya *et al.*, (1995), they observed that the farmers

of the small irrigation project in Sokoto state have improved the crop yield per unit area; cropping intensity (increase to around 220 percent); some new crop introduction and over all management of privately owned irrigation system during the last five years. However, there was still considerable difference between potential and the farmers' yields as recorded in wheat, rice, maize, cowpea, garlic, *okro*, sugarcane, tomatoes, onion, calabash and watermelon. Most of the farmers used frequent and high quantities of water in each irrigation because of high conveyance losses and poor assessment. Generally, 20 to 30 percent high water-use than actual need were observed in several crops like rice, wheat, maize, cowpea, onions and tomatoes.

Deressa *et al.,* (2008) observed that early warning of extreme climatic events, such as drought, can alert farmers to sell their livestock and buy food and other items. Without this warning, such events could shrink or kill livestock that would have been used to insure farmers. In addition, investment in irrigation schemes in places with high potentials for water reserves can also increase the country's food supply. These supplies could then be stored and sold out during drought events instead of depending on food aid from other nations. Strengthening the ongoing micro-level adaptation methods of governmental and non-governmental organizations, such as water harvesting and other natural resource conservation programs, can also boost the adaptive capacities of farmers.

CHAPTER THREE

THE STUDY AREA AND METHODOLOGY

3.1 Introduction

This chapter ushers us into the description of the study area -- Shinkafi Local Government Area and Zamfara State. It also deals with the methods involved in collecting, processing and analyzing rainfall, grain yields and respondents' data.

3.2 The Study Area

3.2.1 Location of the Study area

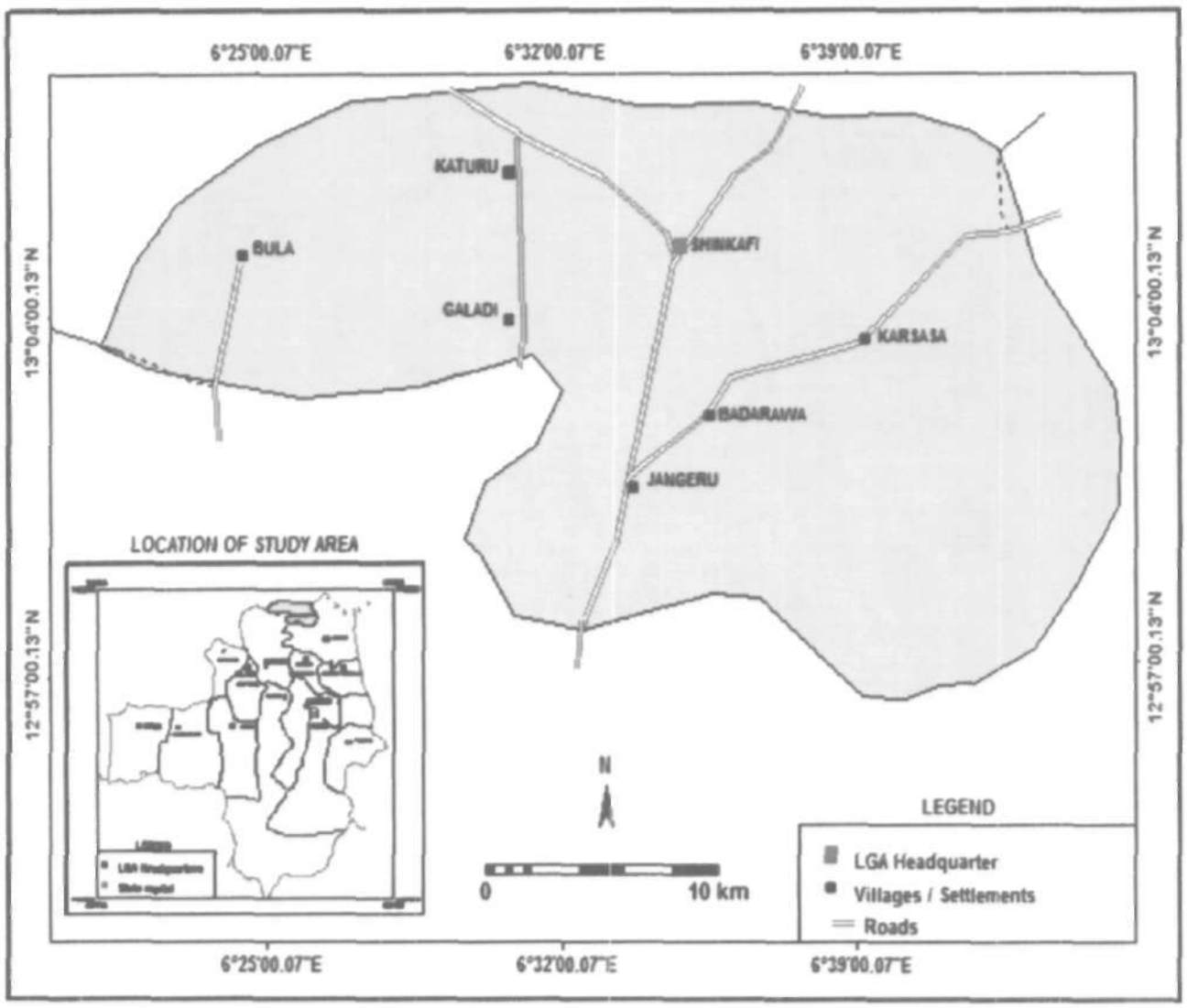
Zamfara State exists in the semi-arid or Sudano-Sahelian region of Nigeria, in sub-Saharan Africa. It is located between longitudes 6° 15′ East of the Greenwich meridian and between 12° 10′ North of the Equator. It is situated in the Northwestern part of Northern Nigeria. The state shares boundary with Sokoto State and Niger Republic to the North; Kebbi and Niger States to the West; Katsina State to the East and Kaduna State to the South. The state comprises of fourteen (14) Local Government areas (including Shinkafi) with an estimated land area of 39,762 square kilometers. The Sahel is now growing larger at the expense of the Sudan savanna. Therefore, it is more meaningful to take the two zones together as the Sudano-Sahelian zone. This zone lies immediately to the south of the Saharan desert.

The study area - Shinkafi Local Government Area is situated at the northern fringes of Zamfara state. Its total landmass area is about 674 square kilometers and it is located between latitudes 12° 54′ North and 13° 09′North of the equator and between longitudes 6° 21′East and 6° 46′ East of the Greenwich meridian (See Figure 2). It shares boundaries with Sokoto state to the north, Zurmi LGA to the east and south and Maradun LGA to the west – all in Zamfara State (Zamfara Agricultural Rural Development Authority, 2008; Federal Polytechnic, Kaura Namoda, 2010).

3.2.2 Historical and Political background

Shinkafi LGA was born on January 1937 from the ancient Kaura town even before the state was created from the erstwhile Sokoto State on 1st October 1996 by the then Military Head of State, General Sanni Abacha (GCON). As at then, the *Gobirawas* populated the area.

The inhabitants of Shinkafi actually migrated from the *Gobir* kingdom of the old Hausa states when their leader, Baham came from *Goron Rimi*. Since then, Shinkafi LGA has enjoyed accelerated development in socioeconomic and political considerations.



Source : Modified from Administrative Map of Zamfara State, 2010

FIGURE 1 : SHINKAFI LOCAL GOVERNMENT AREA : STUDY AREA

3.2.3 Physical Background

3.2.3.1 Climate

The Study area is located in the Subsahelian climatic zone and experiences a typical Tropical Continental climate with marked distinct seasonal regimes oscillating between cool- to- hot dry *harmattan* and rainy season types that are controlled by the apparent movement of the Intertropical Discontinuity divide (ITD) or the Inter Tropical Convergent Zone (ITCZ). The ITD's movement is directed by the northeasterly and southwesterly trade winds blowing over Nigeria bringing dry, dusty *harmattan* and warm rainy conditions respectively. Dry seasons in the state are marked by an abrupt drop in the moisture content of the surface air lasting for about 6 to 7 months. However, considerable rainfall is usually mono model and it usually commences in May and lasts until October as intermittent severe thunderstorms known as the Monsoons move northwards. The pattern of rainfall in this area is thus, highly variable in spatial and temporal dimensions with inter annual variability of between 15 and 20% (Oladipo, 1993a; FRN, 2000). As a result of the large inter-annual variability of rainfall, this zone is subject to frequent dry spells which can result in severe and widespread drought that can impose serious socioeconomic constraints (Oladipo, 1993a; Okorie, 2003). This seasonal characteristic in rainfall further reflects on the low vegetal cover type of the area. During the dry season between October and May, there is practically no rainfall and potential evapotranspiration rates are very high. (Maurya *et al.,* 1995; Federal Polytechnic Kaura Namoda, 2010).

Daytime temperatures also vary with a mean minimum of 38°C and a mean maximum of 40°C as the readings are extremely high at most periods of the year. Temporal temperature characteristics are steadier than that of rainfall but the highest diurnal ranges of temperature are in the dry season. The highest air temperature normally occurs in April/ May and the lowest in December through February (Adefolalu, 2002). The mean atmospheric relative humidity also ranges between 70-90% and 25-30% for the rainy and dry seasons respectively (Midgley, *et al.,* 1989). Evapotranspiration

is also generally high throughout the year. The highest amount of evaporation occurs during the dry season (Ayoade, 1982b). Sunshine hours vary with latitude and with season. The mean annual total number of sunshine hours in this area is also high (Oguntoyinbo, 1982). In general, values are high during the dry season throughout the zone namely because skies are less cloudy than during the rainy season (Ojo, 1977).

3.2.3.2 Geology and Relief

The geology of the Shinkafi area is part of the Zamfara-Sokoto geological belt of the basement complex rocks of Precambrian age, which have been intruded by a series of granitic rocks of late Precambrian to lower Paleozoic age, underlain by gneisses, migmatites and metasediments. The area is also located in a peneplain consisting of various kinds of rocks such as older granite, schist and quartzite in various compositions (Russ, 1952). The granite part comes in two groups – The younger and the older. The older granites are more widespread. They form smooth rounded hills, which characterize the landscape of the basement complex area. The elongated hills occasionally rise up to 200 metres. The younger granites, which are of Jurassic age, intrude into the basement complex in the plateau area. Furthermore, there are tertiary sediments, which have resulted in the vast mineral deposits in the study area. These rocks have been variably metamorphosed and granitized through at least two tectonic-metamorphic cycles so that they have been largely converted to migmatites and granite–gneiss. These rocks have had a complex history involving several phases of orogenesis and subsequent regional uplift and depression. These movements have determined the main pattern of drainage and the regional pattern of erosion and sedimentation since early cretaceous times. The basement complex rocks were subjected to sub-aerial denudation for millions of years so that the original mountainous terrain had been reduced to plain relief (Zamfara State Agricultural and Rural Development Authority, 2008). Rocks of sedimentary series (sedimentary basins) cover some parts of the surface. The sediments occur as sandstones, clayey grits, shale and as calcareous beds, which were

3.2.3.4 Vegetation

Shinkafi LGA is located within the transition of the Sudan-Sahel Savanna ecological zone at the extreme north of Zamfara state. The landscape is largely dotted by few scattered trees of great economic value. The natural vegetation is of shrubby woodland type interspersed by savanna grassland usually 1.0 to about 1.5 metres at a height of the growing season and the vegetation is largely deciduous. The trees hardly rise above 10 metres and several species of dominant economic trees such as the acacia, the date palm, the shea-butter, gum Arabic, *neem* tree, baobab and silk cotton are the most common vegetation (Abaje, 2007b). The vegetation cover is mostly secondary in nature because it has been modified by anthropogenic factors such as bush burning, over-cultivation; firewood gathering and cutting of trees (deforestation) used for building and construction purposes. Additional pressure is also put on the pasture resources by livestock from other Sahel countries (FRN, 2000). This area constitutes the main source of fodder and grazing land for livestock. Hence climatic climax vegetation no longer exists in this zone today.

3.2.3.5 Drainage

The entire state has four major rivers namely: Ka, Bunsuru, Gagare and Zamfara. There are also several lakes in Zamfara. The study area has a lake known as Hobni, which drains the entire area. Owing to the high water deficit associated with this region, the state government has been compelled to explore and exploit groundwater sources, which are available in the region than surface water. Currently, the method of extraction of groundwater through boreholes and hand-dug wells is tapping one or more of the aquifers underlying the area. However, the over-pumping of ground water could result to a continuous fall in the water table (FRN, 2000)

3.2.4 Human Setting

3.2.4.1 Population

The population of Zamfara State was estimated to be about 2,231,402 people as at the 1991 population census. However, in the recent National Population Commission head count conducted in 2006, the population rose to about 3,278,873 - *Male*: 1,641,623 and *Female*: 1,637,250 with 254,411 farm families. In that same census year, Shinkafi LGA recorded a population figure of about 135,649, majorly occupied by the Hausa and Fulani speaking groups with several other ethnic groups migrating into the area over time (Official Gazette, 2006; Federal Polytechnic Kaura Namoda, 2010). There are seven wards in Shinkafi LGA namely: - Badarawa, Bula, Galadi, Jangenu, Karsasa, Katuru and the LGA headquarters at Shinkafi.

3.2.4.2 Agricultural and socioeconomic land-use

Farming is the pride of Shinkafi LGA and the entire state population with almost all its inhabitants as specialized grain croppers. About 85 – 90% of the people are engaged in farming as their mainstay of economic development. The agricultural land use system in Zamfara State is broadly classified into rural residential, semi-urban residential and rural type. Mixed cropping is the predominant type of farming system in the state with the use of traditional inefficient equipment and hand tools. The farming system in Shinkafi LGA permits the production of grains and leguminous crops. The major rain fed crops of great economic value include drought-tolerant crops like Millet, Sorghum and Maize varieties - taking up to 54% of the total cropped area. The production of Sesame is also gaining more popularity. Cowpea, Cotton and Rice are also widely grown though with some ecological limitations. Groundnuts, though formerly the second largest product in Nigeria, is giving way to cereal crops. *Fadama* crops in the area such as tomatoes, pepper, lettuce and sugar cane are usually planted as sole crops majorly during the rainy season. Conservation farming is also on the increase in the area. The inhabitants of the state also engage in massive livestock development such as

the increased rearing of cattle, sheep, goats, poultry, camel and donkeys. Thus, agriculture in the region has become quite intensive.

The region also has wide networks of good inter- and intra- state roads with the award of contracts for further expansion and improvement supported and sponsored by the state government. A railway system connecting Gusau and Kaura Namoda also links Shinkafi to most parts of the country. This rail line is served by a station at the terminus of a branch line of the western line of the national railway network (Federal Polytechnic, Kaura Namoda, 2010).

Some ministry parastatals and commercial centres such as banking facilities and business ventures also exist in the area. Examples include the Shinkafi Local Government Area Secretariat, Nigerian Agricultural Cooperative and Rural Development Bank (NACRDB), First Bank of Nigeria (FBN) and the United Bank of Africa (UBA). The establishment of new and existing settlements over time has modified the settlement pattern within the LGA.

3.2.4.3 Manufacturing industries

The study area is also home to both agro-allied and mineral industries. Investment opportunities abound in agro-allied industries such as the British-American Tobacco Company, oil mills, flour mills, rice mills, tomato canning, ginneries, tanneries, a sweet factory, bakeries, hide and skin, meat processing industries, furniture, calabash and shoe-making factories. Furthermore, Shinkafi LGA has a very sound industrial development base due to the availability of commercial quantities of clay, lead, alluvial gold, granites, chromate, charnovite, asbestos/talc, silica, limestone, feldspar, laterite, phosphate, iron-ore, gypsum, bronze, gravite, galena and potash.

3.2.5 Major Crop Production in Shinkafi LGA, Zamfara State

3.2.5.1 Millet

Millet is the most important and extensively grown cereal food crop in northern Nigeria. The crop grows best on sandy loam soils that are deep and well drained. The millet varieties include the

Pearl millet (*Pennisetum glaucum*), Finger millet (*Eleusine coracana*), Proso millet (*Panicum miliaceum*), Guinea millet (*Brachiaria deflexa*) and Foxtail millet (*Setaria italica*). Local varieties of millet grown in the state include the early *gero* varieties such as *Sammil 1(Ex-Borno)* and *Solsat LCIC 9702* which grows in any part of the state if sown early and the local *gero* varieties of different sorts like the *Zango* and *Wuyan Bajimiand Zamfarawa* which are known to give reasonably good yields. However, the improved long season *Sammil 4 (Maiwa* composite*)* which takes 100-120 days to mature is recommended for all parts of Zamfara state except the Sahelian areas such as Shinkafi.

3.2.5.2 Sorghum (*Guinea corn)*

This is the second most important cereal crop after millet. It is grown in all parts of the state. Sorghum grows best in sandy loam to clay-loam soils that are well drained and fertile for best yield. There are three varieties of sorghum; the Long season Short *Kaura 5912* variety (120 to 150 days), which does not do well in the state; the Medium duration *KSV-8* variety (100 to 120 days) and the Short duration *ICSV line* (75 to 80 days).

