ASSESSMENT OF FARMERS' PERCEPTION AND ADAPTATION STRATEGIES TO CLIMATE CHANGE IN KANO STATE, NIGERIA

BY

Lawrence, Ejeh UDEH
BA (Hons, ABU, M Sc, ABU)
PhD/SCI/51140/2005-06

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Declaration

I, LAWRENCE EJEH UDEH, hereby declare that the work in this dissertation titled "**Assessment of Farmers' Perception and Adaptation Strategies to Climate Change in Kano State, Nigeria"** presented to the Department of Geography, Ahmadu Bello University, Zaria, is the result of my own research and it has not been presented in any form, anywhere for the award of a degree in any institution.

All literature herein referenced and cited have been duly acknowledge. All shortcomings in this are entirely my responsibility.

Lawrence, EJEH UDEH _____ _____

Signature **Date**

Certification

This project dissertation **Assessment of Farmers' Perception and Adaptation Strategies to Climate Change in Kano State, Nigeria** meets the regulations governing the award of the degree of Doctor of Philosophy (Ph.D) in Geography of the Ahmadu Bello University, and is approved for its contribution to literary presentation.

Prof. E. O. Iguisi Chairman, Supervisory Committee	**Signature**	**Date**
Prof. O. F. Ati Member, Supervisory Committee	**Signature**	**Date**
Dr. B. A. Sawa Member, Supervisory Committee	**Signature**	**Date**
Dr. I. J. Musa Head of Department	**Signature**	**Date**
Prof. A. A. Joshua Dean, School of Postgraduate Studies	**Signature**	**Date**

Dedication

To God the only thrice Holy one (the Father, the Son and the Holy Spirit). I also dedicate this work to my lovely wife and children- Mrs. Modupe Lawrence, Ene Ejeh and her sisters who stood by me through it all.

Acknowledgment

I acknowledge the contributions of all authors cited in this work.

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ABSTRACT

Recent research efforts on climate change impacts and adaptation have focused on global and regional assessment using models which paint bigger picture of climate change and only provides estimate of likely consequences. Such efforts, for the most parts, treated each region in isolation and do not integrate assessment potential effects of climate change on specific location. This study which assessed farmers' perception and adaptation strategies to climate change in Kano introduced location specific or micro-level assessment approach to climate change research in the study area which is currently lacking. Data were collected from a questionnaire survey using sample of 1,750 rural farmers in Kano and Focus Group Discussion was conducted. Simple descriptive statistics and Principal Component Analysis (PCA) were the statistics used to analyze the data. The study reveals the following: climate change is present in the area, perception of climate change by farmers in the area, are in line with results of meteorological data records of 10 decades analyzed, farmer's awareness of climate change in their immediate environment seems to be limited compare to their awareness of global climate change, there are few existing coping and traditional adaptation measures in the area, climate change information dissemination in the state is poor and weak, there is poor preparedness of the people for climate change episode in the state hence the high impacts of climate change on the farmers, some climate change challenges in the area include: High rainfall variability, Floods episodes especially in recent years, Increase incidence of new pest and diseases, extreme heat stress due to increasing temperature, Crops failure due to prolonged dry spells or drought condition. Based on the findings, the following actions by the government of Kano state were suggested: raise farmers awareness on issues of climate change, create conducive policy that will enhance adaptive capacity of the rural farmers, improve on existing support service delivery mechanism, seize on new climate change opportunities, diversify livelihood activity in the state, create small credit programme through its MDG, NEED, Poverty Alleviation Scheme etc. to provide access to fund by the farmers, establish a reliable data base generation system to provide real time rainfall and temperature information at local level. The implications of the study is that there is the need to move from the top to down conventional approach based on climate scenarios generated through general circulation models to bottom to top approach which focuses on more holistic impact assessment and adaptation to climate change, so as to develop policies and adaptation strategies that are precise to specific location.

TABLE OF CONTENTS

Title page - - - - - - - - - - - i

Declaration - - - - - - - - - - - ii

Certification - - - - - - - - - - - iii

Dedication - - - - - - - - - - - iv

Acknowledgment - - - - - - - - - - v

Abstract - - - - - - - - - - - vii

Table of contents- - - - - - - - - - viii

List of tables - - - - - - - - - - - xvi

List of figures-- - - - - - - - - - xviii

CHAPTER ONE: INTRODUCTION

1.0 Introduction - - - - - - - - - - 1

1.1 Background to the Study - - - - - - - - - 1

1.2 Statement of the Research Problem - - - - - - - - 7

1.3 Study Aim and Objectives - - - - - - - - - 10

1.3.1 Aim - - - - - - - - - - - 10

1.3.2 Objectives - - - - - - - - - - 10

1.4 Scope of the Study - - - - - - - - - 10

1.5 Justification - - - - - - - - - - 11

CHAPTER TWO: THEORETICAL FRAMEWORK AND LITERATURE REVIEW

2.0 Introduction - - - - - - - - - - 14

2.1 Concept of Climate Change - - - - - - - - 14

2.2 Environmental Challenges, Resulting from Climate Change - - - 16

2.2.1 Flooding - - - - - - - - - - 16

2.3 Past Climate Change Impacts in Africa - - - - - 18

2.4 Livelihood Impacts and Local Coping - - - - - - 21

2.4.1 Local level coping strategies - - - - - - - 22

2.5 Climate Risk Management in Africa - - - - - - 23

2.6 Approaches to Addressing Climate Change - - - - - - 26

2.6.1 Mitigation - - - - - - - - - 26

2.6.2 Adaptation - - - - - - - - - 28

2.6.2.1 Purpose of adaptation - - - - - - - - 30

2.6.2.2 Concepts in adaptation - - - - - - - 33

2.6.2.3 Adaptation and adaptive capacity - - - - - - 34

2.7 Theories and Models in Adaptation - - - - - - - 36

2.7.1 Adaptation framework - - - - - - - 41

2.8 Barriers to Adaptation - - - - - - - 44

2.8.1 Barriers to adaptation preparedness in Nigeria - - - - 46

2.9 Adaptation in Semi arid Regions - - - - - - 47

2.10 Mainstream Adaptation to Climate Change in the Development Process - 48

2.11 Cognitive Heuristics and Climate Change - - - - - 49

2.12 Perception and Climate Change - - - - - - 50

2.12.1 Climate as perceived - - - - - - - - 51

2.12.3 Perception, uncertainty and climate change - - - - - 54

2.12.4 Public perception and climate change awareness - - - - 56

2.12.4.1 Understand individual responsibility and impacts - - - - 57

CHAPTER THREE: THE STUDY AREA AND RESEARCH METHODOLOGY

3.0 Introduction - - - - - - - - - 58

3.1 Origin of Kano- - - - - - - - - 58

3.1.1 Location of Kano - - - - - - - - - 59

3.1.2 Relief - - - - - - - - - - 62

3.1.3 Drainage - - - - - - - - - - 62

3.1.4 Population and tradition - - - - - - - - 62

3.1.5 Description of the study area - - - - - - - 63

3.1.6 Choice of the study area - - - - - - - - 63

3.1.7 Agricultural production in the area - - - - - - - 64

3.1.8 Population and farm labour in the study area - - - - - 65

3.1.9 Labour management - - - - - - - - 66

3.1.10 Water resources of the study area - - - - - - - 67

3.1.11 Soil and vegetation - - - - - - - - - 68

3.1.12 Climatic element - - - - - - - - 69

3.1.12.1 Rainfall - - - - - - - - - 70

3.1.12.2 Temperature - - - - - - - - - 71

3.1.12.3 Evaporation -- - - - - - - - - 72

3.1.12.4 Other elements - - - - - - - - - 72

3.1.12.5 Climatic Controls - - - - - - - - - 72

3.1.12.6 General effects of the climatic controls- - - - - - 73

3.1.12.7 Seasonal effects of the climatic controls - - - - - - 74

3.2 Types and Sources of Data - - - - - - - 76

3.2.1 Primary data - - - - - - - - - 76

3.2.2 Secondary data- - - - - - - - - 77

3.3 Sampling Procedures - - - - - - - - 77

3.4 Questionnaire Administration - - - - - - - - 85

3.5 Research Methods and Techniques - - - - - - - 85

3.5.1 Selection criteria - - - - - - - - - 85

3.5.2 Research operationalization - - - - - - - 87

3.5.3 Questionnaire design - - - - - - - - 87

3.6 Data Analysis - - - - - - - - - 88

CHAPTER FOUR: RESULTS PRESENTATION

4.0 Introduction - - - - - - - - - 89

4.1 Socio-economic Characteristics of the Respondents - - - - 89

4.1.1 Occupational pattern -- - - - - - - - 89

4.1.2 Farming system in the study area - - - - - - 90

4.1.3 Gender and marital status - - - - - - - - 91

4.1.4 Age of respondents - - - - - - - - 93

4.1.5 Religion of the respondents - - - - - - 94

4.1.6 Educational qualification of respondents - - - - - 95

4.1.7 Income sources and status of the respondents - - 96

4.1.8 Farmers Income per year- - - - - - - - 97

4.1.9 Farmers yearly excess expenditure over income - - - - 98

4.1.10 Strategies to overcome income deficit - - - - - - 99

4.2 Awareness Perception of Climate Change in the Study Area - - - 100

4.2.1 Farmers awareness and understanding of climate change - - - 100

4.2.2 Farmers extent of awareness of local climate change issue - - - - 104

4.2.3 Farmers understanding of global climate change phenomena - - - 104

4.2.4 Farmers perception and description of local climate change in the study area - 106

4.2.5 Sources of information on climate change - - - - - - 108

4.2.6 Perceived causes of climate change in the study area - - - - 110

4.2.7 Perceived causes of new insect pests and plant diseases in the study area - - 112

4.2.8 General perception and awareness of the local farmers - - - - 113

4.3 Adaptation and Coping Strategies - - - - - - - 114

4.3.1 Adaptation options in the study area - - - - - - 114

4.3.1.1 Farmers coping strategies to adapt to climate change in the study area - 114

4.3.1.2 Perceived hindrances to modern adaptation strategies to climate change - - 115

4.3.1.3 Farmers response to temperature changes - - - - - 116

4.3.1.4 Farmers response to changing rainfall pattern - - - - - 117

4.4 Climate Change and General Potential Adaptive Measures Practiced by Farmers in the Study Area - - - - - - - - 118

4.5 Community Identified Critical Climate Change Challenges in the Study Area - - 123

4.6 Vulnerable Groups in the Study Area - - - - - - 124

4.7.1 Identified climate change impact and challenges in the study area - - 126

4.8 Comparison of Farmers Perception of Change with Meteorological Data in the Study Area- - - - - - - - - - 127

4.8.1 Precipitation - - - - - - - - - - - 127

4.8.2 Temperature - - - - - - - - - - 130

4.9 Kano State Government intervention in tackling the problem of climate change in the state - - - - - - - - 131

CHAPTER FIVE: DISCUSSION

5.0 Introduction - - - - - - - - - 133

5.1 General Perception and Awareness of Local Farmers- - - - 133

5.1.1 Perception of farmers on temperature change - - - - - 133

5.1.2 Farmers perception of rainfall trends - - - - - - 134

5.2 Local Farmers' General Climate Change Perception in the Study Area - 135

5.3 Awareness and Perception of Local Farmers on Climate Change and their on farm practices - - - - - - - - - 138

5.3.1 Farmers traditional on-farm adaptation strategies to mitigate climate change impacts in the study area - - - - - - - - 154

5.3.1.1 Soil management and tillage practice as a result of climate change- - 138

5.3.1.2 Staggered seed crop planting - - - - - - - - 139

5.3.1.3 Crop diversification - - - - - - - - - 139

5.3.1.4 Irrigation/fadama farming - - - - - - - - - 140

5.3.1.5 On-farm seed selection - - - - - - - - - 140

5.3.1.6 Delayed land preparation - - - - - - - - - 141

5.4 Local Farmers Coping with Identified Climate Change Challenges in the Study Area- - - - - - - - - - 143

5.5 Climate Change Impacts and Vulnerable Groups in the Study Area - - 143

5.6 Synergy of meteorological data and farmers perception of seasonal changes in rainfall and temperature in the study area - - - - - 144

CHAPTER SIX: IMPLICATIONS OF THE STUDY

6.0 Introduction - - - - - - - - - 146

6.1 Practical Implications of the Study- - - - - - - 146

6.2 Adaptation and Coping Strategies to Climate Change in the Dryland Kano - 150

6.2.1 Local farmers mal-adaptation responses to climate change in the study area- 151

6.2.2 Adapting to erratic rainfall pattern in the Kano area - - - - 153

6.2.3 Adapting to rising temperature condition in the Kano area - - - 154

6.2.4 Adapting to pest and diseases due to climate change in the study area - 154

6.2.5 Coping with food insecurity resulting from climate change in Kano area - 155

6.2.6 Religious coping and adaption mechanism against climate change in the study area- - - - - - - - - 155

6.3 Climate Fluctuation and Management of Selected Crops in the study area- 157

CHAPTER SEVEN: SUMMARY, RECOMMENDATION AND CONCLUSION

7.0 Introduction - - - - - - - - - 159

7.1 Summary of Findings - - - - - - - - 159

7.2 Conclusion - - - - - - - - - 161

7.3 Recommendations - - - - - - - - - 163

7.4 Future research areas - - - - - - - - 168

References- - - - - - - - - - 169

Appendix 1: Graph of Temperature Trends over the Study Areas - - - 185

Appendix 2: Total Rainfall Pattern over the Study Area - - - - 232

Appendix 3: Calculated ten (10) Decades of Onset and Ceasation and Length of Growing Season over Kano- - - - - - - - - 240

LIST OF TABLES

Table 2.1 Estimates of Confidence in Observed and Projected Change in Extreme Weather and Climate Event - - - - - - - - - 15

Table2.2 Summary of Adaptation Definitions - - - - - 29

Table2.3 Climatic Variability and Directed Experimental Perception - - - 52

Table3.1 Average Climatic Conditions in Kano Area - - - - - 70

Table3.2 Food Security Zones in Kano State - - - - - - 77

Table 3.3Selected LGAs for the Study - - - - - - - 78

Table3.4 Distribution of Questionnaires LGA by LGA - - - - 85

Table4.1 Farmers Awareness by Level of Education on Climate Change Indicators in the Study Area - - - - - - - - - - 100

Table 4.2 Farmers Awareness by Age Group on Observed Temperature Trends for the last Two Decades - - - - - - - - - - 101

Table 4.3 Percentage Distribution of Farmers Perception on Trends of Rainfall over Kano State - - - - - - - - - - 123

Table 4.4 Percentage Distribution of Farmers extent of Awareness of Local Climate- - 124