3.2.5.3 Maize *(Zea mays)*

It is the third most important staple food crop grown in the state. It grows best on well-drained sandy loam to loamy soil with good water holding capacity. Varieties include the open pollinated ones such as *Sammaz 9* and *Sammaz 10*, and the hybrid varieties *V* (Maurya, *et al.*, 1995).

3.3 Methodology

3.3.1 Types and Sources of Data

The types of data needed for this study include:

i. Daily rainfall data of Zamfara state for 40 years (1971-2010)

ii. Millet, Sorghum and Maize yield data (in tonnes per hectare) for the study area for 15 years (1996-2010).

Daily rainfall data from Gusau station was sourced from the archives of the Nigerian Meteorological Agency (NIMET), Oshodi, Lagos harnessed with that of the Sokoto and Zamfara states Agricultural and Rural Development Authority record archives (SARDA; ZARDA). Sawa (2010) also chose the synoptic station based at Gusau (Station No. 1206.14) to represent the entire state because of the following reasons;

a. the Nigerian Meteorological Services Department, Oshodi had confirmed that the station's data are reliable enough for researches of this type due its ability to record daily climatic readings,
b. there is a long and continuous period of daily rainfall records for the station, and
c. there was no relocation of the station since its establishment in 1942; so this station is deemed fit to be used in this study.

Grain production records of Millet, Sorghum and Maize for Zamfara state was obtained from the Sokoto State Agricultural Development Project (SADP) from 1976-1995 and merged with data from 1996-2010, gotten from the Zamfara State Agricultural Development Project (ZADP) at Gusau. Since Zamfara State was officially carved out from the then Sokoto in 1996, it therefore meant that subsequently, the present ZADP was bifurcated from the erstwhile SADP and so, both still shared corresponding and complimenting data figures.

iii. Socioeconomic data and coping strategies of grain farmers to climate change was obtained from the administration of questionnaires and conduction of interview sessions with respondents resident in Shinkafi LGA of the state.

3.3.2 Sample Size and Sampling Techniques

In determining the sample size for this research, the Summer (2013) method as used in Kansas school districts was adopted which states that for an area with a total population of at least 135,000, the sample size for the 'categorically eligible' (as regards political status, provision of incentives, financial support and care e.t.c) should be 203. Since our total population was 135, 649; the sample

size of 203 became suitable. But for the purpose of accuracy, fair coordination and equal representation of each sampled communities, 204 questionnaires were produced. Respondents were selected by means of random sampling method. The study population was arrived at by selecting community and household heads of three communities out of the seven communities. They were systematically selected based on every third community at interval in alphabetical order namely; Badarawa, Jangeru and Shinkafi. In-depth interview sessions and focus group discussions was also granted to agricultural experts and extension officers of ZARDA who have been conversant with the agro-climatic system in the localities of the study area. The content of the questionnaires was structured into three perspectives as follows;

i. Respondents' personal biodata – This investigates the socioeconomic status of the farmers such as sex, age, marital status, political status, educational qualification, farm size etc.
ii. Integrated vulnerability – This assesses the combined climatic and socioeconomic impacts of climate change on the farmers' status in the three communities.
iii. Farmers' coping strategies – It examines and appraises the traditional and modern techniques of grain farmers employed in curbing adverse effects of climate change in the study areas.

The types of response structure used while administering the questionnaires were both the scale and open-ended questions format. The scale question recognized the degree of intensity in the feelings of respondents while the open-ended question allowed the respondents to express their own opinion.

3.3.3 Methods of Determining Rainfall Amounts and Grain-Crop Yield

3.3.3.1 Annual rainfall amounts

Annual rainfall was obtained from the summation of daily rainfall amounts recorded in millimeters from 1971-2010 for each year.

3.3.3.2 Crop yield data

Yield data for Millet, Sorghum and Maize was obtained by dividing the yearly production (tonnes) of each crop by the area of arable land (hectares) used for cultivating each crop. The total yield for each crop were also summed up and the percentages for each crop from 1996 to 2010 were determined and used in the analysis.

3.3.4 Methods of Data Analysis

3.3.4.1 Test of normality

The standardized coefficient of Skewness (Z_1) and Kurtosis (Z_2) statistics as defined by Brazel and Balling (1986) were calculated for testing the normality of the annual rainfall series (1971-2010) and the 10-year non-overlapping sub-periods (1971-1980; 1981-1990; 1991-2000 and 2001-2010). The Gusau station received over 85% of its annual rainfall totals in these years and these are therefore used to test for the normality in rainfall series. The standardized coefficient of Skewness (Z_1) was calculated as;

$$Z_1 = \left\{ \left[\sum_{i=1}^{N} \frac{(x_i - \bar{x})^3}{N} \right] \Big/ \left[\sum_{i=1}^{N} \frac{(x_i - \bar{x})^2}{N} \right]^{3/2} \Big/ \left[6/N^{1/3} \right] \right\} \text{ ---------- (1)}$$

Moreover, the standardized coefficient of Kurtosis (Z_2) was determined as

$$Z_2 = \left\{ \left[\sum_{i=1}^{N} \frac{(x_i - \bar{x})^4}{N} \right] \Big/ \left[\sum_{i=1}^{N} \frac{(x_i - \bar{x})^2}{N} \right] \Big/ \left[24/N-3 \right]^{1/3} \right\} \text{ ---------- (2)}$$

Where; $\bar{x}$ is the long-term mean of x_i values and

N is the number of years in the sample.

These statistics were used to test the null hypothesis that the individual temporal samples came from a population with a normal (Gaussian) distribution. If the absolute value, Z_1 or Z_2 is greater than 1.96, a significant deviation from the normal curve is indicated at the 95% confidence level.

For the purpose of this research, only the log transformation of base 10 and Lambda transformations of Box and Cox (1964) were used to normalize the abnormal rainfall series. The Microsoft Excel package was used to accomplish this.

3.3.4.2 Trends in rainfall attributes

The temporal climatic changes over the years were examined by employing the time series analysis between 1971 and 2010. Standardized anomalies of total rainfall amount and duration (number of rainy days) of rainy season were plotted against the year of record and the decadal moving means was calculated. Simple statistical technique to examine the moving mean over longer periods, and moving the group mean one year at a time was used. Given a set of numbers; $y_1, y_2, y_3, \ldots . y_n$. A running mean of order, n is defined to be given by the sequence of arithmetic means as follows;

$$\frac{y_1+y_2+\ldots .+y_n}{n} \quad , \quad \frac{y_2+y_3+\ldots .+y_n+1}{n} \quad , \quad \frac{y_3+y_4+\ldots .+y_n+2}{n} \qquad \text{---------- (3)}$$

The sums of the numerators of equation 3 are called the moving totals of order n. Here, the order is 10. In this work, the 5-year and 10-year running means (moving averages) were used in order to smoothen the time series thereby removing 'noise' caused by short term fluctuations (reducing the irregular fluctuations) and highlighting those that were regular as expressed by Hoskins (1964).

The Annual rainfall mean($\overline{x}$), standard deviation (SD) and the coefficient of variation (CV) were calculated thus;

$$\overline{x} = \frac{\sum x}{n} \qquad \text{---------- (4)}$$

$$SD = \sqrt{\frac{\sum (x-\overline{x})^2}{n-1}} \qquad \text{---------- (5)}$$

$$CV = \frac{SD}{\overline{x}} \times 100 \qquad \text{---------- (6)}$$

Where; x is the value of rainfall observation and

n is the number of rainfall observations.

Trends to relate the long-term mean and the periodic means of decadal non-overlapping sub-periods (1971-1980, 1981-1990 through 2000-2010) and the 20-years overlapping sub-periods (1971-1990, 1981-2000 and 1991-2010) were also illustrated. This reveals the sub-periods that rainfall amounts in Zamfara state were high above normal and low below normal, thus showing periodic years of climatic vulnerability.

3.3.4.3 Testing for rainfall trends

The Mann-Kendall Rank Statistics (τ) was used to investigate secular trends in both series in order to show whether there were any monotonic increase or decrease in the average values between the beginning and the end of the rainfall series. A statistical parameter is derived thus;

$$t = \frac{\left(\sum_{i=1}^{N-1} N_i \right)}{N\,(N-1)} \quad \text{---------- (7)}$$

Where N_i = Number of subsequent terms (X_1+1 *to* X_N) in the time series that exceeded X_1

N = Number of values in the series

The Mann-Kendall Rank Statistics (τ) was also subjected to statistical parameter, Z.

$$Z = \frac{t}{\left(\frac{2\,(2N+5)}{9N\,(N-1)} \right)^{1/2}} \quad \text{---------- (8)}$$

If Z exceeds the critical value of 1.96 at 95% confidence level, we may conclude that some form of trends exist in the non-random variance structure. The Microsoft Excel package was used to analyze this.

3.3.4.4 Comparisons between trends in pattern of grain yields and rainfall amounts

Total Millet, Sorghum and Maize yields were plotted in crop yield percentages against the periods to show changes in each crop yield pattern as at the period when data was available (1996-2010). This trend depicted years in which grain production was high or low in Zamfara state.

More so, the above grain yield pattern was used to compare with rainfall trends from 1996 to 2010 to determine whether the impacts of rainfall amounts was responsible to the outcome of crop yield in the study area. The Microsoft Excel package was used to analyze this.

3.3.4.5 Crop-climate relationship test

The Pearson's Product moment Correlation coefficient *(r)* is a form of linear regression analysis used to ascertain the strength or index of the relationship between the yields of the three-grain crops and rainfall attributes from 1996 to 2010. Pearson **(*r*)** was employed because the distribution is bivarite, continuous and normal. Both crop yield data and annual rainfall data were harmonized by converting the yield records to percentage before analyzing them. The value ***r***, must fall within the ranges of ($-1 \leq 0 \leq +1$). If the value ***r*** tends towards +1, it indicates a perfect positive relationship. If it tends towards -1, it shows a perfect negative relationship. If it tends towards zero, there is no relationship. The Microsoft Excel package was used to accomplish this. The mathematical expression is;

$$r = \frac{\sum(x - \bar{x})(y - \bar{y})}{\sqrt{\sum(x - \bar{x})^2 . \sum(y - \bar{y})^2}} \quad \text{----------} \quad (9)$$

Where; **x** is the attribute of each yearly rainfall,

y is the yearly crop yield,

$\bar{x}$ is the mean of each of the rainfall attribute

$\bar{y}$ is the mean of the yearly crop yield.

3.3.4.6 Crop-climatic Productivity Index

Sawa (2002) has already established that from 1971-2000, there was significant dryness in most parts of northern Nigeria including Zamfara state. Nevertheless, this study attempts to continue the analysis of rainfall series from 1971-2010 and investigate how grain farmers are vulnerable to

climate change with the occurrences of wet and dry years in the study area. In order to determine this, the rainfall series were subdivided into;

a. 10-year non-overlapping sub-periods (1971-1980, 1981-1990, 1991-2000 and 2001-2010), in order to know wet decades and dry decades, and
b. 20-year overlapping sub-periods (1971-1990, 1981-2000 and 1991-2010), in order to determine sub-periods that were wet and those that were dry.

The periodic means of each of these sub-periods were then determined and subsequently used to compare with the Crop-climate productivity index in the northern fringes of Zamfara state where Shinkafi LGA is located, as expressed by Maurya *et al.*, (1995) in Table 3.2. These analyses will further help to show those periods in which grain farmers were vulnerable to climate change and indicate those grains crops, which were best suited for planting in each of the sub-periods and able to withstand harsh climatic conditions such as drought and flooding occurrences (if any).

Table 3.2: Grain crop-climate Productivity Indices for Sudano-Sahelian regions in Nigeria

Grain Crops	Mean Rainfall Requirements	Maturity Days	Growing Season	Yield Requirement (tones/hectare)
Millet (Early and local *gero* varieties)	650 mm	65 – 90 days	2- 3 months	1.0 - 1.5
Sorghum (Medium Short duration varieties)	675 mm	Medium-to-short (75 - 100 days) Medium-to-late (110 – 130 days)	$2^{1}/_{2}$ – 4 months	1.5 - 2.5
Maize (Short duration varieties)	900 mm	90 – 120 days	3 – 4 months	1.5 – 2.5

Source: Maurya *et al.*, (1995) *Crop production manual.*

3.3.4.7 Climatic (Impact) Vulnerability index

A Vulnerability index value is typically a single number far more useful than raw data used for decision-making. It is a quantifiable measure of the drought and flooding index values used in assessing every agricultural or seasonal year (Keyantash and Dracup, 2002).

In this study, the Normalized Rainfall Index (NRI) was used in depicting periods of different vulnerability intensities based on drought and flooding occurrences (Oladipo, 1993b). The Normalized Rainfall Index (NRI) is a measure of drought intensity using annual or seasonal rainfall totals and the standard deviation to indicate the shortage of water of any given season. The NRI for a given station as defined by Türkes (1996) is computed with;

$$NRI = \frac{Rsy - \bar{Rs}}{Ss} \quad \text{----------} \quad (10)$$

Where; Rsy = the rainfall total for the station during a year (or a season)

$\bar{Rs}$ = the long-term mean (of the period specified for the station) and

Ss = Standard deviation of the annual (or seasonal) rainfall total for that station.

The table below is a modified version of classifications of the index as defined by Türkes (1996).

Table 3.3: Remodified Classes of NRI values

Index	Character of rainfall	Farmers' Vulnerability status
1.31 or more	Very wet	Highly Vulnerable
0.86 to 1.30	Moderately wet	Vulnerable
0.51 to 0.85	Mildly wet	Slightly vulnerable
0.50 to -0.50	Near normal	Not vulnerable
-0.51 to -0.85	Mild drought	Slightly vulnerable
-0.86 to -1.30	Moderate drought	Vulnerable
-1.31 or less	Severe drought	Highly Vulnerable

3.3.4.8 Integrated vulnerability and farmers' adaptive strategies to climate change

Descriptive statistics such as tables, bar graphs, a linear graph and a pie chart were presented in frequencies and percentages, and used to summarize respondents' responses to the questionnaire items. These were meant to determine the *Socioeconomic vulnerability* of grain farmers to climate change. It was achieved using the socioeconomic status of the farmers such as sex, age, marital status, political status, educational qualification, farm size etc. The *Biophysical* or *Climatic vulnerability* was

also analyzed from the various statistical analyses of rainfall characteristics over time (1971-2010). The socioeconomic and climatic vulnerabilities both served as major approaches and indices in determining and explaining the *Integrated vulnerability* of climate change on income, crops yields and farmers' household and overall livelihood in the three sampled communities.

In addition, traditional farming strategies for mitigating and adapting to climate change in Shinkafi LGA were appraised and new modern techniques were also proposed. In that way, the agricultural sector of the state will be revived for sustainable food security not only in the driest regions of the state but also in northern Nigeria and in the nation as a whole.

CHAPTER FOUR
PRESENTATION OF RESULTS AND DISCUSSION

4.1 Introduction

This chapter shows the application of several quantitative approaches in this research in analyzing climatic and socioeconomic vulnerability of grain farmers to climate change in the state and in Shinkafi LGA. Statistical parameters were used to investigate rainfall amounts and grain crop yields while qualitative measures were employed in assessing the respondents' responses to the impacts of these changes on their general sustenance and livelihood in the area.

4.2 Statistical Analysis of Rainfall Characteristics

4.2.1 Normality test

The annual rainfall series for Zamfara State was subjected to the normality test using the Coefficients of Skewness (Z_1) and Kurtosis (Z_2) as described by Brazel and Balling (1986) as explained in Table 4.1. The Coefficient of Skewness (Z_1) was 1.358 and that of Kurtosis (Z_2) was 1.861. This indicated that the rainfall series had no significant deviation from the normal curve (1.96) at 95% confidence level. Hence, it was normally distributed.

Table 4.1: General Statistics of Annual Rainfall for Gusau station, Zamfara State (1971-2010)

Total amount(mm)	Mean (mm)	SD (mm)	CV(%)	Max (mm)	Min (mm)	Range (mm)	τ		Z_1	Z_2
							τ	Z		
29250.78	731.27	468.15	64. 02	1597.5	298.5	1299	0.092	0.836	1.358	1.861

Source: Data Analysis for Gusau station, Zamfara State (2012)

4.2.2 Long-term statistics of annual rainfall amount

The standard deviation, **SD** (468.15mm) decreased below the **Long-term Mean** (731.27mm) while the Coefficient of Variation, **CV** was 64%. The general results are summarized in Table 4.1.

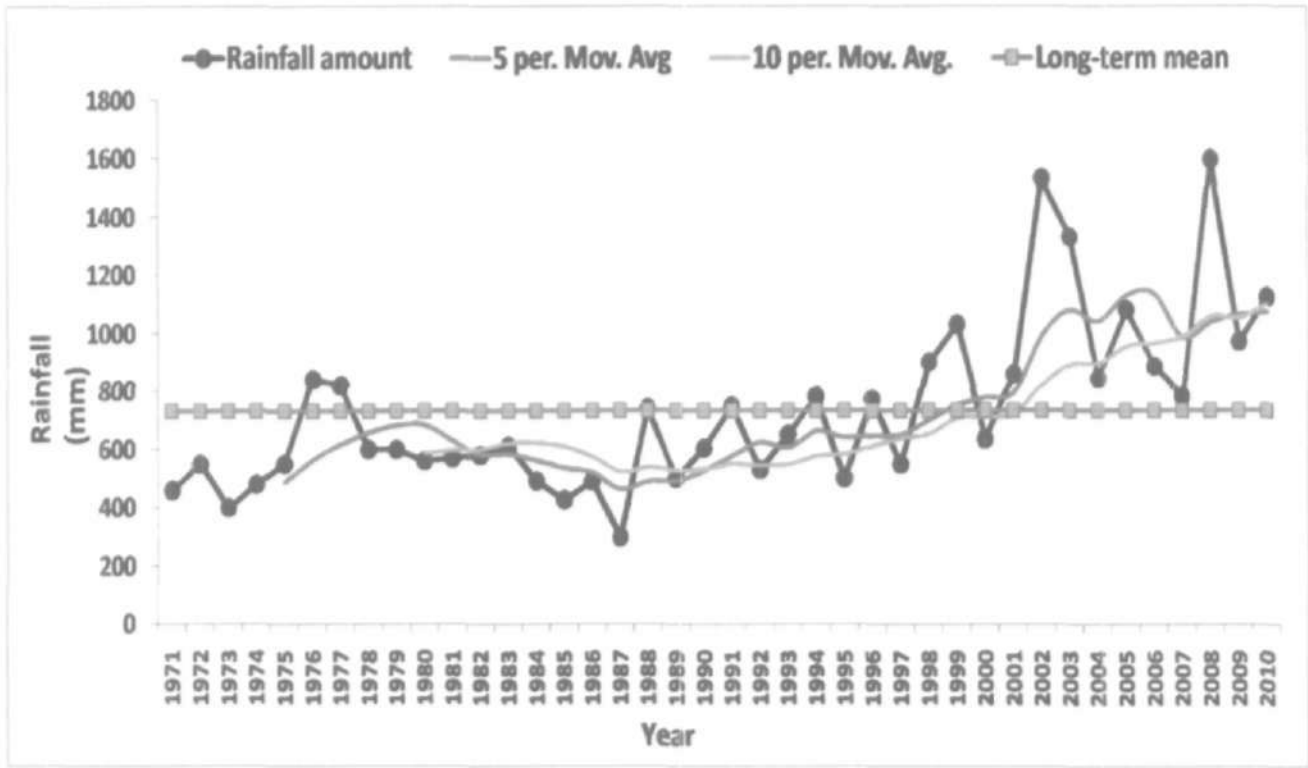
4.2.3 Test for trends in rainfall amounts

The rainfall series for Gusau station were also subjected to the Mann-Kendall's Rank test statistics (τ) to determine whether there was any significant rise or fall in the annual rainfall amounts.

The results are shown in Table 4.1. The calculated r was 0.092 with a Z value of 0.836. There was no significant trend shown by this test at 95% confidence limit. This depicts that there was monotony in rainfall trends below the long-term mean from 1971 to the late 1990's.

4.2.4 Trends in annual rainfall pattern

To further specify the character of the rainfall during the period, the 5-year and 10-year running means as presented in Figure 4.1 were used to filter and smoothen the rainfall series.



Source: ***Data Analysis for Gusau station, Zamfara State (2012)***

Figure 4.1 - Trends in Annual Rainfall in Gusau station, Zamfara State (1971-2010)

The 5-year running mean (or moving average) generally showed annual rainfall amounts below the long-term mean from 1971 to 1998. However, after then, there was a rise in the rainfall above the long-term mean until the end of the data (1999-2010). The 10-year running mean also followed the same pattern as the former. However, from 1971-2001 it was below the long-term mean, and from 2002 until the end of the period, there was an accelerated rise above the mean.

This reveals that from the early 1970s to the early millennium, the state generally experienced fluctuating rainfall amounts below normal, giving rise to periods of long dryness and drought occurrences in the area. However, from the early millennium (2002) until the end of the study period, rainfall attributes were significant and steadily increased above the long-term mean.

4.2.5 Relationship between long-term mean and periodic means of rainfall amounts

The 10-year non-overlapping sub-periods (1971-1980, 1981-1990, 1991-2000 and 2001-2010) and the 20-years overlapping sub-periods (1971-1990, 1981-2000 and 1991-2010) were both used to determine sub-periods that were wet above normal and those that were dry below normal. They were then used to relate the long-term mean of rainfall amounts in the area.

Decadal statistics (non-overlapping sub-periods) of the annual rainfall of Gusau station are presented in Table 4.2. The decadal rainfall means were below the long-term mean from the first decade (1971-1980) to the third decade (1991-2000). However, in the last decade, 2001-2010, there was an accelerated rise above the long-term mean.

Table 4.2: Decadal Statistics of Annual Rainfall Amounts for Gusau station, Zamfara State

Decadal Periods (Non-overlapping periods)	Long term mean (mm)	Mean decadal rainfall (mm)
1971-1980	731.27	586
1981-1990	731.27	530.87
1991-2000	731.27	708.93
2001-2010	731.27	1099.28

Source: Data Analysis for Gusau station, Zamfara State (2012)

The 20- years overlapping sub-periods (1971-1990, 1981-2000 and 1991-2010) was also used to compare with the long-term mean as summarized in Table 4.3. The overlapping means were below the long-term mean on the first and second periods (1971-1990 and 1981-2000 respectively). However, in the last period, it rose above the long term mean.

Table 4.3: 20-years Overlapping Statistics of Annual Rainfall Amount in Gusau Station

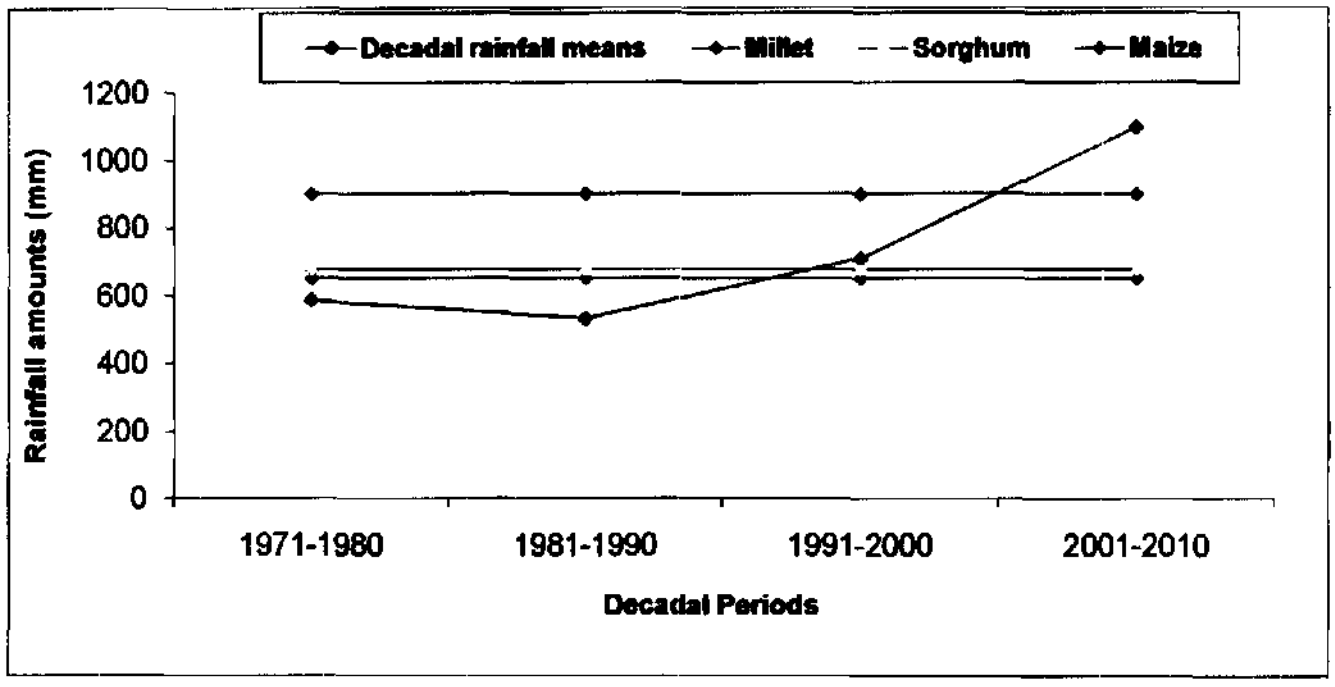
20-years overlapping Periods	Long term mean (mm)	Mean amount of rainfall (mm)
1971-1990	731.27	558.44
1981-2000	731.27	619.90
1991-2010	731.27	904.10

Source: Data Analysis for Gusau station, Zamfara State (2012)

From the above table, it can be concurred that drought periods occurred between 1971 and 2000, but after that, annual rainfall amounts began to increase from the early millennium till the end of the period. Thus, indicating a tendency towards increasing rainfall amounts in the future.

4.2.6 Crop-Climate Productivity Index

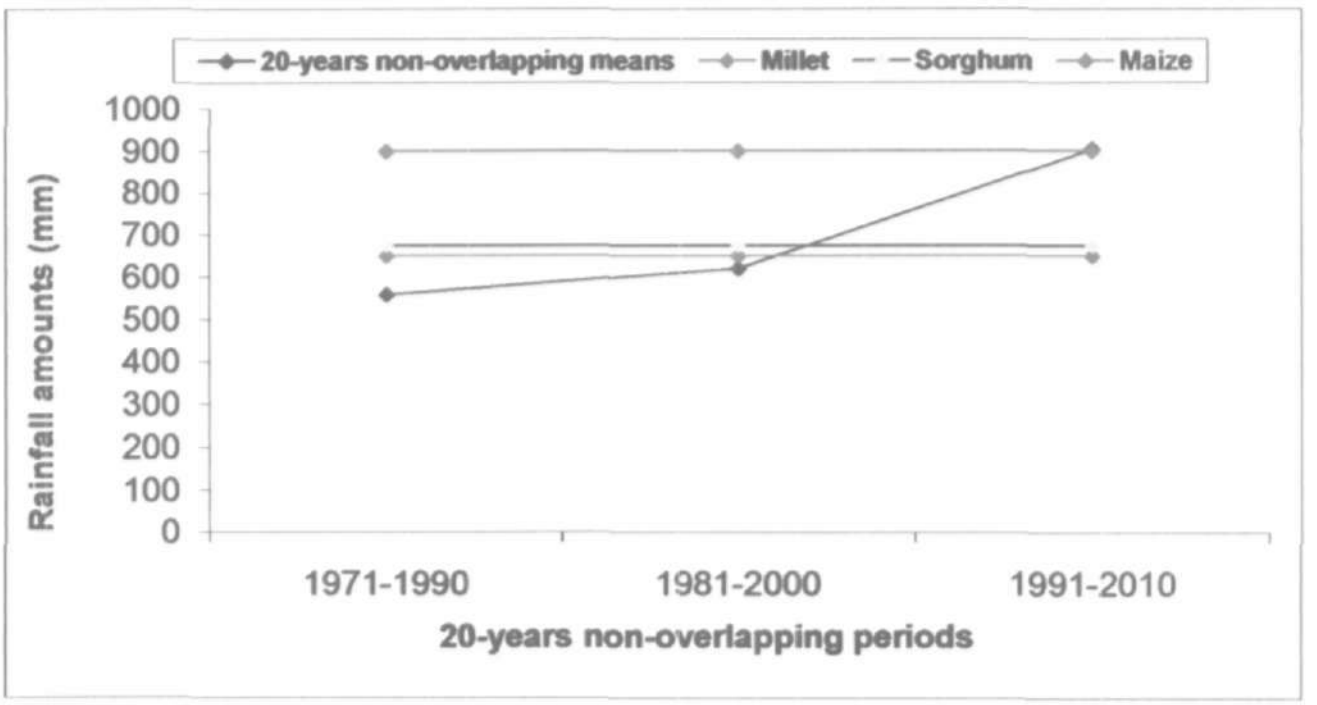
The sub-periodic means as presented in Tables 4.2 and 4.3 were both used to compare with the rainfall requirements for each of the state's economic grain crop namely; Millet, Sorghum and Maize. Maurya *et al.*, (1995) in Table 3.2 expresses the Crop-climate productivity Index for the then Sokoto state of which the northern fringes of Zamfara state especially Shinkafi LGA, is located.



Source: Data Analysis for Gusau station, Zamfara State (2012)

Figure 4.2 - Trends in the Decadal non-overlapping Mean Rainfall requirements for Grain crops

From Figure 4.2, the mean decadal rainfall periods of 1971-1980 and 1981-1990 (586mm and 530.87mm respectively) did not meet up with the rainfall requirements of Millet, Sorghum and Maize crops invariably meaning that there were low yields in the production of these crops during the first and second periods. However, in the third period, (1991-2000), mean rainfall amount (708.93mm) only met the requirements of Millet and Sorghum and that of 2001-2010 (1099.28mm) aided in the production of Maize with exception to flooded years. Millet and Sorghum thrives well in such situation provided temperatures are also high. Howbeit, the tendency for flood occurrences cannot be overemphasized because if increases in rainfall amounts persist in future, it could lead to higher vulnerability impacts on the part of farmers.



Source: ***Data Analysis for Gusau station, Zamfara State (2012)***

Figure 4.3 - Trends in 20 years overlapping Mean Rainfall requirements for Grain crops

The 20-years non-overlapping sub-periodic means as shown in Figure 4.3 also showed fluctuating rainfall trends like that of the decadal statistics but with insignificant difference. In the first period (1971-1990), the mean annual rainfall (558.44mm) could not meet up with Millet, Sorghum and

Maize rainfall requirements. In the second period, (1981-2000) only Millet survived the drought season, but in the last period (1991-2010), all of the crops met the rainfall requirement.

The Crop-Climate Productivity Index for the two sub-periods indicate that grain farmers were highly vulnerable to drought periods from 1971 to the late 1990's while grain production improved from year 2000 to the end of the period. However, further persistent increase in rainfall amounts in the state could lead to higher vulnerability to flooding in the area and hamper production due to the mean rainfall requirement of majorly Millet and Sorghum while Maize would easily cope with rainfall increase.

4.2.7 *Comparison between trends in rainfall amounts and pattern of grain yields*

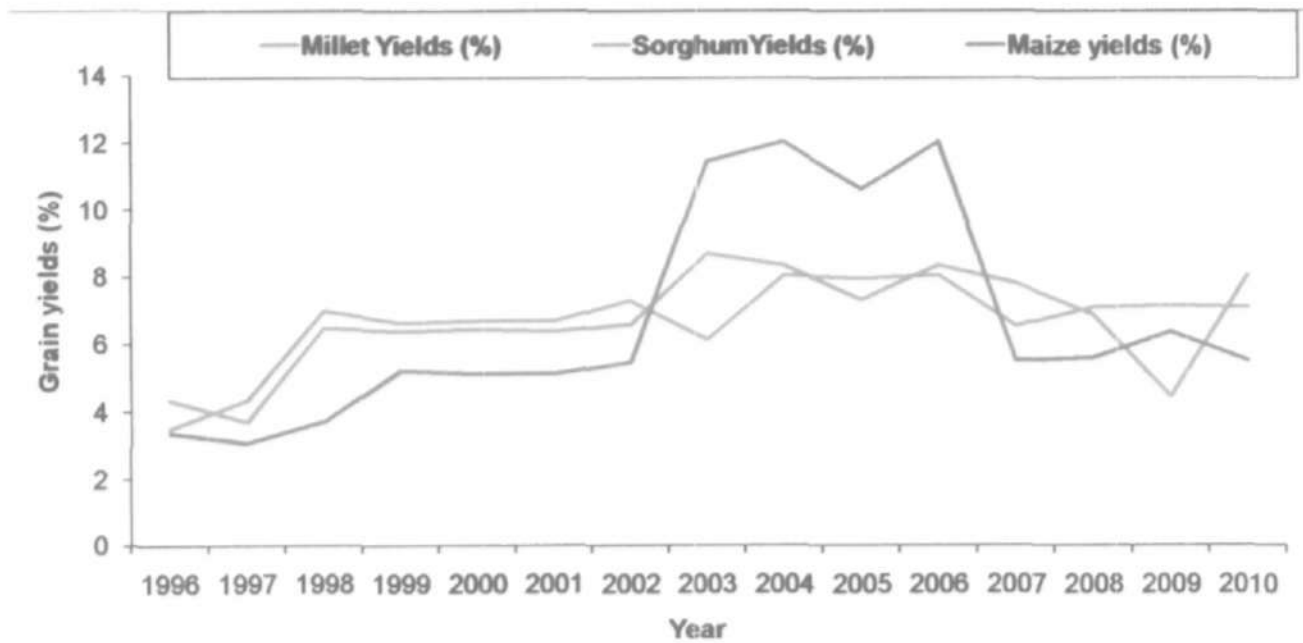
Table 4.4 shows the yield (Kg/Ha) of major grain crop produced in Zamfara State from 1996 to 2010. The trends for Millet, Sorghum and Maize were analyzed as portrayed in Figure 4.4.