Table 4.5 Percentage Distribution of Farmers extent of Awareness of Global Climate Change - - - - - - - - - - 124

Table 4.6 Farmers Local Knowledge or view of Climate Change - - - - 106

Table 4.7 People's Perception and Observed Environmental Change at Local Level- - 113

Table 4.8 Farmers Reaction in the face of Climate Change Episode - - - 114

Table 4.9 Adaptation in Response to Change in Rainfall - - - - - 117

Table 4.10 Percentage Distribution of General Traditional Adaptation Strategies to Climate Change in Dryland Kano - - - - - - 120

Table 4.11 Perceived Climate Change Challenges - - - - - 123

Table 4.12 Distribution of Wealthy Groups in the Study Area - - - - 125

Table 6.1 Management of Selected crops in the Area in the face of Climate Change - - - - - - - - - - 157

LIST OF FIGURES

Figure 2.1	The adaptation framework - - - - -	43
Figure 2.2	Decision making framework for climate adaptation strategies- -	44
Figure 3.1	Nigeria showing Kano state - - - - - -	60
Figure 3.2	Kano state showing selected local government area - - -	61
Figure 3.3	Kura local government area showing study point- - - -	78
Figure 3.4	Alhasu local government area showing study point-- - -	79
Figure 3.5	Rogo local government area showing study point- - - -	80
Figure 3.6	Sumaila local government area showing study point- - -	82
Figure 3.7	Shanono local government area showing study point- - -	83
Figure 3.8	Bichi local government area showing study point- - - -	84
Figure 4.1	Percentage proportion of distribution of respondents primary occupation- - - - - - - -	89
Figure 4.2	Farming systems by percentage proportion in the study area- -	90
Figure 4.3a	Gender status of respondents across the local government areas- -	91
Figure 4.3b	Marital status of the respondents across the local government areas -	92
Figure 4.4	Age distribution of respondents - - - - - -	93
Figure 4.5	Religion of respondents - - - - - - -	94
Figure 4.6	Highest education qualification of the respondents - - - -	95
Figure 4.7	Percentage sources of respondents income - - - - -	96
Figure 4.8	Income distribution of respondents - - - - - -	97
Figure 4.9	Farmers annual excess expenditure over income - - - -	98

Figure 4.10 Farmers strategies to overcome deficit in times of crop failure or offseason- - - - - - - - 99

Figure 4.11 Sources of information on climate change to farmers in the study area - 108

Figure 4.12 Perceived causes of climate change in the study area - - - 110

Figure 4.13 Perceived hindrances to adoption of modern techniques in combating climate change - - - - - - - - 115

Figure 4.14 Farmers responses to increased temperature - - - - - 116

Figure 4.15 Farmers identified climate hazards and ranking in the study area- 126

Figure 4.16a Graph of Onset of rain over the study area - - - 128

Figure 4.16b Graph of Cessation of rain over the study area - - - 129

Figure 4.16c Graph of length of growing season over the study area - - - 130

Figure 6.1 A model of perception and adaptation to climate change in a traditional farming community - - - - - 147

CHAPTER ONE: INTRODUCTION

1.1 Background to the Study

Climate change is one of the most significant challenges facing human society in the 21st century. Recent scientific findings by individuals (e.g. Stern, 20006; 2008), and institutions such as the Inter-Governmental Panel on Climate Change (IPCC, 2007), the United Nations Development Programme and the World Bank, (2010) have demonstrated that climate change is a reality and a primary environmental threat to sustainable development in the 21st century.

Industrialization has led to the release of green house gases (GHG's) into the atmosphere, with subsequent changes in the earth's temperature and weather systems. Mean global temperature is predicted to increase by between 1.4 -5.8^{0}c over the coming century (IPCC, 2001), which will cause changes in the distribution of rainfall, frequency and intensity of extreme weather events, and sea –level rise. Many human systems will be affected by these changes, particularly agriculture, water resources, industry and human health. However, the impacts of climate change will not be uniform across the globe and considerable differences are expected among different regions (McCarthy *et al*, 2001). Surprisingly, the poorest countries, who are the least contributors to global GHGs emissions, are amongst the most vulnerable to climate change. Poor communities are not only located in high-risk areas, but their lack of economic and social resources means they are ill-equipped to adjust to the long-term changes in climate.

In the last few decades, cyclic patterns between drought and floods have become more frequent, while the severity and spatial distributions have also changed, with devastating impacts. The phenomenon and direction of trends in weather and climate events has become increasingly deviant from normal, with more warmer and fewer cold days and nights, and more frequent hot days and nights over most land areas (IPCC, 2007). Similarly, heavy

rainfall events over many areas have become more frequent and brought more devastating consequences. The impacts of these changes has manifested in decreased yields in agricultural crops, increased pest outbreaks, rampant soil erosion and water logging (especially in coastal and humid areas).

Drought affected areas have become vulnerable to land degradation, crop damage or failure and increased livestock deaths due to lack of forage and dehydration. In sub-Saharan Africa yields from rain fed crops could be halved by the year 2020 and the net revenue from crops could fall by 90% by 2100 (IPCC, 2007, Adejuwon 2006) if the trend continues. This situation will engender poverty in Nigeria making its agriculture highly vulnerable to the impact of projected climate change.

It has been predicted that Africa will experience a rise in temperature of between 1-2.5^{0c} by 2030 (IPCC, 2007). This coincides within the period of Nigerian vision 2020 development plan. Consequently, it is expected that there will be haphazard shift in crop growing seasons, poor crop productivity and abrupt outbreaks of disease vectors. The country's population will therefore be at greater health and life risk than before. One of the present major development problems facing Nigeria is persistent and increasing food insecurity linked to poverty. Almost 57 million or more Nigerian live below the poverty line, the majority of which live in the rural areas, with more than 70% of them relying on rainfed subsistence or crude farming to survive (Ogungbile *et al*, 1998, Okali, 2007, Adefolalu 1998). Evidence shows that continued climate change episodes may exacerbate the poverty level, leaving many local farmers, mainly the subsistence or small holder, trapped in a cycle of poverty and vulnerability to climate change.

While many attempts have been made to strengthen the adaptive or coping capacity of communities in dry land areas of Nigeria to climate change, many of these have failed due to lack of awareness induced by endemic illiteracy and poverty level. Nigeria therefore needs

innovative and proactive adaptation strategies that will empower the rural dwellers, especially the local farmers in coping with livelihood vulnerability often accompanying climate change.

In general, in order to tackle the problem of food insecurity, the challenges and opportunities presented by climate change and innovative adaptation strategies must be related to the communities who interact directly with natural resources, especially the subsistence farmers who forms the majority of the population and live in the rural areas.

Traditional farmers of the fragile Kano ecosystem will suffer greater impacts from the emerging climate change related problems, such as increasing rainfall variability, extreme temperatures (extreme hot days), shorter growing seasons, high solar radiation, greater moisture stress, new pest and diseases etc. This called for, adaptation strategies to offset negative impacts of climate change (Klien et al, 2007, Adjer *et al* 2007).

That the climate is changing is no longer the issue, but ways to address this challenge is the issue. Mitigation and adaptation is the key. While mitigation seeks to reduce the anthropogenic forcing resulting in climate change; adaptation aims to ensure that people's livelihood, public perception and private enterprises, assets, communities, infrastructures and the economy are resilient to the realities of changing climate.