Table 4.4: Grain Yields and Percentages in Zamfara State from 1996 to 2010

YEAR	MILLET		SORGHUM		MAIZE	
	Yield (Kg/Ha)	Percentage (%) of yields	Yield (Kg/Ha)	Percentage (%) of yields	Yield (Kg/Ha)	Percentage (%) of yields
1996	700	3.51	890	4.33	700	3.37
1997	860	4.32	760	3.70	640	3.08
1998	1390	6.98	1330	6.48	770	3.71
1999	1320	6.63	1310	6.38	1080	5.20
2000	1330	6.68	1320	6.43	1060	5.10
2001	1330	6.68	1310	6.38	1060	5.10
2002	1450	7.28	1350	6.57	1130	5.44
2003	1220	6.13	1780	8.67	2380	11.45
2004	1600	8.03	1710	8.33	2500	12.03
2005	1580	7.93	1500	7.30	2200	10.59
2006	1600	8.03	1710	8.33	2500	12.03
2007	1300	6.53	1600	7.79	1140	5.49
2008	1410	7.08	1410	6.87	1160	5.58
2009	1420	7.13	910	4.43	1320	6.35
2010	1410	7.08	1650	8.03	1140	5.49
	19920	**100**	**20540**	**100**	**20780**	**100**

Source: ***Yield Data Zamfara State Agricultural and Rural Development Project (ZARDA 2012)***

On the overall basis, the highest yield for the period was recorded in Maize production (20780 Kg/Ha), with its peaks in 2004 and 2006 (12.03%) while the overall lowest yield was recorded in 1997 (3.08%). Sorghum yield was next; highest in 2003 (8.67%) and lowest in 1997 (3.70%) and then Millet; highest in 2004 and 2006 (8.03%) and lowest in 1996 (3.51%).



Source: ***Data Analysis for Gusau station, Zamfara State (2012)***

Figure 4.4 - Trends in Millet, Sorghum and Maize yields in Zamfara State (1996-2010)

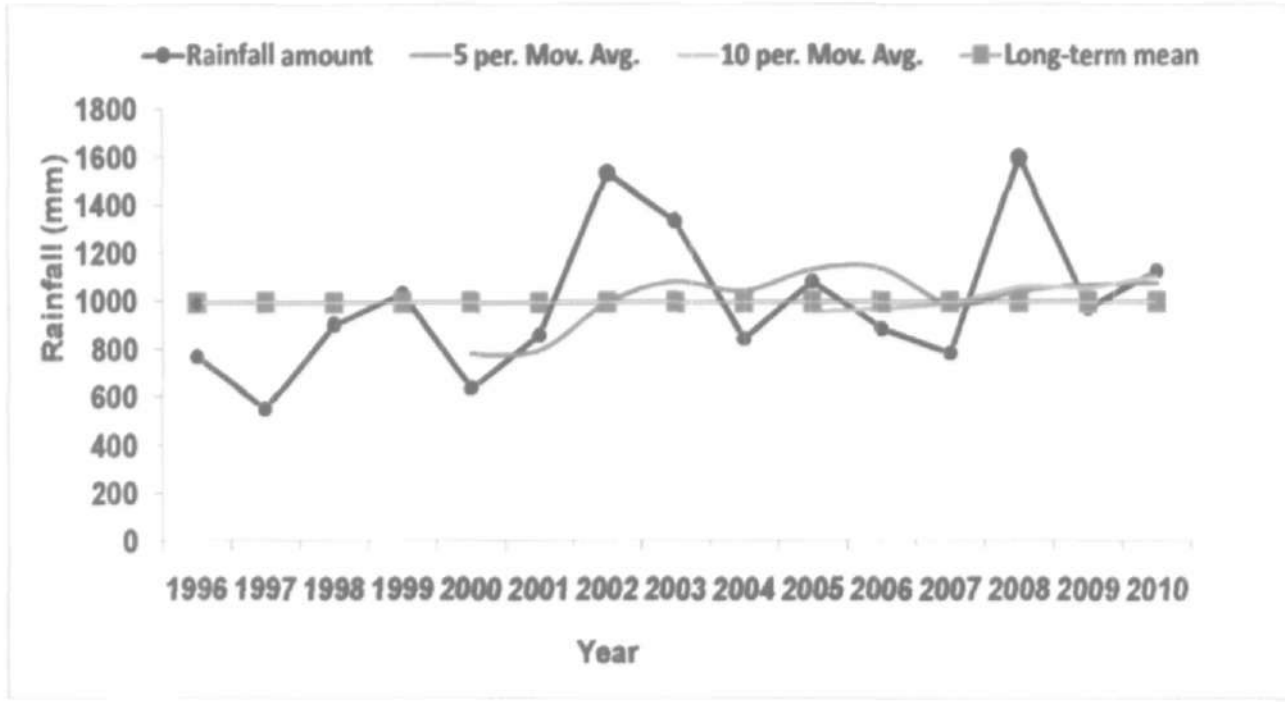
The figure above reveals a fluctuating yield trend in grain production. Although significant increases in the yields occurred from 1997 to 1998 and between the early- to the late- millennium (with Maize more pronounced), yet it was not sustained throughout the period. The yield was monotonous within the late 90's and early millennium, and a drop occurred in 2007 to 2009.

Table 4.5: General Statistics of Annual Rainfall for Gusau station, Zamfara State (1996-2010)

Total amount(mm)	Mean (mm)	SD (mm)	CV(%)	Max (mm)	Min (mm)	Range (mm)	Z_1	Z_2
14875.08	991.67	302.44	30.50	1597.5	548.66	1048.84	0.781	0.096

Source: Data Analysis for Gusau station, Zamfara State (2012)

The table above summarizes the annual rainfall statistics from 1996 to 2010 coinciding with the period of grain production in the state. The annual rainfall amount was plotted against the periods as seen in Figure 4.5 with fluctuating trends in the running means (or moving averages). However, the 5-year moving average was slightly above the long-term mean (991.67mm) from 2002 to the end of the period while the 10-year moving average remained the same with the mean from 2005 to 2007 but slight increased above normal till the end of the period.



Source: ***Data Analysis for Gusau station, Zamfara State (2012)***

Figure 4.5 - Trends in Annual Rainfall in Gusau station, Zamfara State (1996-2010)

In comparing the yield pattern with that rainfall trend from 1996-2010, it can be deduced that the sharp increases in grain yields from 2002 to 2007 also coincided with that of the 5-year running mean of annual rainfall. This shows that increases in rainfall amounts were responsible for increase in grain production in the state, and vice versa.

4.2.8 Crop-Climate relationship

The Pearson's Product moment Correlation coefficient *(r)* was used to relate rainfall amounts and Millet, Sorghum and Maize yields from 1996-2010, as presented on Table 4.6. The Pearson's Product Moment Correlation coefficient *(r)* showed that Millet, Sorghum and Maize yields were positively related with rainfall during the periods but not significant at 0.05 level of significance. The positive relationship of rainfall with each of the grain crops indicates that higher rainfall increases the yield of these crops and vice versa.

Table 4.6: Crop-Climate relationship from 1996-2010 in Zamfara State

Pearson's coefficient *(r)*	Millet (y_1)	Sorghum (y_2)	Maize (y_3)
Rainfall amounts	0.363	0.360	0.200

Level of Significance = 0.05

Source: ***Data Analysis for Gusau station, Zamfara State (2012)***

4.2.9 Climatic Vulnerability Index

The characteristics of vulnerability are expressed in terms of drought and flood index, intensity, duration and frequency. The table and results of analysis of the Normalized Rainfall Index (NRI) for the study area are presented in Table 4.7.

Table 4.7: Intensity of Flooded and Drought Years in the Study Area using NRI

Intensity	Years	Frequency	Vulnerability status
Very wet	2002, 2008	2	Highly vulnerable
Moderately wet	2003	1	Vulnerable
Mildly wet	1999, 2005, 2010	3	Slightly vulnerable
Near normal	1972, 1975, 1976, 1977, 1978, 1979, 1980, 1981, 1982, 1983, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 2000, 2001, 2004, 2006, 2007, 2009	27	Not vulnerable
Mild drought	1971, 1973, 1974, 1984, 1985, 1986	6	Slightly vulnerable
Moderate drought	1987	1	Vulnerable
Severe drought	-	Nil	Highly vulnerable

Source: Data Analysis for Gusau station, Zamfara State (2012)

The results of the Normalized Rainfall Index appears to be effective in detecting both drought and flooded periods and showing how vulnerable farming was during these periods in the

study area. For instance, the above table showed that the well-known great drought of the early 1970s and the moderate to severe drought in each of the years between 1984 and 1987 as described by Oladipo (1993a and 1993b) are qualitatively well depicted by the meteorological drought index. More so, the rising rainfall amounts in the early to late millennium as depicted by Sawa (2002) in most parts of northern Nigeria, was also found to be the same outcome in this study area.

4.3 Analysis of Responses from Questionnaire Administration

A total of 169 questionnaires were analyzed due to unusable data in some of them. 52 sampled respondents emerged from Badarawa ward, 56 from Jangeru and 61 from Shinkafi (the Shinkafi LGA headquarters).

4.3.1 Demographic characteristics of respondents

The analysis of demographic characteristics centered on the sex (gender), marital status, household age distribution (by age and sex) , typical household size, attainment of highest educational qualification, mean number of years in farming, membership of farmers' group and off-farm occupation of respondents in each of the three sampled wards of Shinkafi LGA.

4.3.1.1 Sex (gender) status

The distribution of gender (sex) of the respondents is presented in Table 4.8.

Table 4.8 - Sex Composition of Respondents in Sampled Wards

Wards	Male	Female	TOTAL	PERCENTAGE
Badarawa	45	7	**52**	**31**
Jangeru	43	13	**56**	**33**
Shinkafi	57	4	**61**	**36**
TOTAL	**145**	**24**	**169**	**100**

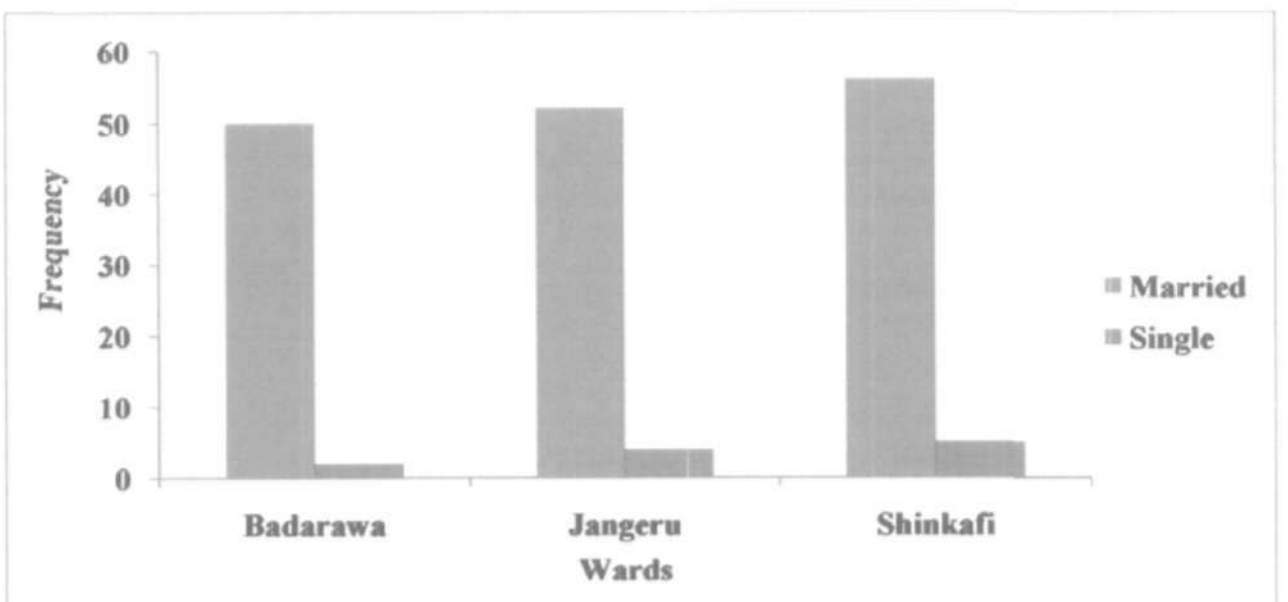
Source: Fieldwork 2012

Out of the 169 sampled respondents, 86% of them are male while the remaining 14% are female. Jangeru ward had the highest percentage (23%) of female respondents followed by Badarawa (13%) and Shinkafi (7%). However, Shinkafi recorded the highest number of male respondents (57) followed by Badarawa (45) and Jangeru (43). The dominance of male respondents is not unconnected

with the cultural practices prevalent in this part of northern Nigeria limiting most women from functioning in outdoor activities.

4.3.1.2 Marital status

The marital status of respondents is divided into married and single groups. Generally, this showed that about 94% of the respondents were married while 6% were unmarried as shown in below.



Source: Fieldwork 2012

Figure 4.6 – Marital Status of Respondents in Sampled Wards

This may not be also unconnected with the fact that marriage is an important aspect of adulthood in most African societies. Thus, individuals who have attained marriageable ages are left alone to fend for themselves outside the comfort of their parents' care as observed in Table 4.9.

Table 4.9: Marital Status by Sex (Gender)

Wards	Badarawa		Jangeru		Shinkafi		TOTAL
	Male	Female	Male	Female	Male	Female	
Married	44	6	40	12	53	3	158
Single	1	1	3	1	4	1	11
TOTAL	45	7	43	13	57	4	169

Source: Fieldwork 2012

Judging from the marital status of respondents by sex from the table above, it can thus be deduced that the male respondents were generally higher than that of their female counterparts in all the three sampled wards. The married men group dominated all of the wards. However, not many single men were available for interview. It is significant to note that the interaction was restricted to those who were available at the time when the questionnaires were administered, without any form of bias (first come, first serve basis).

4.3.1.3 Household head age distribution

The household head age distribution is shown in the table below.

Table 4.10 – Household Head Age Distribution of Respondents in the Sampled Wards

Wards	18-22	23-27	28-32	33 -37	38 - 42	43 - 47	48 and above	TOTAL
Badarawa	0	3	7	10	9	11	12	**52**
Jangeru	3	11	6	6	10	12	8	**56**
Shinkafi	2	5	4	5	11	19	15	**61**
TOTAL	**5**	**19**	**17**	**21**	**30**	**42**	**35**	**169**
PERCENTAGE	**3**	**11**	**10**	**12**	**18**	**25**	**21**	**100**

Source: Fieldwork 2012

The highest age group of respondents (43-47 years) formed about 25% of the household heads interviewed. This was followed by those above 48 years recording about 21% and then the middle aged group (38-42 years), totaling about 18% followed by those within the age grades of 33-37 years. Specifically, those within the ages of 18-22 years represented only 3% of the respondents, which formed the lowest percentage. Respondents in Shinkafi ward dominated the respondents group aged between 43-47 years and had the highest respondents above 48 years than any other age group. The situation simply indicates that majority of households in the selected sites are in their prime ages of productive agriculture. In that way, it is expected that they have amassed a long lasting experience of farming activities in the study area. This will really be of great advantage to this research by providing the researcher with authentic and accurate information concerning the agro-climatic nature

and condition of the study area over the past 35-40 years; depicting farmers strategies in coping with the issue of climate change impacts.

Table 4.11: Mean Age Distribution by Sex (Years)

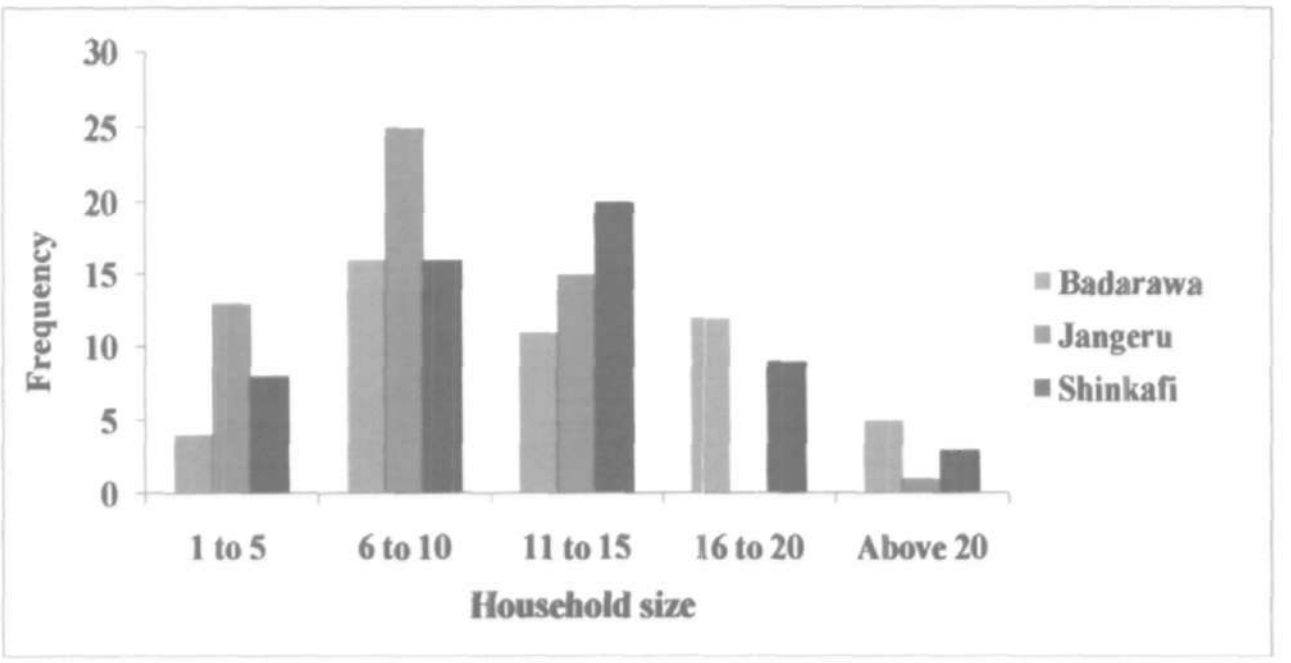
Wards	Badarawa		Jangeru		Shinkafi		TOTAL
Mean Age/ Sex	Male	Female	Male	Female	Male	Female	
20	0	0	2	1	2	0	**5**
25	2	1	5	6	5	0	**19**
30	7	1	5	1	3	1	**18**
35	9	1	6	0	4	1	**21**
40	8	0	9	1	11	1	**30**
45	8	3	10	2	17	1	**41**
50	11	1	6	2	15	0	**35**
TOTAL	**45**	**7**	**43**	**13**	**57**	**4**	**169**

Source: Fieldwork 2012

From the table above, the general age distribution by sex shows that the mean ages in the sampled wards of Shinkafi LGA are highest in the frequency of those who fall within the mean ages of 45 years (41) and 50 years (35). However, the age group with the lowest frequency is those within 20 years of age (5). In each ward, the male groups dominate their female counterparts in each of the mean ages. Respondents with the highest record of male population are located in Shinkafi (34%), followed by those in Badarawa ward (27%) and then those in Jangeru (25%). Among the three sampled wards, the female group is highest in Jangeru (8%) followed by those in Badarawa (4%) and Shinkafi (2%). Generally, the highest frequency of female respondents in Table 4.09 is in Jangeru where the mean age was 25 years while that of male respondents was 45 years as recorded in Shinkafi ward. This illustrates that women within 25 years and men within 45 years are more industrious and productive than others in the sampled areas. It also suggests that most of them within these age limits are breadwinners of their families.