The literature on adaptation makes it clear that perception is a necessary prerequisite for true adaptation. Perception is the process by which we receive information or stimuli from our environment and transform it into psychological awareness (IPCC, 2001, Brooks (1999), UNFCCC 2006, UNEP 1998). It is interesting to see that people infer about a certain situation or phenomenon differently using the same or different sets of information. Knowledge, interest, culture and many social processes seem to shape the behaviour of an actor who uses the information and tries to influence that particular situation. Saarinen, (1976), Barber *et al* (2003) described perception as an extremely complex concept and confines "social perception" which is concerned with the effects of social and cultural factors

to cognitive structuring of our physical and structural environment. This varies with the individual's past experiences and present sets or attitudes acting through values, needs, memories, moods, social circumstances and expectations.

Individuals play an important role in responding to climate change whether they are leaders in government, business or a neighborhood association, or members of the public at large. Individuals are ultimately the actors who initiate, inspire, guide and enact the necessary cuts in greenhouse gas (GHG) emissions to slow down global warming and they develop and implement the sustained and sustainable adaptive responses to minimize its impacts.

Local farmers who are vital and form active parts of many ecosystems may help to enhance the resilience of these ecosystems. Their livelihoods depend on natural resources that are directly affected by climate change, and they often inhabit economically and politically marginal areas in diverse, but fragile ecosystems. In addition, they interpret and react to climate change impacts in creative ways, drawing from traditional knowledge as well as new technologies to find solutions, which may help society at large to cope with the impending changes (Jan and Anja, 2007).

Doss and Morris (2001) opine that the perspectives of the local people, the way they think and behave in relation to climate, as well as their values and aspirations have a significant role to play in addressing climate change. In spite of this, traditional people are only rarely considered in academic, policy and public discourse on climate change, though the impact of impending changes of climate is greater on them (Adefolalu, 1986).

Traditional knowledge has over the years played significant roles in solving problems including climate change. Local people live close to the natural resources, and have immense knowledge of their micro-environment, observe the activities around them and are first to identify any changes and adapt to them. They display a clear understanding of changes in times and seasons through their traditional knowledge and are able to use certain events e.g.

appearance of certain birds, mating of certain animals, or flowering of certain plants as indicators. A classic example is, how local communities escaped the 26th December, 2004 tsunamis' wrath due to their traditional knowledge unlike those attracted to the shoreline by the unusual spectacle of fish flopping on a seafloor exposed by the sea's withdrawal. Local communities of India, Indonesia and Thailand's coasts and Islands all knew to head rapidly inland to avoid the destructive force of the sea. Their villages were destroyed, but the inhabitants escaped unscathed. 80,000 Simeulue people moved beyond the reach of the tsunami. Only 7 died (undated). Traditional knowledge has played a significant role in Africa's adaptation efforts, in the face of low technology. Farmers and other natural resource dependent communities in Nigeria have been coping quite well with changes in climate through traditional knowledge and practices although the country has no climate change adaptation policy.

Climate models paint the bigger picture of climate change and provide estimates for the likely consequences of different future scenarios of human development. They are not very good at providing information about changes at the local level. In recent years, there has been an increasing realization that local groups are valuable sources of this information. Local people are not only keen observers of climate changes but are also actively trying to adapt to the changing conditions. In some instances, people can draw on already existing mechanisms for coping with short term adverse climate conditions. Some of these responses may be traditionally included in their normal subsistence activities, while others may be acute responses, used only in case of critical weather conditions (Stott and Kettleborough, 2002).

Most research on people's perception of climate changes were carried out in the developed countries of the world which dominate the uppermost northern region of the earth where the relationship between scientists and local people is high (Jan and Anja, 2007). In developing countries the situation is different. The local people are rarely considered in spite

of the fact that they are effective managers of the natural environment and they are very successful at preventing deforestation.

Though, efforts have been made towards fighting climate change through scientific views, research and policies directed towards local knowledge and perception are highly needed. It is, therefore, important to understand local people perceptions of climate change and their preferences of strategies towards adaptation to climate change. The specific drive of this study is to assess the perception of local farmers in selected Local Government Areas of Kano State on climate change issues, and adaptation/coping measures, that will help in policy making that may have positive impact on their lives.

In view of the role of the local farmers in mitigating climate change and adapting to building changes, the emerging questions are:

- How do farmers in the study area perceive climate change and how are they using their adaptation measures to increase their resilience?
- How do the local farmers adjust to climate change impacts in the study area?

Sub-questions

- How do farmers in the area perceive climate change and what are the roles of traditional perceptions and practices in mitigating climate change in the area?
- What is the source of their knowledge?

1.2 Statement of the Research Problem

Climate change is probably the most complex and challenging problem facing the world today. Currently, intriguing questions include questions on weather uncertainty, persistent climate abnormalities, rampant environmental degradation and eminent food insecurity. Some of these complexities are exacerbated by increased human population and demand for more land for agricultural production, urban expansion, and industrialization, which have resulted in destruction of the vegetation cover and subsequently rampant environmental degradation. The demand for food, fuel wood and forest products by locals expands this problem and the results are devastating effects that include climate change, droughts, floods and subsequently food insecurity. Local farmers as used here describes rural producers who farm using mainly family labour and for whom the farm provides the principal source of income. Local farmers grow most of Nigerian grains and significant quantities of potatoes, beans, sorghum, vegetables, tree fruits etc. However, these farmers are faced with the challenges of increasing production while preserving natural resources. Meeting these challenges is vital to sustained livelihoods and reduction of poverty, especially within the fragile dryland and semi-arid area of Nigeria.

Africa is generally acknowledged to be the continent most vulnerable to climate change. West Africa is one of the most vulnerable to the vagaries of the climate, as the scope of the impacts of the climate variability over the last four decades have shown (IPCC, 2007). Recent food crises in Nigeria as in other countries of West Africa are strong reminders of the continuing vulnerability of the region to the vicissitudes of climate change. This is in large measure due to very weak institutional capacity, limited engagement in environmental and adaptation issues, and a lack of validation of local knowledge (Mirza 2003, Okali, 2007, Mendelson and Dinar 1999, Adams *et al*, 1988). Therefore, there is the need to gain information, as much as possible, and learn from the position of local farmers and their needs,

about what they know on climate change, in order to recommend adaptation practices that meet these needs.

Climate variations worry peasants in the study area on a daily basis and they respond differently to its damages depending on their adaptive capacity. Among such damages are the loss of crops due to intense droughts and prolonged dry spells, flood, and the emergence of new plants and livestock diseases. There are further impacts including lack of proper nutrition (both livestock and man), the loss of income, and a change to traditional farming systems, (which are often mal-adaptive). Reduction in available water for agriculture will only make the present situation worsened if nothing is done immediately. The selected LGAs for this study is a representative of the state as it cuts across the ecological and food security zones of the state sharing similar geographical, climatic and socio-economic characteristics with the rest part of the state, with slight variation.

Previous studies in the savanna in which Kano state belong include Fiki and Lee (2004); Nyong and Fiki (2005); Obioha (2005, 2009); Oladipo (1993a, 1993); Benoit (1997); Ati (2006); Ati *et al* (2000 and 2009); Ogungbile *et al* (1998). Ogunbinle *et al* (1998), analyzed farmers constraints in agricultural production in the savannah using multi-scale, characterization. Ati et al, (2009), appraised trends in the duration of rainy season in the study area. He observed an increase in the amount of rain fall. Ati, (2002) compared traditional method with empirical ones for calculating onset of the growing season in Kano. He found that the length of growing season was not consistent. Nyong and Fiki, (2005) appraised drought related conflicts management and resolution in the west African Sahel. Oladipo, (1993) appraised some aspects of the spatial characteristics of droughts in northern Nigeria. Ati, (2006) analyzed rainfall characteristics in drought prone sudan sahel zone of Nigeria, and Benoit, (1997) analyzed the start of the growing seasons in northern Nigeria. Much of the

above studies reported have been on drought, desertification, growing season, land use management and changes in ecosystem and biodiversity.

Elsewhere outside Africa, a small but growing number of studies have examined perceptions of climate change using small samples. The studies employed mainly qualitative, in-depth methodologies such as focus groups, semi-structured questionnaire survey and interviews. In all the studies, perception was observed to be vital to good adaptation to climate change. No work of this nature focusing on rainfall variability, farmer's perception and adaptation strategies has been done in the Kano to the best of the author's knowledge.

In spite of the fact that efforts have been made towards fighting climate change from scientific view, researches directed towards local farmers knowledge and perception is highly needed. It is important to understand local people's perceptions of climate change and their preferences of strategies towards adaptation.

Recent research efforts have focused on regional and national assessments of the potential effects of climate change on agriculture (Fischer *et al*, 2002, Charles and Rashid 2007). These efforts, have, for the most parts, treated each region or nation in isolation and do not integrate assessments of potential effect of climate change on specific location but mostly focus on world or regional agriculture. The differences of this research is that it used a bottom-up approach which seeks to gain insight from the farmers themselves based on a farm housed hold survey. This approach helped to acquire a better understanding of the local people's perception of climate change and existing adaptation strategies.

1.3 Study Aim and Objectives

1.3.1 Aim

The aim of the research is to assess local farmer's perception and their adaptation strategies to climate change in Kano state.

1.3.2 Objectives

The above aim will be fulfilled through the following objectives: to

i. Assess the perception of local farmers on climate change in the study area.
ii. Assess the degree of synergy between farmers' perception and climatological time series.
iii. Find out the major impacts of changing climate in local people's view.
iv. Document how traditional farmers adapt to climate change and their constraints to adaptation in the study area.

1.4 Scope of the Study

The scope of this study focused on examining the local farmers' perception of climate change and their coping strategies in the dryland farming communities of Kano state. The study is limited to the rural farmers in dryland area of northern Nigeria. The choice of Kano is based on the fact that;

i. It is a dryland state of northern Nigeria threaten with climate change impacts.
ii. It is one of the major grain producing state of northern Nigeria
iii. In recent time its rural agriculture has came under the impacts of climate change affecting its yields
iv. Small enough to be covered in a study of this nature by a student with very limited budget.

The result obtained should be to similar dryland agriculture elsewhere.

1.5 Justification

It has been argued that, many climate change studies, while effective in alerting policy makers of the possible effects of climate change, have limited usefulness in providing local-scale guidance on adaptation, and that the climate change community should learn from experience gained in food security and natural hazards studies. Such analysis must begin with the recognition that climate change exist today, change that will not disappear on its own and may indeed be growing, and with the desire to make active interventions to reduce the vulnerability. The scientific knowledge on impacts of climate change is increasing all this time, as are practical experiences in responding to adaptation needs. This knowledge needs to be exploited. In Kano state, the lack of research and credible scientific evidences on the impacts of climate is a major challenge. There is limited understanding on such basic issues such as the nature and scale of climate change and farmers perception of the change.

Agriculture is the mainstay of rural food and economy of the state, and accounts for over 80% of the total water use of the State. This sector is presently facing challenges from erratic weather patterns such as heat stress, longer dry seasons and uncertain rainfall and longer dry spells within the rainy season. Decline leading to low agricultural yield due to productivity. Unfavorable weather and climate will lead to vulnerability in the form of food insecurity, hunger and shorter life expectances). There are some impacts for which proper perception and adaptation is the only available and appropriate response.

Studies on perceptions, local knowledge, and adaptive strategies at the local farmers and community levels, as well as lessons learned, can provide the basis for concepts and methods of assessing climate change impacts, vulnerability and adaptation on livelihood of the local people.

There are very few indepth climate change study on farmers perception and adaptation in this part of the country. Information on local farmers' perception and

adaptation, to climate change in particular is scanty, in spite of the importance of agriculture in the economy of the rural communities of Kano state. This study will serve as information source for policy makers, planners, agricultural extension officers and other stakeholders

CHAPTER TWO: THEORETICAL FRAMEWORK AND LITERATURE REVIEW

2.1 Introduction

This chapter deals with the literature reviewed, framework and models studied for this study. Concepts on climate change and perception was studied. Theories and models on adaptation treated include: the social capital or collective action models, impact models, numerical models and the analogue models.

2.2 Concept of Climate Change

It is expedient to define climate in order to understand climate change. Climate is the synthesis of weather at a given location or area over a period of at least 30 years (Ayoade, 2003). Climate is dynamics; sometimes there's climate trend, fluctuations, climate cycles and anomaly. These are not climate change. Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity (IPCC, 2007).Climate change implies a new mean climatic state or climate normal (Ayoade, 2003). It may also mean a shift in average weather condition on the earth, including changes in temperature, precipitation and wind patterns (CIESIN, 2005). Climate change involves complex interaction between the climatic environment and economic, political, institutional, social and technological processes (IPCC, 2001b). There are several causes of global climate change; there are increased concentration of green house gases, human drivers, and other land use changes, human activities increasing aerosol and methane in the atmosphere e.t.c. Moreover, it has been attributed to natural causes such as the earth's orbital cycle, solar radiation (Ayoade, 2003; CIESIN, 2005; IPCC, 2001b). Some area will experience droughts while others experience increased precipitation, leading to environmental impacts. Average sea level rise of 10 to 20cm over 1000 years (expected to rise further to 10 to 90 by the year 2100) and an increasing intensity of drought in parts of Asia and Africa in recent decades are part of expected impacts. Many of these changes have already led to multiple social-

economic impacts. These include floods, droughts, storms, heat waves, change in growing seasons in same regions, changes in water quality and quantity, sea level rise and glacier melt (Postnote, 2006, IRIN 2005). Climate change posses a serious threat to development and poverty reduction in the poorest and most vulnerable regions of the world (Postnote, 2006; IPCC, 2001a, 2007).

Below is an estimate of confidence in observed and projected change in extreme weather and climate events.

Table 2.1 Estimates of Confidence in Observed and Projected Change in Extreme Weather and Climate Events.