4.3.1.4 Typical household size

The information on the typical household composition in the study area is shown in Figure 4.7



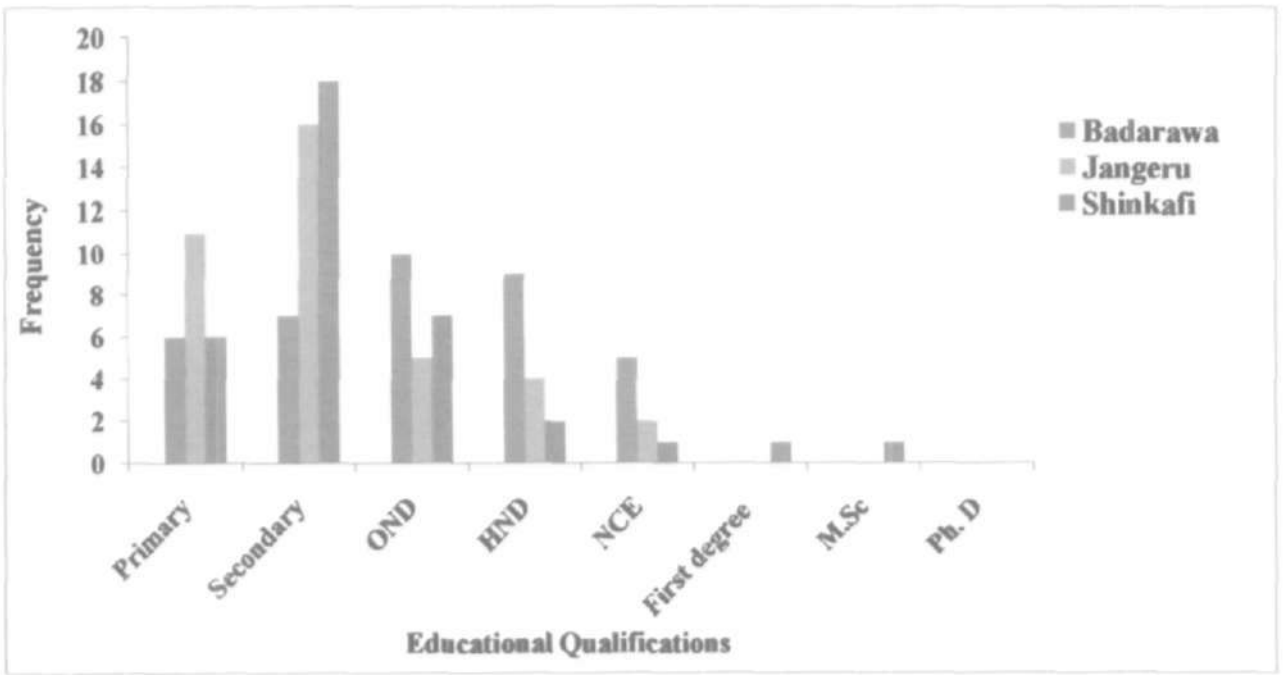
Source: Fieldwork 2012

Figure 4.7 – Typical Household Size of Sampled Wards

The highest number of people per households is that between 6 to 10 persons (36%). The next are those with 11 to 15 persons (29%), followed by those with 1 to 5 persons (15%), then 16 to 20 persons (16%). The average household size in Shinkafi ward was 13 persons, while that of Badarawa and Jangeru are eight persons respectively. This implies that on the average, a typical household size is about 11. This may not be unconnected with the fact that most African societies place great value on children. To many people, a large household is regarded as an economic and agricultural asset to the society and the nation at large. For this purpose, polygamy and early marriages are permitted to facilitate more procreation. However, in the face of the present global economic meltdown, high rate of poverty, food insecurity, unemployment and gross decline in the standard of living especially in most developing nations, much is yet to be seen as regards the relevance and significance attached to the breeding of large households to the economic development of most of today's African societies.

4.3.1.5 *Highest educational qualification*

Figure 4.8 presents the formal educational attainment of the respondents in the selected wards.



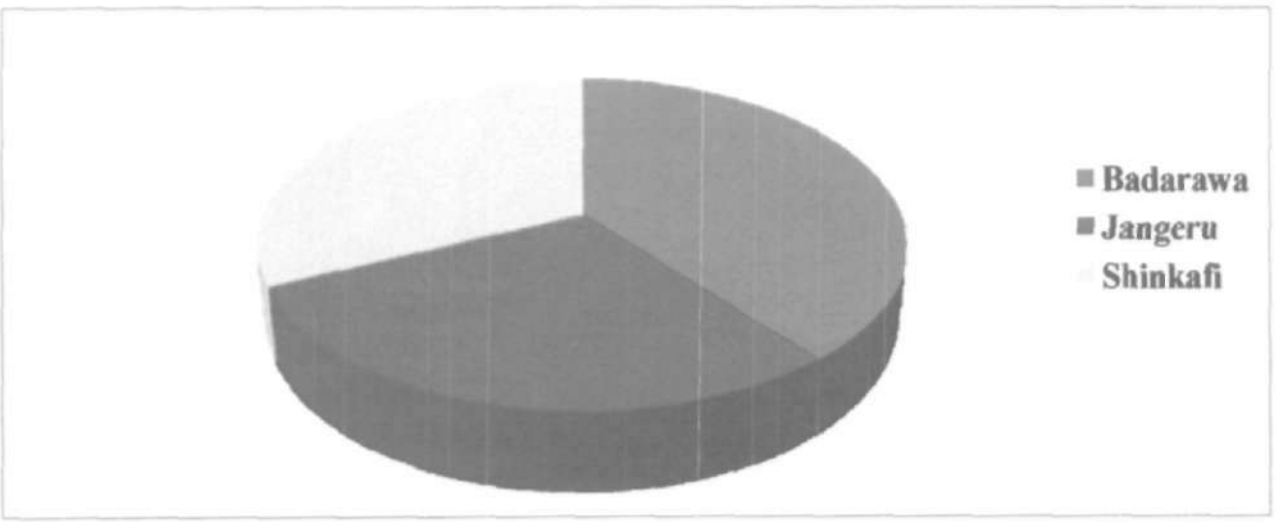
Source: Fieldwork 2012

Figure 4.8 – Attainment of Educational Qualifications in the Sampled Wards

The Secondary form of education was high in frequency especially in Shinkafi (43%) and Jangeru (39%) wards especially the Government Secondary School (GSS) located at Shinkafi that appears to be the highest level of educational institution in the area based on respondents' observation, while the Primary education came next and highest in Jangeru (48%). None of the respondents interviewed in Badarawa and Jangeru wards acquired a University or a Postgraduate degree except one respondent in Shinkafi.

4.3.1.6 Mean number of years in farming

The mean number of years of respondent in farming differs in the three different wards as seen in the pie chart in Figure 4.9. In Badarawa, the highest number of farming years was recorded to be 26.4, followed by that of Shinkafi (21.4) and then Jangeru (19.5).



Source: Fieldwork 2012

Figure 4.9 – Respondents Mean Years in Grain Farming in each Sampled Wards

From the above pie chart, it was observed that grain farmers in the study area have a long history and experience of farming activities in the area. Thus they are familiar with the agro-climatic situation of the area such as the best period of planting, suitable crops to plant during each period, traditional estimation of onset, termination dates including the duration of the rainy season, adaptive strategies in overcoming harsh climatic conditions and several means employed to improve crop productivity. However, it is important to note that experience may not necessarily be a criteria for boosting better yield and productivity especially if archaic traditional methods are not yielding any results with changes in climate. But this is the stage where farmers become highly vulnerable.

4.3.1.7 Membership of Farmers' group

About 53.3% of respondents in the sampled area belong to one form of farmers' group or the other in their locality as seen in Table 4.12.

Table 4.12: Membership of Farmers' Group in Sampled wards

Wards	Members of farmers group	Total respondents	Percentage (%)
Badarawa	31	52	59.6
Jangeru	35	56	62.5
Shinkafi	24	61	39.3
TOTAL	**90**	**169**	**100**

Source: Fieldwork 2012

About 62.5% of respondents in Jangeru carry the bulk of farmers' group members than other wards, followed by Badarawa (59.6%) and Shinkafi (39.3%). Each farming association has been established to see to the wellbeing of farmers and this implies that the groups' approach of doing things is not new to the State. It is still unclear if Zamfara State Agricultural and Rural Development Authority (ZARDA) has through its numerous programmes such as the Zamfara Agricultural Comprehensive Revolution Programme (ZACAREP), Zamfara state Agricultural Supply Ltd (FASCO) and FADAMA III are also part of the farmers' groups.

4.3.1.8 Off-farm occupation of grain farmers

In typical Nigerian households, different members of the family are involved in different forms of off-farm income-generating activities to augment income from farming activities. This is also evident in the three selected wards of Shinkafi LGA as seen in Table 4.13.

Table 4.13: Off-farm Occupation of Respondents in the Sampled wards

Wards	Civil Servant	Trader	Cattle rearer	Commercial transporter	Mechanic	House wife	Politician	Carpenter	Teacher	Total
Badarawa	7	9	3	3	0	0	0	0	0	**22**
Jangeru	7	9	0	3	1	2	1	1	0	**24**
Shinkafi	7	20	2	10	1	0	0	2	1	**43**
TOTAL	**21**	**38**	**5**	**16**	**2**	**2**	**1**	**3**	**1**	**89**

Source: Fieldwork 2012

The highest percentage of off-farm activity is trading and business (43%), while 24% are civil servants either employed in the Shinkafi local government secretariat or in other white-collar jobs, then followed by the commercial transporters (18%) dealing on motorcycle and vehicle- movement of goods and passengers. Politicians and teachers carry the lowest percentage of respondents. Shinkafi ward has the highest percentages of traders (47%) and commercial commuters (23%). A sizeable number of civil servants are also represented in the three wards.

This all goes to say that most of the respondents are not solely dependent groups who hawk the streets begging for alms; instead, most of them are highly productive (even the aged) and are involved in other numerous activities to meet their basic family needs. They also generate income to

involved in other numerous activities to meet their basic family needs. They also generate income to compliment farm inputs especially during the long periods of the dry season. More so, most of them are involved in trading grains during the dry season, while others specialize in selling meat obtained from their livestock produce especially when food-grain resources becomes scarce or expensive.

4.3.2 Socioeconomic characteristics of the respondents

The socioeconomic status of grain farmers in the study area ranges from farming specialties, varieties of crops produced, forms of benefits enjoyed by the farmers, sources of farmers' capital and the number of arable lands each farmer owns from the sampled wards.

4.3.2.1 Types of Farming Specialty

Table 4.14 shows the various farming specialties of respondents in the sampled wards.

Table 4.14 – Various Types of Farming Specialties in the Sampled Wards

Wards	Commercial	Subsistent	Both	Undecided	TOTAL
Badarawa	5	10	36	1	**52**
Jangeru	14	12	29	1	**56**
Shinkafi	13	11	34	3	**61**
TOTAL	**32**	**33**	**99**	**5**	**169**
PERCENTAGE	**19**	**20**	**58.6**	**1.8**	**100**

Source: Fieldwork 2012

It has thus been observed that over 59% of respondents engage in both commercial and subsistent practices. It implies that this percentage is involved in the sale of farm produce and at the same time producing food crops for their household's consumption. Farmers who engage in only subsistent practices are over 20% while 19% are commercial distributors. Respondents in Badarawa (69%), Jangeru (52%) and Shinkafi (56%) are involved in both ventures. However, apart from the other wards where marketing of crops are solely practice, 19% of respondents in Badarawa specialize in subsistent rather than commercial agriculture. Generally, this shows that farmers resort to different farming practices depending on the condition of the season. In periods of bumper harvest, they could decide to hoard or store grains in silos or rhombus awaiting any news of a hike in food prices so that they can profit from their sale, while others may consume their harvest with their households but still

preserve seeds for subsequent planting seasons. Nevertheless, farming is the pride of Zamfara state because it has over the years, produced raw materials for industries (through a process known as the backward industrial linkage) which in turn processed them into cash crops for export, thereby providing income for peasant farmers, enhancing large-scale industrialization and providing revenue for the government.

4.3.2.2 Types of crops produced

Shinkafi's climate permits the production of grain, tuber and leguminous crops as presented in the table below.

Table 4.15: Crop types produced by Respondents in the Selected Sampled wards

WARD	Badarawa	Jangeru	Shinkafi	TOTAL
Major Rain-fed crops				
Millet	35	25	34	**94**
Sorghum	30	29	34	**93**
Maize	43	38	50	**131**
Rice	7	12	9	**28**
Beans	9	10	25	**44**
Soya bean	3	4	2	**9**
Cowpea	0	0	2	**2**
Cotton	4	5	7	**16**
Ground nut	1	0	3	**4**
Irrigated crops				
Sugar cane	2	0	1	**3**
Melon	1	0	0	**1**
Cassava	2	0	1	**3**
Tomato	3	1	1	**5**
Potato	1	2	14	**17**
Garden egg	1	0	0	**1**
Onion	0	1	0	**1**
Vegetable	0	3	2	**5**
Okra	0	1	1	**2**
Yam	0	0	1	**1**
Pepper	0	0	1	**1**
TOTAL	**142**	**131**	**188**	**461**

Source: Fieldwork 2012

Out of all the rain-fed crops produced in Shinkafi LGA; Maize, Millet, Sorghum, Beans and Rice are mostly cultivated (in descending order of importance). Most of the farmers have found it

economical to practice mixed farming since rainfall in the area has been found to be irregular and unreliable. Over the past 25 years, Maize, Millet and Sorghum are the farmers' preferred choice in all the three wards because they are *drought resistant* or *tolerant* crops. The respondents' high patronage to Maize in Table 4.15 coincides with Table 4.04 which is not far-fetched from the fact that the crops gained more economic prominence in Zamfara state from the mid millennium largely due to increase in annual rainfall. The least grown rain-fed crop is Cowpea and groundnut. Out of the three wards, Shinkafi ward dominates in respondents' choice of rain-fed crops. This may not be unconnected with the fact that most grain crops such as Maize, Millet and Sorghum thrive well in semi-arid regions and take shorter periods to grow, mature and develop with minimum climatic requirements as compared to other crops which require a longer growing season, increased moisture requirements with attendant increase in the probability of evaporation and drought occurrences.

Irrigation practice is still at its rudimentary level in some parts of the area and only very few respondents as also shown in Table 4.15, are into irrigation farming. Unlike the case of rain-fed crops where some specific crops cut across all or many of the sites, that of the irrigated tends to be location specific. For example, Sugar cane, Melon, Cassava, Garden egg and Tomatoes were unique to Badarawa ward; Onion and Vegetable in Jangeru while Potato is the major irrigated crop in Shinkafi with some pockets of Yam and Pepper. This invariably means that most of the irrigated crops mentioned in the above table are either scarce in supply or sold at exorbitant prices - and so not all farmers can afford them. However, wealthy merchants who can afford them, end up monopolizing these farm produce by way of politicizing them or giving them to peasant farmers in exchange for political favours.