Changes in climate phenomenon	**confidence in observed Changes (latter half of Twentieth century)**	**confidence in projected changes (during twenty-first century)**
Higher maximum temperatures and more hot days over nearly all land areas	Likely	very likely
higher minimum temperatures, fewer cold days and frost days over nearly all land areas	very likely	very likely
Reduced diurnal temperature range over most land areas	very likely	Very likely
Increase of heat index over land areas	likely over many areas	very likely over most areas
More intense precipitation events	likely (northern hemisphere mid-high lat latitude areas)	very likely over most areas
Increased summer continental drying And associated risk of drought	likely in a few areas	likely over most mid-Latitude continental interiors
Increase in tropical cyclone peak wind intensities	not observed in few analysis available	likely over some areas
increase in tropical cyclone mean and peak precipitation intensities	insufficient data for assessment	likely over some areas

Source: IPCC, (2001a)

2.3 Environmental Challenges, Resulting from Climate Change

Some examples of environmental challenges that may result from climate change include the following:

2.3.1 Flooding

In the Philippines, policy makers have begun to acknowledge the flood threats posed by the gradual sea level rise of 1 to 3 millimeters per year, projected to occur with climate change. This flood risk is caused by excessive ground water extraction, which is lowering the land surface by several centimeters to more than a decimeter per year (Pielke and Sarewiz, 2005). Vidal (2005) in his study of agricultural systems in Tanzania, opined that in the past, drought occurred every 10 years, now droughts are unpredictable, they are more frequent, but then so are floods. The climate is far less predictable. There might be floods in May or drought every three years. Upland areas, which were never affected by mosquitoes, now are, water levels are decreasing every day. The rains come at the wrong time for farmers and it is leading to many problems

Warmer climate resulting from rising temperatures causes evaporation to increase, and since the world is a closed system, warmer ocean release more water to the atmosphere through evaporation, consequently this will result in heavier rainfall, with more erosion. Whereas, increased rainfall lead to growth of forest in dry desert areas. Higher temperature is leading to glacier retreat. It is increasing especially since 1995 (IPCC, 2001). The carbon dioxide in the atmosphere is taken up by the ocean, because the ocean serve as a sink for carbon dioxide, this will increase acidification. Acidification affects corals. Indeed the world already lost 16 percent of her corals, in 1998 termed the warmest year ever. The corals were lost to bleaching. Increased risk of drought will increase the risk of forest fire (IPCC, 2001a).Transport system such as railway line, oil pipeline will be affected, due to the melting

ice resulting in flooding and consequently the washing away of pipe and rail lines. Agriculture will also be affected. Vidal, (2005) working in Tanzania observed that maize yield had dropped by about 33% and maize is the staple food in Tanzania.

Wirth (1989) found the production of ordinary rice varieties goes down alarmingly at temperatures just a few degrees higher than those presently existing in most rice-growing areas. Climate change will also result in environmental migration. In 1990s the figure for environmental refugees was put at about 25 million, and this figure may be as high as 150 million by the year 2050 (IPCC, 2001). This will be mainly due to coastal flooding, shoreline erosion and agricultural disruptions. Some pacific Island nations, for example, Tsuvu have signed a gradual evacuation arrangement with New Zealand. Thus, a phased evacuation has already commenced.

There will be ecosystem disruptions, forest extinction, for instance, the pine beetle infestation of pine forest destroyed about half of the pine forest (Robin, 2008). Water scarcity, sea level rise is projected to increase salt water intrusion into ground water in some regions, affecting drinking water and agriculture in costal zones.

Diseases will spread, especially insect borne disease. This is because insects will be able to thrive in areas which they could not hitherto. Example is the malaria infestation of Papua New Guinea. East Africa is facing severe power shortages and declines in agricultural productivity due to droughts that experts are linking to climate change. In Tanzania drought has sharply reduced reservoirs that supply hydroelectric plants. The waters of Lake Victoria have reduced by at least 2 meter between 2000 and 2006 (Barclay, 2008). The IPCC, (2001) report has predicted that temperature increases in Africa will be greater than the global average. The general predicted rise will be 4^0 by 2080. But temperatures could rise to 7^{0c} in South Africa and 8^{0C} in Northern Africa. This increase will lead to increase aridity and drought, wide spread diseases and even floods.

Research has suggested that many of the urban poor in Africa face growing problems of severe flooding, increased storm frequency and intensity related to climate change are exacerbated by such factors as the growing occupation of flood plains, increased runoff from hard surface inadequate waste management and silt up drainage (Douglas *et al,* 2008). Mozambique has witnessed floods which have rendered many homeless.

2.4 Past Climate Change Impacts in Africa

Africa that has contributed least to causing climate change has been facing countless climate change related problems. Africa's contribution to greenhouse gas emissions is the least of any continent. It is estimated that each year Africa produces an average of just over 1 metric ton of the greenhouse gas carbon dioxide per person (U.S Department of Energy's International Energy Annual, 2002; cited in Fields, 2005). "Africa's share of global $C0_2$ emission rose from 1.9% in 1973 to 3.1% in 2002, representing an emission of about 747 Mt of $C0_2$ in 2002" (IEA, 2004, cited in Manful, 2005).

While industrialized countries, such as South Africa, produce 8.44 metric tons per person, the least developed countries, such as Mali, produce less than a tenth of a metric ton per person. Thus, the largest proportion of greenhouse gas emissions in Africa belongs to South Africa, which is the fifteenth largest industrial emitter of greenhouse gases globally and the seventh largest 'developing' country emitter. "For example, it is estimated that in 1997 South Africa generated 2% of global $C0_2$ emission and 3-7% of the global total emissions of N0X". (McCawn *et al* 1991, Majule *et al* 2010)

By comparison, the United States pumps out about 25 percent of all greenhouse emissions. The G8 countries emit about half the world's total output. The entire African countries emits less than four percent of the world's total output. Recently, change in rainfall has been observed in different parts of Africa. Among others, the African Sahel suffers from

very variable annual rainfall and a prolonged drought. Annual rainfall during the period of 1931-60 had been between 20% and 40% greater than during the most recent three decades (Hulme, 1992; cited in Hulme *et al*, 1995). "Individual years, such as 1984 and 1990, have seen rainfall totals drop below 50% of those typical of the last decades of the colonial era prior to 1960. The human suffering that has accompanied this prolonged drying out provides a stark indication of the vulnerability of parts of African society to climate change" (Hulme *et al*, 1995).

A recent study also shows that there was a dramatic decline in average rainfall conditions in all west African drylands for the period 1960-1990 (Majule *et al* 2010, McCown *et al* 1991). "Some of the regions in the northern zone with semi-arid conditions in 1930-60 had clearly becomes arid (on average) in the 1960-1990 period, for millet and sorghum production in most years. A considerable part of the sub humid zones in the period 1930-1960 had become semi-arid in 1960-1990 with considerable drought risks, certainly for crops which are less adaptable to stress (maize, cotton)".

Furthermore, some studies have shown that El Nino-Southern Oscillation (ENSO) has had negative impact on climate in Africa. ENSO phenomenon and the temperature of the Indian ocean affect Eastern and southern Africa whereas the conditions in the Atlantic Ocean affect West Africa. The interactions between the Pacific tropical ocean and the global atmosphere drive El Nino phenomenon, which can bring large year-to-year changes for some parts of Africa (Basher and Briceno, 2005). Drought is a recent feature in most parts of southern Africa, with five recent major episodes, in 1980-1983, 1987-1988, 1991-1992, 1994-1995, 1997-1998 and 2002 (Basher and Briceno, 2005). Severe drought has reduced the amount of rain over parts of southern Zimbabwe and southern Botswana. During the rainy season of 1991/92 largely owing to the (ENSO) phenomenon, the periodic warming of the tropical Pacific Ocean and related shifts in the atmospheric circulation which brings climatic

disruption to many low-latitude areas (Glantz *et al*, 1991; cited in Hulme *et al*, 1995). The severe drought that affected nearly 100 million people in south-eastern Africa in 1991-1993 coincided with an ENSO event (Cane, Eshel & Bukland, 1994; cited in Lovett *et al*, 2005).

The devastating floods from tropical cyclones in 2000 reduced Mozambique's economic growth rate from 8% to 2.1% and droughts in the same year substantially reduced hydroelectric power output in Kenya, leading to a $72 million (U.S dollars) emergency loan form the World Bank. South Africa lost cereal crops worth of billions of dollars during the 1990s because of droughts.