It is also worthy to note that the irrigated crops mentioned in Table 4.15 are majorly tuber crops. This may not be unconnected with the fact that tuber crops require more moisture content (such as flood plains or marshy areas), suitable temperature and soil nutrients because they grow deep down

the soil. This unfortunately is not the case in Shinkafi LGA because rainfall is seasonal, uncertain and unpredictable. Thus, it has been discovered that during the dry season, they do not thrive well in the study area as compared with grain crops.

4.3.2.3 Forms of external benefits enjoyed by farmers

Table 4.16 shows the various forms of external benefits enjoyed by farmers in the sampled wards. Generally, Badarawa enjoyed more farm inputs (44%) than Shinkafi (31%) and Jangeru (25%).

About 32% of the respondents indicated that they enjoyed the supply of fertilizers and agrochemicals in the study areas more than others, and the result was higher in Badarawa (34%), then Shinkafi (32%). This is because they are key inputs in crop management and productivity especially in many parts of the country. Provision of seeds (21%) and open market for trade (19%) were also regarded as indispensible inputs to farmers. Though sourcing from open markets had attendant effects of adulteration and purchase of fake products on respondents in Jangeru and Shinkafi. About 11% of respondents enjoyed credit facilities, 8% benefited from good transport network linking the farm site to the market, 6% owned various modern farming implements but water supply in the study areas were low. This is not unconnected with the fact that rainfall in the region is irregular and most times fluctuating. Ownership of arable land is also lacking because most of the farmers are too poor to purchase lands so the best they can do is to hire for the duration of the planting season.

Table 4.16 – Forms of benefits enjoyed by farmers in each Sampled Wards

Wards	Insecticides/ Fertilizers	Water supply	Seeds	Credit facilities	Farming implements	Transport network	Open market	Land	TOTAL
Badarawa	32	0	19	10	3	1	27	1	**93**
Jangeru	14	7	8	8	4	9	4	0	**54**
Shinkafi	21	1	17	6	5	6	9	0	**65**
TOTAL	**67**	**8**	**44**	**24**	**12**	**16**	**40**	**1**	**212**
PERCENTAGE	**32**	**4**	**21**	**11**	**6**	**8**	**19**	**0.4**	**100**

Source: Fieldwork 2012

Most of the respondents attested to the fact that the Zamfara State Agricultural and Rural Development Authority (ZARDA) has played some vital roles in their activities. ZARDA whose

headquarters is situated at the state capital (Gusau), has through its various cooperatives like Zamfara Comprehensive Agricultural Revolution Programme (ZACAREP), Zamfara State Agricultural Supply Ltd (FASCO), Maslaha seeds group and FADAMA III; helped in supplying fertizers, seeds, agro-chemicals (insecticides, fungicides and pesticides) and market facility for farmers benefit.

In addition, the Shinkafi Local Government Area has been boosted with the alocation of extension agents to educate and assist farmers on the usage of these inputs to improve crop yield. However, it is not clear with ZARDA being the source of input for the LGA because buying from the LGA Secetariat is an issue and whether these inputs get down to the peasant farmers, is another issue. Therefore, it is not certain if the Shinkafi LGA procures these inputs for her citizens or individuals sell at the LGA Secetariat.

4.3.2.4 Sources of farmers' capital

The various sources of credit (both formal and informal) open to the farmers and their households is shown in Table 4.17.

Table 4.17 – Sources of Farmers' Capital in Sampled Wards

Wards	Owned Farm	Off-farm	Farmers Group	ZADP	Agric banks	Input suppliers	Friends	Political Groups	TOTAL
Badarawa	22	19	10	6	7	2	0	1	**67**
Jangeru	17	14	7	16	8	3	0	0	**65**
Shinkafi	43	37	3	14	4	0	1	0	**102**
TOTAL	**82**	**70**	**20**	**36**	**19**	**5**	**1**	**1**	**234**

Source: Fieldwork 2012

Sourcing credit for agricultural production is still posing a serious challenge to farmers in the survey area which impedes grain production. In the three wards generally, over 35% depend on their yearly farm income which sometimes is irregular due to poor yield and drought occurences, 30% depend on off-farm income through other means of living, 15% depend on funds provided by the Zamfara State Agricultural and Rural Development Authority (ZARDA) which some respondents claim is irregular and untimely. About 9% of respondents have benefited from farmers' groups while

about 8% have seldom enjoyed loans from the Nigerian Agricultural Cooperative and Rural Development Bank (NACRDB), First Bank of Nigeria (FBN) and the United Bank of Africa (UBA) all situated at the Local Government headquarters. The effects of the informal approaches such as *local imput suppliers (2%), money lenders or assistance* from friends and political groups are expectedly seasonal and minimal with insignificant proportions. However, it is not clear why respondents in Jangeru (25%), Shinkafi (14%) and Badarawa (9%) do not effectively and efficiently benefit from ZARDA seeing that is a state wide initiative programme meant to links farmers with the state government in providing funds for their activities. It is important to note that farmers and their households eventually fall at great economic risks if they only produce cash crops for government benefit with little or no renumerations or compensations to augument all the months of hardwork and income generated.

The role of NACRDB, FBN and UBA to farmers' wellbeing is not also understood even with the presence of an agricultural department in the Local Government Area secetariat all located in Shinkafi headquarters. It therefore means that there is either a nonchalant attitude on the part of the government to fully assist farmers or that farmers on their part have not done enough to be assisted as regards regular tax payment or remitting revenue allocation from farm produce. However, linking farmers to funds will be the focus of this research because of its importance to improved productivity.

4.3.2.5 Number of arable lands owned by farmers

Table 4.18 reveals the number of arable land owned by individual farmers in the wards.

Table 4.18 – Hectares of Land owned by Grain Farmers in Sampled Wards

Wards	1 to 5	6 to 10	11 to 15	16 to 20	Above 20	Undecided	TOTAL
Badarawa	10	11	12	5	12	2	**52**
Jangeru	12	16	7	9	11	1	**56**
Shinkafi	12	19	15	5	10	0	**61**
TOTAL	**34**	**46**	**34**	**19**	**33**	**3**	**169**
PERCENTAGE	**20**	**27**	**20**	**11**	**20**	**2**	**100**

Source: Fieldwork 2012

About 27% of respondents owned an average of 8 pieces of lands for cultivation, followed by 20% who averagely owned 3, 13 and more than 20 pieces of lands. Even though Zamfara state claims to have a large landmass yet closed door investigations revealed that most farmers do not own lands but rather hire land for their farming activities. Land is a fixed asset and an expression of wealth but the economic status of farmers have hindered most of the respondents from buying and acquiring personal arable land because it is expensive. Instead they resort to hiring it (on mutual agreement) from the state government or from well-to-do individuals for some specific period, usually during the rainy season. Others who can afford it may later use it as mortgage or collateral from banks when they cannot settle their debts as at when due or may sell it during poor yields or severe drought occurences to save their families from abject poverty.

4.3.3 Climatic vulnerability and impacts of grain farming in selected wards

4.3.3.1 Grain farmers' perception of periodicity in planting season

Traditionally, May/June is the most suitable and best period to plant grain crops in Shinkafi LGA according to Table 4.19.

Table 4.19 – Periodic Months of Planting in Sampled Wards

Wards	Mar/April	April/ May	May/June	June/July	July/August	TOTAL
Badarawa	0	2	32	18	0	**52**
Jangeru	7	6	33	9	1	**56**
Shinkafi	1	11	45	4	0	**61**
TOTAL	**8**	**19**	**110**	**31**	**1**	**169**
PERCENTAGE	**5**	**11**	**65**	**18**	**1**	**100**

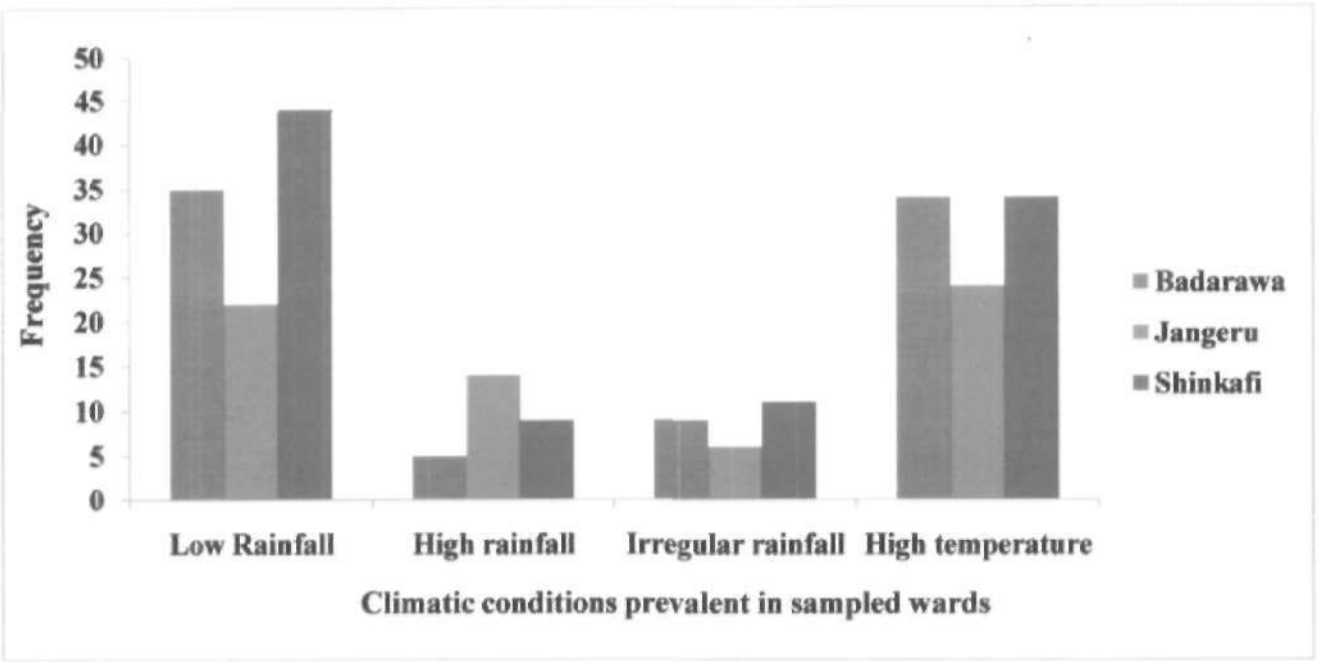
Source: Fieldwork 2012

Over 65% respondent grain farmers in the three sampled wards of Shinkafi LGA have reaffirmed this. According to the Islamic calendar, *Rajab*, which is the 7th month, is equivalent to May 29 or May ending – the period when the early rains set in taking into consideration, the onset and termination dates of the rainy season. About 18% of respondents went further to reveal that instead of May 29, planting commence every June 10. However, farmers who preferred planting in June/ July

reasoned that the soil are well developed after the first rains in May/June and thus would be ready for cultivation after a long period of drought and desertification.

4.3.3.2 Assessment of the climatic condition of Shinkafi LGA over the past 35 years

Figure 4.10 shows respondents assessment of the climatic conition of Shinkafi LGA. About 41% of respondents opined that there has been low amount of rainfall in the area for the past 35 years. 37% stressed that the low rainfall has been coupled with very high and harsh temperature conditions during the same period. 11% were of the opinion that rainfall has been generally high and to an extent irregular over the years. 45%, 42% and 33% of respondents in Shinkafi, Badarawa and Jangeru wards respectively attested to the fact that there was an abrupt drop in the duration of the rainy season over the past 35 years while 41%, 36% and 35% of respondents in Badarawa, Jangeru and Shinkafi claimed that next to low temperature was high temperature regimes in the area.



Source: Fieldwork 2012

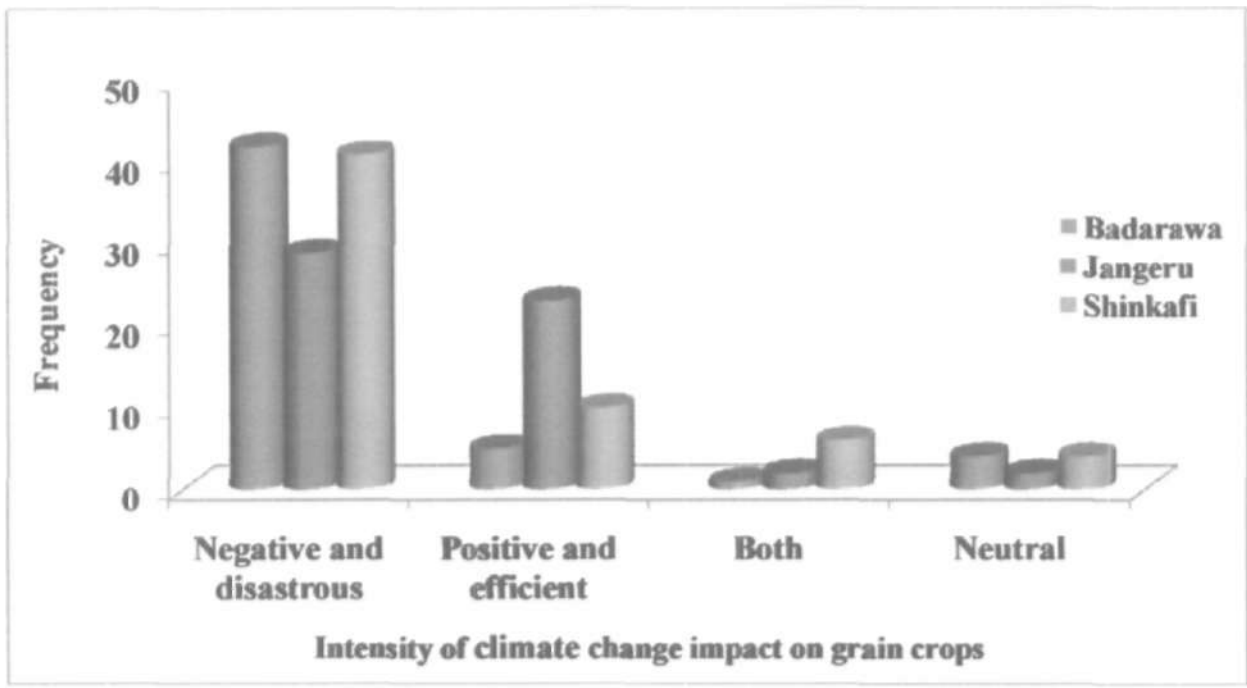
Figure 4.10 – Respondents' assessment of climatic conditions in the sampled wards over 35 years

The above observation may not be unconnected with the fact that Shinkafi LGA is part of sub-Saharan Africa and situated in the semi-arid, Sudano-Sahelian region of northern Nigeria. Thus, low rainfall and high temperatures will mean that poor climate will hinder the performance and

productivity of most agricultural and economic activities. Crops which cannot adapt to harsh drought conitions will wither off while those who have adaptive features will thrive well in the area. This gives reasons to why farmers are engaged in whatever they do; and why yield is high in some cases and low in others.

4.3.3.3 Intensity of climate change impacts on crop production

From the farmers' respondents summarized in Figure 4.11, it can be deduced that climate change has been disastrous on their crops.



Source: Fieldwork 2012

Figure 4.11 – Respondents' Evaluation of Climate Change impacts on grain crops in Sampled Wards

Respondents in Badarawa (81%) and Shinkafi (67%) attested to this fact. However, 23% objected to the above fact by claiming that climate change played a positive and beneficial role in crop productivity. This therefore means that farmers face hectic time in trying to combat problems from climate change than its benefits, and so means that farmers and their crops are at great risk if nothing serious is done to arrest this alarming situation.

4.3.3.4 Impacts of climate change on the environment

Table 4.20 shows several negative impacts of climate change on the environment in Shinkafi LGA. These problems range from severe poor crop yield as indicated by respondents, to short and stunted growth of crops, drought occurrences and pests and diseases. Some respondents complained of related problems such as erosion, flooding, soil in fertility and heat damage on crops. Over 45% of respondents in Shinkafi said that their crops had been badly affected by climate change. About 31% in Badarawa ward were next on the line followed by Jangeru (24%). All these problems can be traced to the low rainfall regime and high temperature conditions.