Another study suggests that vegetation productivity and desertification in sub-Saharan Africa may be influenced by climate variability attributable to the North Atlantic Oscillation (NAO) and ENSO (Gupta and Hisschemmaler, 1997). According to these authors, "fully 75% of the interannual variation in the area covered by the Sahara Desert was accounted for by the combined effects of the NAO and ENSO" (2001). However, most variance is attributable to the NAO. Much of the interannual variability in vegetation productivity in the Sahelian zone and southern Africa is the outcome of the combined indices of NAO and ENSO.

According to the database of the EM-DAT, flood, droughts/famine, windstorms, extreme temperature and wildlife killed 15,713 and affected 136,590,000 people in Africa between 1993-2002 (Basher and Briceno, 2005). At the United Nations Climate Change conference in November 2006 in Nairobi, the U.N also reported that climate-related disasters in Africa affected and killed over 36 million people between 1993 and 2002 (Mulama, 2006). Floods account for the most deaths whereas droughts affected over a hundred million people over the decade. According to Hussein Abdullahi, from a pastoralist community in north-eastern Kenya, "changing weather patterns, resulting in periods of intense drought, had forced pastoralist to abandon their traditional pursuit of cattle herding and migrate to towns.

Many now depend on food aid for survival, while some had even lost their lives to drought" (quoted in Mulama, 2006).

2.5 Livelihood Impacts and Local Level Coping Strategies to Climate Change

The extent to which African countries are vulnerable to climate change depends on both exposure and sensitivity to changes in climate, as well as the ability to adapt to new conditions (Kelly and Adger, 2000). Sudden shocks caused by climate change, when coupled with existing vulnerabilities and institutional weaknesses, could lead to much larger and longer term poverty traps than local livelihood systems, national governments and the international humanitarian systems seem capable of coping with (Devereux and Edward, 2003).

Nearly 70% of Africa's population depends on agriculture for a living (IFPRI, 2004). Agriculture in Africa is highly vulnerable to climate variability and long-term climate change, which could result in higher food prices, lower domestic revenues and widening of current account deficits due to lower export earnings together with increased inflation and increased external indebtedness. Such changes will only compound the difficulties faced by a region where agricultural yields and per capita for food production have been steadily declining and where population growth tends to doubled demand for food, water and livestock forage in the next 30 years (Davidson *et al*, 2003, Khandji *et al* 2006). Countries in Africa are already among the most food insecure in the world (Devereux and Edward, 2003), and climate change will only aggravate falling harvests. In Tanzania, for example, famine resulting from either floods or drought has become increasingly common since the mid-1990s, undermining food security.

2.5.1 Local Level Coping Strategies

Over time, households and communities have developed a number of coping strategies in response to extreme climate events. Some of these measures can only assist families in the short-term and cannot deal with increased and more severe shocks. However, many traditional coping strategies do provide an important lesson for how African countries can better prepare and adapt to climate change in the long-term. There is a need to strengthen these coping strategies to enable households to live with current climate variability as well as well help them to adapt to long-term climate change. And this is only possible if we first understand local people's vulnerabilities, capacities and risks.

Local level coping strategies to shocks such as drought and floods differ among households and communities depending on the resources available and social capacity. They may include remittances from migrant household members, collecting wild fruits, switching to non-farming activities or, in extreme cases, selling assets. Eriksen *et al*, (2005) found in Saweni Village, in Tanzania that households' coping mechanisms during drought include coausal labour, brick making, handicraft, collecting honey and charcoal burning. Traditional fruits were also highly regarded because they could be harvested by any household member and did well in drought conditions. These activities provide an important source of cash to allow households to purchase food and cater for other necessities at such times.

Remittances from migrant family members and relatives do play important role in household well-being during difficult periods. People who receives remittances tend to be less affected by shocks in terms of access to food, health services and school attendance (Eriksen *et al*, 2002, Khalil, 1974).

2.6 Climate Risk Management in Africa

What kinds of strategies have been used to respond to climate change in Africa? Can Africa influence the magnitude and rate of future global warming? Can it contribute to the solution of the negative effects of global environmental change?

Until recently, African countries have not considered climate as their priority area in development. To a certain extent, development planning within Africa has taken a limited account of climate in an explicit sense (climate has generally been implicit as one of many biophysical considerations), despite the significant vulnerability of the human population to the high levels of climate variability over the continent. IRI also found gaps in four main areas: integrating climate into policy, integrating climate into practice; climate services and climate data (IRI, 2006, cited in Hellmuth, 2007a).

As has been stated earlier on, there have been other multiple stresses, particularly from poverty, infectious disease, fragile environments, and external intervention, on African countries that have limited their power to make significant change. These factors have made African countries vulnerable to the impacts of climate change, and prevented them from paying sufficient attention to climate compared to other pressing needs. African countries could not use their meager resources to handle climate variability. They have been forced to give priority to address other urgent and pressing issues.

Moreover, Africa has not fully utilized the opportunities offered by the United Nations Frame work Convention on Climate Change (UNFCCC) to advance the process of achieving sustainable development. It has not benefited from the Clean Development Mechanism (CDM) (Article 12 of the Kyoto Protocol), which allows Annex 1 countries to meet their commitments by undertaking projects with non-Annex 1 counties. Emissions limits or reduction commitments apply only to 39 Annex 1 countries. On the other hand, "investments by industrialized countries in the energy sector and land-use change carbon

offset projects on forestry and energy are being made in several tropical and subtropical countries, e.g. Costa Rica, Bolivia and India, with Africa falling well behind in knowledge and revenue gained" (Justice *et al*, 2005). However, it is worth noting that several multilateral and bilateral agencies, for instance UNEP Riso Centre on Energy, Climate and Sustainable Development (URC) in Denmark, United Nations Industrial development Organization (UNIDO), the World Bank, the UNFCCC secretariat, and the WMO) have undertaken various initiatives to enhance the capacities of African countries to implement CDM projects. The Global Environmental Facility (GEF) has also supported capacity activities in Africa (Manful, 2005).

Nonetheless, there have been attempts to address the problems of climate variability and change in Africa. The Environmental Initiative of the New Partnership for Africa's development receives support from the African Union Commission (AUC). AUC, in collaboration with UN Economic Commission for African Development Bank has just started to support a major new initiative, Global Climate Observing System (GCOS)- Africa Climate for Development (Babangana, 2007). It aims to integrate climate information and services into development and thereby support Africa's progress towards the Millennium Development Goals. Regional cooperation is another way of dealing with climate change in Africa. It can be a cost effective way of greenhouse gas mitigation. Coordinated action among neighbouring countries could reduce greenhouse gas emission in ways that are environmentally, economically and social beneficial. Regional mitigation strategies have economic (developmental gains), and political (greater bargaining strength in negotiations with external actors) advantages.

African countries formed regional organizations to deal with climate change related problems. The permanent Interstate Committee for Drought Control in the Sudan-Sahelian region in 1970-1974, following the 1984-1985 droughts in the Horn of Africa, governments

in the region created the Intergovernmental Authority on Drought and development (IGADD) in 1986. The need to address the persistent issues of drought, desertification and food insecurity led to the creation of its successor, the Intergovernmental Authority on Development (IGAD). Likewise, governments in Southern Africa created the Southern African Development Coordination Conference (SADCC), and its successor the Southern African Development Community (SADC) to deal with drought and other related issues (Basher and Briceno, 2005).