Table 4.20 – Climate change impacts on the environment in each Sampled Wards

Wards	Stunted growth	Pests	Poor yield	Soil fertility	Drought	Flooding	Erosion/ Leaching	Heat Damage	TOTAL
Badarawa	31	17	32	2	22	0	4	1	**109**
Jangeru	16	14	16	5	14	5	13	0	**83**
Shinkafi	36	31	36	5	30	7	9	2	**156**
TOTAL	**83**	**62**	**84**	**12**	**66**	**12**	**26**	**3**	**348**

Source: Fieldwork 2012

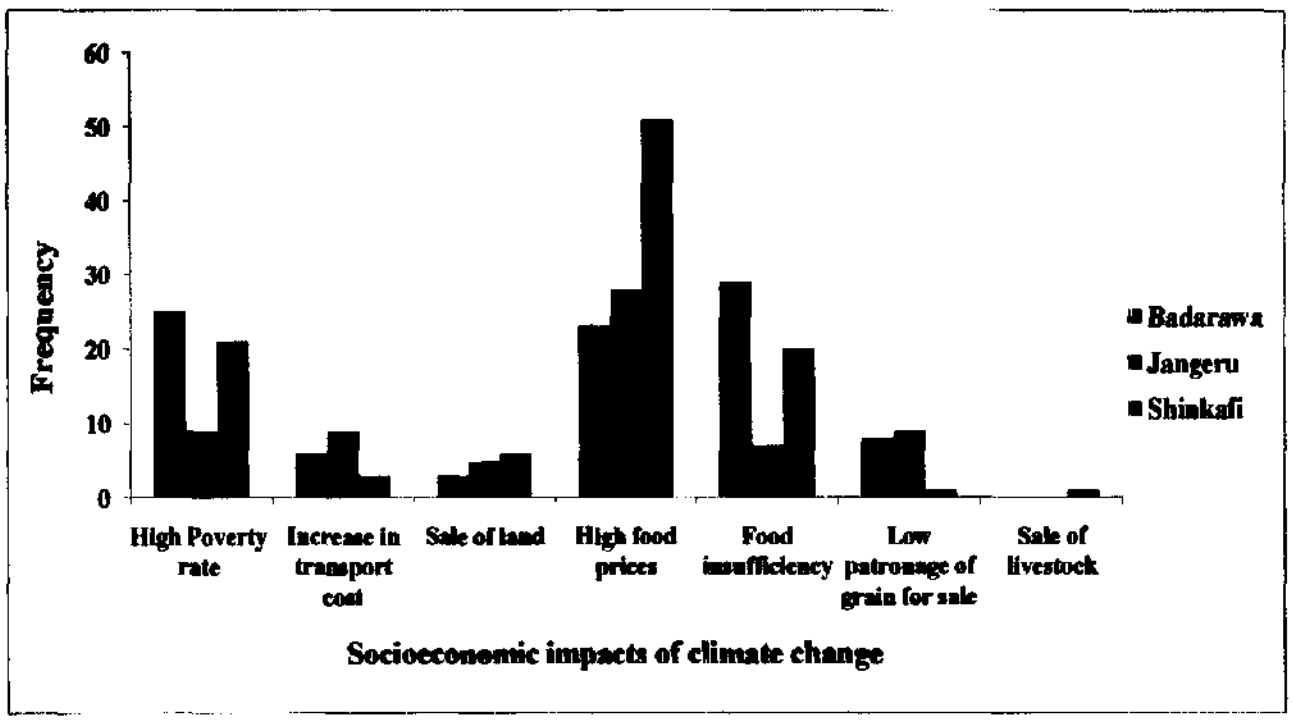
4.3.4 Socioeconomic vulnerability and impacts of climate change on grain farmers

4.3.4.1 Climate change impacts on farmers' household

From Figure 4.12, it was deduced that over 39% of respondents attested to the fact that yearly hike in food prices was a major bane and influence of climate change on their households.

About 50% of the respondents from Shinkafi claimed that high food prices (51), food scarcity (21) and high poverty rate (20) are major effects of climate change. Other respondents in Badarawa and Jangeru - 31% and 27% respectively, were the next in line. Other attendant socioeconomic effects include low patronage of crop sales, increase in transportation cost in moving goods from the farm site to the market, sale of land due to inability to meet family needs and sometimes sale of livestock as recorded in Shinkafi. This means that due to high purchasing prices and low income, farmers are left

socioeconomically vulnerable to the effects of climate change leading to food insufficiency and high-level poverty rate in the area.



Source: Fieldwork 2012

Figure 4.12 – Respondents' Assessment on Socioeconomic impacts of Climate change on their Livelihood in the Sampled Wards.

Generally, farmers agreed that market demands are at the increase during the long dry season periods, which leads to rise in food prices. It is yet unclear if Shinkafi LGA has played any role in mediating between market forces of demand and supply during these periods or they are privy to it in one way or the other. It was also observed that during periods of drought and food scarcity, most farmers at the same time become wealthy because they use the opportunity to sell their hoarded or stored grains at exorbitant prices.

4.3.4.2 Average annual income generated by grain producers

Table 4.21 summarizes the average income generated by farmers in the selected sampled areas.

Table 4.21: Average annual income generated from these major grain crops

Wards	Millet (*in naira*)		Sorghum (*in naira*)		Maize (*in naira*)		TOTAL
	Rain-fed	***Irrigation***	***Rain-fed***	***Irrigation***	***Rain-fed***	***Irrigation***	
Badarawa	1,160,000	336,750	650,000	203,500	628,000	56,000	**3,034,250**
Jangeru	120,000	77,500	54,000	31,000	84,000	56,000	**422,500**
Shinkafi	98,000	132,000	132,000	44,000	270,000	36,000	**712,000**
TOTAL	**1,378,000**	**546,250**	**836,000**	**278,500**	**982,000**	**148,000**	**4,168,750**

Source: Fieldwork 2012

Badarawa ward generates more than 3 million naira yearly followed by Shinkafi that has generated over 700, 000 naira and Jangeru, over 400, 000 naira. Among the three crops, Millet carried the largest share of income generated, totaling about 2 million naira in both rainy and dry season. Maize was next with about 1,130, 000 naira and Sorghum - 1,114,500 naira.

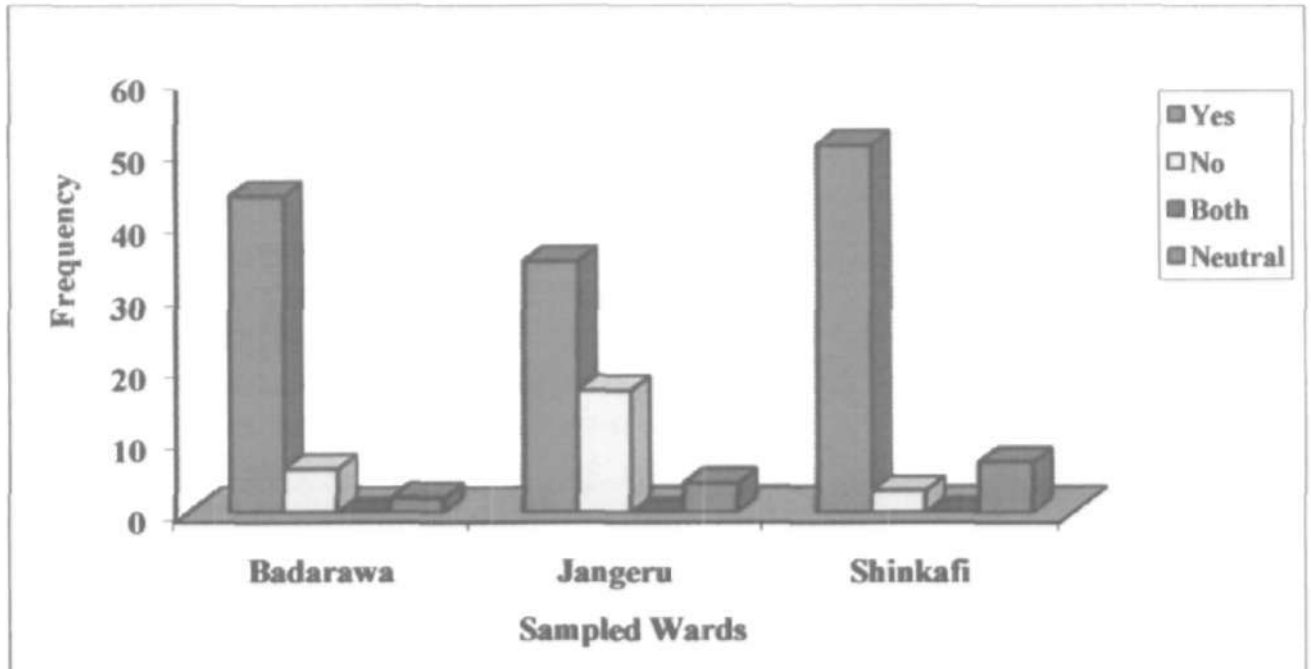
It was also gathered that a bundle or bag of grain in Badarawa cost between 4000 and 8000 naira in the rainy season and between 5000 and 12000 naira in the dry season. A bag of grain in Jangeru cost 8000 naira in the rainy season and 12000 naira in dry season while that of Shinkafi cost between 4000 and 5000 naira in rainy season but rises to 8000 naira in the dry season.

It is also worthy to note that rain-fed crops generate more income than irrigated crops because during the rainy season, any fall in the cost of grain bag inversely leads to an influx of farmers in the market. During the dry season, high prices in grain bags scare farmers from buying. However, farmers have devised a means of storing their grain crops in sacks and silos till another planting season to sell it when the price increases.

4.3.4.3 Climate change influence on income generation

Respondents in Shinkafi LGA shared their views on climate change influence on their income generation in Figure 4.13. About 77% of respondents said that their yearly income had been grossly affected by changes in climatic conditions of the area while, 15% disagreed that climate change affects their yearly farm income. Although more respondents from Badarawa (85%), Shinkafi (84%) and Jangeru (63%) affirmed that there has been a decline in income over the years. Yet, Figure 4.20

appears to be a contrast to the responses in Figure 4.22. This is because respondents in Badarawa vehemently maintained that they have not generated as much income as they should have from their farm produce due to the climate change saga and government's non-chalant attitude to address the situation is a thing of serious concern. This explains the fact that man's needs are insatiable and unlimited though it is still unclear if farmers in Badarawa were economical with the truth and trying to attract sympathy and attention from sponsors or they were really sincere.



Source: Fieldwork 2012

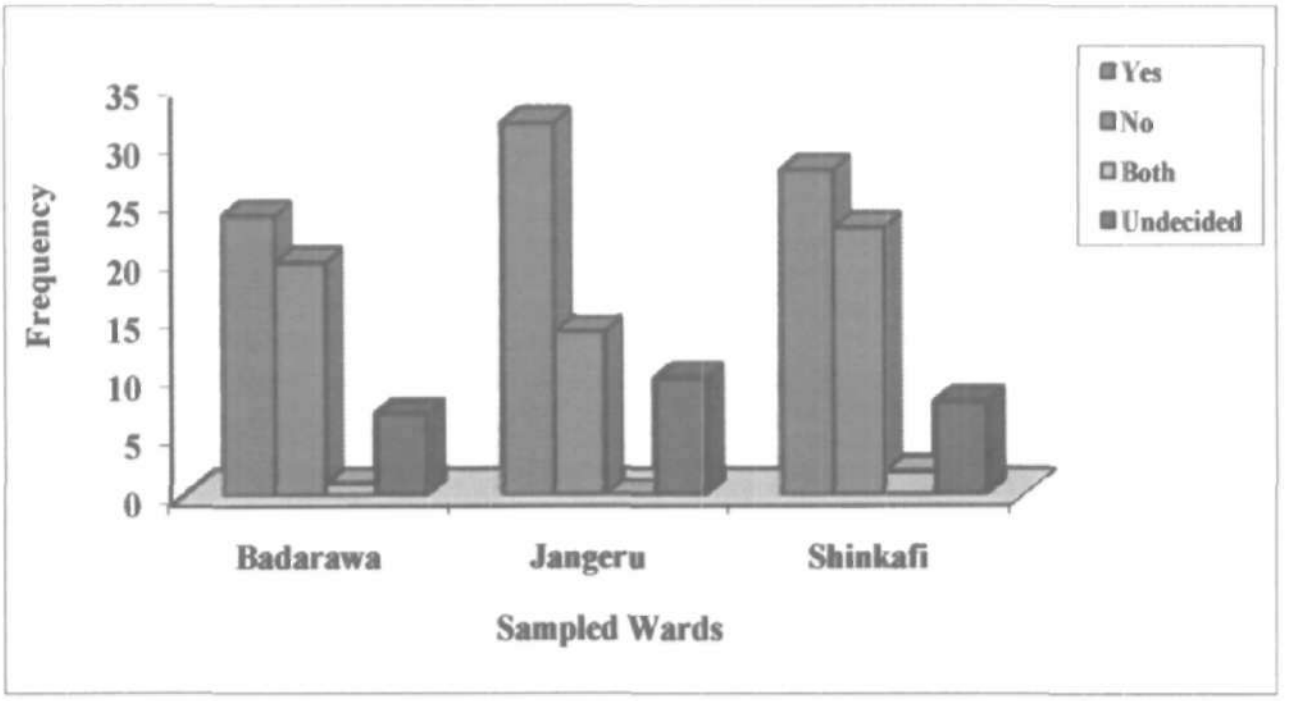
Figure 4.13 – Respondents' Responses to Climate change influence on income generation

4.3.5 Grain farmers' adaptive strategies to climatic stress and vulnerability

Adaptation to climate change have been described as a local, state and federal government effort and strategy to allocate adequate, predictable and sustainable physical and financial resources to control the looming impacts of climate change on the general populace. While considering humans and animals, the ability of crop types to successfully adapt to climatic stresses are not also left out. These strategies may be traditionally or modernly inclined but the most important accomplishment is that goals are realized, grain yields is enhanced and farmers benefit greatly.

4.3.5.1 Ability of farmers to successfully adopt adaptive strategies to curb climatic stress

Figure 4.14 showed the respondents ability to adapt to climatic stress with the help of the Zamfara state Agricultural Rural Development Authority (ZARDA) to assist farmers through training programmes on how to realize farmers' goals of generating yearly bumper harvest.



Source: Fieldwork 2012

Figure 4.14 – Respondents' Responses on their ability to adopt adaptive strategies to mitigate Climate change impacts on crop yield

About 50% of respondents in all the sampled wards agreed that the programmes put forward by ZARDA have been quite useful to them and is yielding dividends especially in Jangeru ward. Some have even devised strategies to curb or minimize climate change impacts through several farming practices.

However, about 34% indicated that all methods they have adopted have proved abortive and neutral. They also maintained that they are still handicapped despite the assistance and efforts put forward by the extension agents. Availability of extension agents is of great importance in the transfer

of technology to farmers and bringing back responses of farmers to researchers. It is still not clear what type of training farmers have received and the rate at which it has enhanced crop yield.

4.3.5.2 Adaptive strategies of farmers through ZARDA to curb climate change impacts on grain crops

The Zamfara state Agricultural Rural Development Authority (ZARDA) has through its programmes set up several initiatives through out the whole state. These initiatives include Zamfara Comprehensive Agricultural Revolution Programmme (ZACAREP), Zamfara State Agricultural Supply Ltd (FASCO) and Maslaha seeds group have assisted in implementing the several adaptive strategies for grain farmers. A World Bank initiative called the FADAMA 3 is also working in collaboration with ZARDA to improve agricultural output in the rural areas of the state.

Respondents' reports on the strategies adopted by farmers through ZARDA are displayed in Table 4.22.

Table 4.22– Adaptive Strategies to Climate change impacts on grain crops in each Sampled Wards

Wards	Good storage devices	Insecticides, Fungicides & Pesticides	Soil additives	Soil conservation practices	Irrigation methods	TOTAL
Badarawa	12	17	3	14	9	**55**
Jangeru	12	17	2	14	10	**55**
Shinkafi	15	19	0	20	12	**66**
TOTAL	**39**	**53**	**5**	**48**	**31**	**176**
PERCENTAGE	**22**	**30**	**3**	**27**	**18**	**100**

Source: ***Fieldwork 2012***

About 30% of the respondents who answered in the affirmative in the three wards claimed that with increasing temperatures conditions prevalent in the area, pests and insects of different categories thrive and attack crops severely which have been relatively controlled. For instance, Head Smut and Ergot are fungal diseases, which attack the inflorescence. They also darken the colour of Millet, Sorghum and Maize seeds and turn them into powder, thereby resulting to considerable yield losses. Stem borer or Midge is an earworm in the lava of insects that bores into stalk or stems and hinders

movement of water and air in Millet and Sorghum thereby turning the stem red colour and giving place for agents of dispersion (wind) to blow them away.

The Blister Beetle also affects Millet by sucking the pollen grain and condemning the crop. Downey Mildew causes plant leprosy in Millet, Sorghum and Maize, folds the cubs of Maize and rusts the seeds. The Maize streak virus also affects yields in Maize crop. In addition, Head or grain socus also saps the milk of grain plants at their growing stage and leaves the grains empty. The anthracnose is the most destructive disease and can attack Sorghum at all stages of growth resulting in serious yield loss. Sorghum is also a good host to *Straga hamoltiga*- a weed pest with beautiful flowers that causes low crop yields. Not to talk of the action of insects like spitting bugs which attacks late-planted Sorghum crops; aphids, army worms, grasshoppers, locust, millipedes, termites, shoot flies and crickets that sometimes invades farmlands and they all eat up leaves of plants. Quella birds and village weaverbirds also pick the grains when newly planted and feed voraciously on them at maturity stage (Focus group discussion 2012).

About 27% of the respondents also said that they have adopted soil conservation practices such as mulching, crop rotation and shifting cultivation. Mulching is one of the best techniques to retain the soil moisture and improve soil conditions. Mulch is any type of material, which is spread or laid over the soil surface as a form of covering or protection against the sun's radiative effects. Crop rotation is also an agricultural practice involving the rotation of crops in sequence year after year to maintain its soil fertility. In this case, 3 – 5 different crops can be grown on the same piece of land but on different plots. Shifting cultivation is the movement of the farmer and his family from one piece of land to another when soil has lost its fertility. In that way, it creates an oily structure in the soil that will help to retain as much moisture as possible and imbibe more nutrients into the soil. Shifting cultivation is also affiliated to bush fallowing and dry farming.

Traditional storage processes, methods and facilities have also helped in mitigating climate change in the area. About 22% of farmers' respondents are involved in preserving grains in sacks, silos and rhombus, which are subsequently sealed up with preserving herbs included to scare away pests, diseases, rodents and burrowing animals like rats and birds. Farmers then store them in a safe room or place until the dry season.

Irrigation is one of the oldest farming techniques used in the area not only in supplying additional water in moisture deficient farmlands but also in improving the aeration in the soil. About 18% of respondents depend on irrigation practices but since there are no major rivers in Shinkafi LGA, the farmers have resorted to using the most ancient, traditional *Shaduf* method, which involves the use of buckets to fetch water from wells and water the plants or diverting the water in streams to water their farm. However, much is yet to be seen from governmental promises to construct a modernized borehole system in other wards aside Shinkafi, where electrical operated pumps will be used in generating water for agricultural use. It is also significant to note that the irregularity of hydroelectric power supply is a serious issue to be considered in this area if government seriously intends on embarking on such a huge project scheme as this.

The use of soil additives like organic manure ranging from cow-dung, bird droppings, green manure, farm wastes, compost and other decayed vegetative matter; and fertilizers made up of Nitrogen, Phosphate, Potassium, Potash and Calcium are all important to soil fertility and subsequently, quality crop yields. However, this constituted about 3%, which is insignificant. This might not be unconnected to the fact that fertilizers have been politicized because it mostly gets to the hands of the wealthy and it is most times sold to peasant farmers at exorbitant prices. It is still unclear if the officials of the Local Government Secretariat are party to this or have helped to abate it.

In Shinkafi, 38% of respondents have adopted all the listed adaptive strategies in curbing climate change impacts than the other wards who had equal percentages each (31%) . This is so

because Shinkafi is the headquarters of the LGA secretariat and so development is expected in most urban centres than others.

4.3.5.3 Reasons for failures to adopt adaptive strategies to curb climate change stress and vulnerability

Table 4.23 summarized the views of respondents who bluntly felt that they were not able to adopt any successful strategy to curb climatic stress due to several reasons.

Table 4.23 – Respondents' reasons on failures to adopt adaptive strategies to curb climate change stress

Wards	Lack of governmental support	Poor funding from other sponsors	Little or no knowledge	Expensive to irrigate farms	TOTAL
Badarawa	18	20	9	0	**47**
Jangeru	15	11	10	0	**36**
Shinkafi	24	22	3	1	**50**
TOTAL	**57**	**53**	**22**	**1**	**133**

Source: ***Fieldwork 2012***

Among these reasons, lack of governmental support carried the largest share of respondents (43%). Most of the respondents especially those in Shinkafi ward (48%) concluded that government at all levels had completely abandoned them either because they found nothing worthwhile in the area since it is very close to the border between Nigeria and Niger, or they don't just care about supporting them.

About 40% of respondents were of the opinion that other financial sponsors had since ceased from helping farmers in the area from adopting successful adaptive strategies. Respondents in Shinkafi (44%) and Badarawa (43%) complained that they had been left on their own to fend for themselves and for their activities. Even agricultural banks had stopped giving them loans since they could not pay back at a stipulated date and they had no valuable collateral. Thus they could not purchase modernized tools for farming, acquire pesticides and insecticides and fertilizers were very expensive. Most farmers also discovered that most Farmers' groups could not really meet their needs despite their several promises made and fees paid; thus, they have withdrawn their membership. Most respondents

also felt that ZARDA's activities were largely politicized and peasant farmers could not really feel their impacts at the grass-root levels. Corruption is also the bane of the day as respondents observed that Public service officers attached to farmers enriched themselves with public funds instead of meeting the farmers' needs.

About 17% of respondents claimed that they have failed to adopt any adaptive method to address climate change stress because they lacked the knowledge of modernized soil conservative practices that could improve soil fertility and have thus resorted to their traditional unproductive methods. This is not strange due to the absence of higher institutions and research institutes in the area where agricultural and climatic studies and researches can be carried out. The only highest educational institution in the area is an old Government Secondary School (GSS) located at Shinkafi. This is a bad omen for the study area until something drastic is done to address the educational backwardness.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter summarizes the research carried out in the previous chapter, concludes the overall study and aims at proffering meaningful stringent solutions and recommendations in addressing the issue of climate change and its looming effects on grain production.

5.2 Summary

This study assessed the climatic and socioeconomic vulnerabilities of climate change on grain farming in Shinkafi LGA, Zamfara State by first, analyzing the trends of rainfall characteristics over Zamfara State using the Gusau Station as an example from 1971 to 2010 (40 years), depending on the availability of rainfall data on annual rainfall amounts. Trends for rainfall amounts, trends in sub-periods (decadal non-overlapping and the 20-year overlapping means), relationship between long-term mean and sub-periodic means of rainfall amount, trends in sub-periods with rainfall requirements for grain crops and trends in pattern of grain yields from 1996-2010 were all determined. More so, various statistical methods were used to explain the impacts of the variations and changes in rainfall pattern on respondents' livelihood.

The results showed that the standard deviation (468.15mm) decreased with the long-term mean (731.27mm) and the coefficient of variation was averagely high of about 64%. The Annual maximum rainfall (1597.5mm) was recorded in 2008, the annual minimum rainfall (298.5mm) was in 1987 and annual rainfall range was 1299mm. The Coefficients of Skewness and Kurtosis of the annual rainfall series indicated a normal distribution at 95% confidence level. The Mann-Kendall's Rank test statistics (τ) observed that there was no statistical significant trend against the years at 95% confidence limit. The five-years and ten-years running means further confirmed that the annual rainfall trends showed dry periods below the long-term mean from 1971-2001. However, rainfall amounts steadily

increased from the early millennium until the end of period. To further determine the significant changes in the rainfall amounts, the long-term data were subdivided into decadal or 10 year non-overlapping and 20-years overlapping sub-periods. The means were calculated for each sub-period all showed a tendency towards increasing amounts.

The Pearson's Product Moment Correlation coefficient *(r)* was used to relate both rainfall amounts and each of the grain yields from 1996-2010. It showed that Millet, Sorghum and Maize yields were imperfect but positively correlated. The sub-periodic means were also used to compare with the rainfall requirements for Millet, Sorghum and Maize. The analysis showed that Millet and Sorghum were of great economic value in the area during the drought periods of 1971-2001 while Maize gained wider acceptance and coverage much later within the middle of the millennium to the end of period when rainfall amounts began to gradually increase. Trends in the pattern of grain yields also showed that rainfall was only regular and suitable for crop production from the middle of the millennium to the end of the data but very low in the mid and late 90's; and that greatly affected the outcome of crop yields. The Normalized Rainfall Index (NRI) revealed that drought occurrences were prevalent within 1971-1987 while flooding occurrences occurred from 1998-2010.

The analysis of demographic characteristics of respondents in the three sampled wards generally revealed that more male folks within the ages of 43 years and above had 19-26 years experience and were familiar with the agro-climatic situation of Shinkafi LGA. Most of the respondents also have an average household size of about 11 persons and so engage in several off-farm activities to keep body, soul and family together. Majority of the farmers' group membership however, are at the average if not declining stage due to government politics and favoritism.

In analyzing the socioeconomic characteristics of the sampled wards, respondents were found to be both subsistent and commercial farmers as Millet, Sorghum and Maize were the prominent crops produced in the Shinkafi LGA. Farmers also benefited from the provision of insecticides, fertilizers,

seeds and open market from the Zamfara State Agricultural and Rural Development Authority (ZARDA). However, they argued that they obtained their capital majorly from their farming and off-farm activities. Most farmers claimed that at the average, they owned eight arable lands but further investigations proved contrary as farmlands are often hired due to high cost prices and government policies involved in acquiring land.

Integrated vulnerability on grain farming was also assessed in Shinkafi region. It was observed that based on climatic impacts, May/June was the best period for planting because it coincided with the Islamic calendar and rainfall is unpredictable with late onset periods of the rainy season in the area. Climatic effects were also pronounced on crops' growth and development in the area leading majorly to low yields during most periods. On the socioeconomic impacts of climate change on farmers' wellbeing, few grain bags were mostly produced; and it meant that the forces of demand were greater than that of supply. Thus, most respondents are faced with the inability to meet up with the high food prices coupled with their low-income capacity and large family size thereby resulting to food insufficiency, malnutrition and high poverty rates.

In adapting to climatic stress, farmers claimed that soil/crop additives like fertilizers and insecticides, soil conservative practices and traditional storage facilities have somewhat helped to control pest problems as related to the change but stressed that they needed external support.

5.3 Conclusion

Rainfall distribution and variability occur as a result of climate change and these changes have raised serious concerns in Shinkafi LGA and Zamfara state in general. It is more critical from the analysis that rainfall is dynamic, unstable, irregular and generally unpredictable.

Varieties of statistical analysis proved that rainfall amounts in these areas was gradually rising above normal from the early millennium tending towards flooding occurrences and abnormalities in calculating onset and termination dates. Grain yield have also been found to be dependent on annual

rainfall amounts as strongly indicated between 1996 and 2010. It has thus, raised the urgency of timely planting exercises among the populace of this region where consistency in per capita food availability has declined invariably leading to changes in crop development, phenology and structure, which affects crop yield, nutritional value, taste and storage quality of the crops.

This study acknowledges that grain farmers are aware of climate change impacts and have tried within the best traditional means such as shifting cultivation, mulching, soil additives and application of agro-chemicals to adapt to its extremities even though its impacts have persisted. This leaves farmers at a more helpless and defenseless state with increasing rate of illiteracy, large family sizes, high poverty rate and hike in food prices. There is therefore the need to recommend new modern adaptive strategies to reduce the impact of climate change.

5.4 Recommendations

Based on the findings of the researcher through direct focus group interview sessions and discussions with officials of ZARDA and the Agricultural department of Shinkafi LGA Secretariat, several biophysical and socioeconomic adaptive measures in combating climatic change impacts were documented as follows.

In addressing biophysical vulnerability of climate change impacts on grain crops, the following points were recommended;

- Planting the best seeds of the best resistant varieties in periods of drought such as the major millet varieties like *Pennisetum glaucum* (Pearl millet), *Eleusine coracana* (Finger millet) and *Panicum miliaceum* (Proso millet) and short duration sorghum varieties like sweet sorghum or guinea corn. More so, agricultural researchers should also adopt a new hybrid of short-duration maize varieties best fitted to the often-harsh climatic conditions in the area.
- Delaying the planting of short duration millet and sorghum varieties in cases of accelerated rainfall increases because they are more productive in short growing season under dry, high

temperature conditions but are drowned under very heavy rainfall and flooding conditions. It is very important that the quality, quantity, phenology and structure of the yields are not affected.

- Initiating the best techniques and skills such as the application of agro-allied chemical like fertilizers for maize during drought and also incorporating green manure crops such as sweet clover, groundnut and peas into the soil to suppress pests, disrupt their lifecycles and provide the additional benefits of fixing nitrogen thereby improving soil properties.
- Executing the best soil conservation practices for farming such as shifting cultivation, mulching, terracing, planting shelterbelts trees against wind erosion, use of seed-dressing fungicides and insects' treatments, deliberate tree planting exercises, crop rotation of grains to reduce pests attack, late seeded and fall-seeded crops should all be encouraged so that the fertility of the soil would be conserved.
- Developing a more improved grain processing and storage facility is vital which ensures that harvested grains are properly dried before threshing and storage. Maize could be stored in cobs or shelled and kept in tightly closed bags sprayed with actellic dust or even dried pepper. Storehouses should be properly sanitized thoroughly by spraying insecticides, well-ventilated with louvers, lightly painted and cracks on the wall mended to avoid grain pests attack.
- Improving rainfall and temperature data, continuing data monitoring and analysis of data to verify future climatic trends in the study area.

Socioeconomic vulnerability of climate change on grain farmers in Shinkafi LGA can be addressed through the following ways;

- Government and Agricultural banks through the Farmers' group should identify hardworking grain farmers with potentials for improvement and help to finance their farming businesses with the provision of farming inputs like seedlings, tractors, arable land, interest-free loans and opening up savings account.

- Active government policies as related to agricultural and water resource development should be based on annual rainfall trends such as river basin developments schemes, establishing solar system-boreholes and dam constructions to enable water harvesting and farm irrigation during periods of drought.
- Proper enlightenment of grain farmers through agro-climatic research institutes on the impacts of climate change, its ravaging effects on the environment and the necessary steps to avoid its impacts on crop production, the best strategies to adopt during each climatic year such, minimizing vegetation clearing and deforestation.
- Setting up active, organized and service-oriented farmers' groups, free from party politics and that ensures that farmers' basic needs are properly solicited for- and channeled to the right persons; such as non-interest loans, free arable land, fertilizers, insecticides, affordable transport costs and stable market prices for grain crops at subsidized rate.

The above recommendations stated may look simple but often overlooked. Thus, adaptive measures should be strictly and constantly monitored, centering on the best seeds of the best varieties, best skills for farming and the best support for all operations relating to agriculture and livelihoods; which all represent a host of components in climate change programmes. A major example is the National Special Programme for Food Security (NSPFS) designed by the Federal Government of Nigeria and aimed at assisting northern farmers in achieving their potentials for increasing productivity, profitability and household income through appropriate agricultural intervention models. This Programme should be further expanded and used as a bench mark to measure the success or failure of the Zamfara state Agricultural Development Programmes (ZADP) coupled with the needed input and effort by the government (devoid of politics and corruption), populace and the scientific communities to minimize vulnerability and facilitate yearly crop productivity.

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APPENDIX

DEPARTMENT OF GEOGRAPHY
AHMADU BELLO UNIVERSITY
ZARIA – NIGERIA

Dear Respondent,

I am an M.Sc student of the above named University undertaking a research on the *Vulnerability and adaptive strategies of grain farmers to climate change in Shinkafi Local Government Area, Zamfara state, Nigeria.* Please help fill this questionnaire. All the information you provide will be treated with all confidentiality and none will be used for any other purpose than this research. Thank you.
Please tick (√)) where appropriate.

RESPONDENTS PERSONAL BIODATA

1. Ward _____
2. Sex Male ☐ Female ☐
3. Age (years) 18 – 22 ☐ 23 – 27 ☐ 28 – 32 ☐ 33 – 37 ☐
   38 – 42 ☐ 43 – 47 ☐ 48 and above ☐
4. Marital status Married ☐ Single ☐
5. Household size 1 – 5 ☐ 6 – 10 ☐ 11 – 15 ☐ 16 – 19 ☐ 20 and above ☐
6. Political status Community head ☐ Family head ☐ Others _____
7. Occupation Farming ☐ Others _____
8. Do you belong to any Farmers' Group /Association? Yes ☐ No ☐
9. Highest educational qualification
   Primary ☐ Secondary ☐ OND ☐ HND ☐ First-degree ☐ Masters degree ☐
   PhD. ☐
10. For how long have you been farming? _____
11. What type of farmer are you? Commercial ☐ Subsistent ☐ Both ☐
12. What is your farm size? 1 – 5 hectares ☐ 6 – 10 hectares ☐ 11 – 15 hectares ☐
    16 – 20 hectares ☐ Above 20 hectares ☐
13. Tick (√) and list the crops you produce
    Millet ☐ Sorghum ☐ Maize ☐ Others _____
14. Why did you choose to produce the crops you mentioned above? _____

INTEGRATED VULNERABILITY

1. Where do you source for capital during each planting season?
   Owned farm income ☐ Off-farm income ☐ Farmers' Group ☐ ZADP ☐
   Agricultural banks ☐ Input supply agents ☐

INTERVIEW AND FOCUS GROUP DISCUSSION GUIDE AND PROBES

Core Questions	Related Probe Questions
General Questions 1. How much do you know about climate change? 2. How will you describe the climatic situation of your ward? 3. Why do you think climate plays a vital role in the agricultural sustainability of your area? 4. Why do you think grain crops thrive well than other crops in your ward?	1. Probe for comments on awareness of the issue of climate change. 2. Probe for comments on trends in the climatic system of the study area. 3. Probe for comments on crop-climate relationship in the area. 4. Probe for comments on adaptive capacity, sensitivity and exposure of farming activities in the study area.
Questions on Vulnerability	
1. How has climate change affected grain farming activity in your locality? 2. What are the socioeconomic implications of climate change on grain farmers?	1. Probe for comments on biophysical vulnerability. 2. Probe for comments on socioeconomic vulnerability
Questions on Farmers' Adaptive Strategies	
1. What method(s) have grain farmers devised to curb climate change? 2. What form(s) of support do grain farmers receive from the government? 3. What other source(s) of assistance do farmers benefit? 4. How regular are these supports? 5. Do you think farmers in your community have been empowered enough to overcome these limitations set by climate change to be successful?	1. Probe on the use of traditional and modern adaptive strategies by farmers. 2. Probe for comments on whether there are any organized form(s) of support rendered by the government. 3. Probe for comments on other form(s) of assistance other than the government. 4. Probe on the frequency and reliability of support offered. 5. Probe for comments on agricultural sustainability in national development