Some countries have also created the following regional technical institutions to address the consequences of climate hazards: the Africa Centre for Meteorological Application for Development (ACMAD) in Niamey, Niger, the Regional Centre for Training and Application in Agrometeorlogy and Operational Hydrology (AGHYMET) also in Niger and linked to CILSS (Permanent Interstate Committee for Drought Control in the Sahel); the Drought Monitoring Centre at Harare, Zimbabwe (DMC-Harare), linked to SADV; and the Drought Monitoring Centre at Nairobi, Kenya (DMC-Nairobi), linked to IGAD. These institutions receive support from UN agencies such as the World Meteorological Organization (WMO), Food and Agriculture Organization (FAO), United Nations Environment Programme (UNEP), and United Nations Development Programme (UNDP) (Basher and Briceno, 2005).

In west Africa, the 16-country Economic Community of West African States (ECOWAS) has programmes including a regional meteorological and water resources management programme, and sub regional programmes for desertification control, "but there is no designated subregional activity on natural disaster risk reduction or consolidated regional strategy on risk management" (Basher and Biceno, 2005).

It is worth noting that various regional institutions have organized the Regional Climate Outlook Forum (RCOF) to disseminate early warning information and to formulate a

consensus seasonal forecast for the concerned region (Basher and Briceno, 2005). The important lesson here is that a regionally coordinated approach can help African countries to respond to global climate change challenges.

2.7 Approaches to Addressing Climate Change

The impacts of climate change will most likely continue well into the next century, due to the inertial in the climate system. It requires both mitigation and adaptation to deal with the potential damage that climate change might inflict on the planet. (UNEP, 1998) Mitigation and adaptation may either exhibit synergies, where both actions reinforce each other, or be mutually counterproductive. It may be possible in agriculture and forestry, while in water management it may be counter productive, this is so because the energy needed to produce more water will equally increase the GHG unless more energy efficient systems are used.

2.7.1 Mitigation

According to the glossary of terms IPCC mitigation is an anthropogenic intervention to reduce the anthropogenic forcing in the climate system, it includes strategies to reduce emissions and enhancing green house sinks. Mitigation has also been defined as steps taken to reduce the amount of green house gases being produced by human societies over the long-term (usually through international policy). It must be noted however, that mitigation can only deal with man made causes (Ayoade, 2003). It is also an anthropogenic intervention to reduce the anthropogenic forcing in the climate system. Ayoade, (2003) defines it as measures taken by man to prevent or retard the increase of green house gas concentration in the atmosphere.

Pascala and Socolow, (2004), have proposed about fifteen ways to reduce the anthropogenic factors of climate change, among them are; improving the efficiency of today's coal plant from the present 40 to 60 percent, use biomass to make fuel, capture and

store carbon, make more efficient cars and a host of others. Other methods proposed are carbon trading, seeding oceans with iron, GHG remediation and carbon tax.

Integrating mitigation and adaptation into climate change concerns is not a completely new idea in the African Sahel. The African Sahel is characterized by recurrent droughts, the magnitude and intensity of which have been on the increase over the last 100 years and consequently in the destruction caused by it (Benson and Clay 1998; Ouattar and Feyen 1987). Records show that the region has experienced marked rainfall declines and droughts that exceed those predicted by models of future climate (Hulme *et al*, 2001). The fact that the communities in this region have survived till today with a fast population growth rate is an indication that they have developed traditional mechanisms and strategies to cope with these droughts. Some of these actions combine elements of mitigation and adaptation. Traditional knowledge about how local populations have coped with previous droughts has the potential of providing guide for addressing current future climatic events.

While the importance of traditional knowledge has been realized in the design and implementation of sustainable development projects, little has been done to incorporate this into formal climate change mitigation and adaptation strategies. Climate change cannot be divorced from sustainable development as sustainable development may be the most effective way to frame the mitigation question and a crucial dimension of climate change adaptation and impacts. Incorporating traditional knowledge into climate change policies can lead to the development of effective mitigation and adaptation strategies that are cost-effective, participatory, and sustainable (Saka 2008, Willem 2009). However, incorporating traditional knowledge into climate change concerns should not be done at the expense of modern/western scientific knowledge. Traditional knowledge should complement, rather than compare with global knowledge system.

2.7.2 Adaptation

Many definitions of the term adaptation abound in literature, but perhaps the most quoted is that provided by the IPCC, Third Assessment Report, which defines adaptation as ecological, social or economic systems in response to actual or expected climatic stimuli and their effects or impacts. This term refers to changes in processes, practices or structures to moderate or offset potential damages or to take advantage of opportunities associated with changes in climate (IPCC, 2001, Jan & Aja, 2007).

United Nations Framework Convention on Climate Change (UNFCCC) defined adaptation as the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (UNFCCC, 2008). The European Environmental Agency (EPA) defined adaptation as policies, practices and projects with the effect of moderating damages and or realizing opportunities associated with climate change. (Smit and Pifosova, (2001), define adaptation to climate as adjustment in ecological, social and economic systems in response to the effects of changes in climate.

The IPCC broad definition of adaptation to climate change puts it as an adjustment in natural or human system to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. In practical and operational terms, adaptation involves a process of sustainable and permanent adjustment in response to new and changing environmental concerns or circumstances. This means adjusting behaviour, livelihoods, infrastructure, laws and policies and institutions in response to experienced or expected climatic events. AMCEN, (2008) described adaptation as a process, beginning with understanding current vulnerability, building capacity to support adaptation planning and implementation, learning from pilot actions and deploying strategies and measures to operationalise climate change adaptation in vulnerable regions, sectors and populations'. In

all ramifications, adaptation is closely linked with development and this linkage is critical to reducing vulnerability (or increasing resilience) to climate change. Sustainable development in particular can reduce vulnerability to climate change. A summary of adaptation definitions is given in table 2.2.

Table 2.2: Summary of Adaptation Definitions

Source	Definition
Burton *et al* (1992)	refers to all those responses to climate change that may be used to reduce vulnerability.
Burton, (1992)	Adaptation to climate is the process through which people reduce the adverse effects to climate on their health and well-being and take advantage of the opportunities that their climatic environment provides
Downing *et al*, (1997)	Adaptation is synonymous with "downstream coping"
Fusel and Klein, (2002)	All changes in a system, compared to a reference case, that reduce the adverse effects of climate change.
IPCC, (2001)	Adjustment in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. This term refers to changes in process, practices, or structures to moderate or offset potential damages or to take advantage of opportunities associated with changes in climate. It involves adjustments to reduce the vulnerability of communities, regions, or activities to climate change and variability.
Pielke, (1998)	Refers to adjustment in individual, group and institutional behaviour in order to reduce society's vulnerabilities to climate.
Rennie and Singh, (1996)	Adaptive strategies are ways in which local individual, households and communities have changed their mix of productive activities, and modified their community rules and institutions in response to vulnerabilities, in order to meet their livelihood needs.
Scheraga and Gramsch,(1998)	Adaptive actions are those responses or actions taken to enhance resilience of vulnerable systems, hereby reducing damages to human and natural systems from climate change and variability.
Smit, (1993)	Involves adjustments to enhance the ability of social and economic activities and to reduce their vulnerability to climate, including its current variability and extreme events as well as longer term climate change.
Stakhiv, (1993)	Means any adjustments, whether passive, reactive or anticipatory, that is proposed as a means for ameliorating the anticipated adverse consequences associated with climate change.

Source: Oladipo, 2012

Adaptation occur at a range of interlocking scales, and can either occur in anticipation of change (anticipatory adaptation, which may also be a response to those changes occurring in the environment also referred to as reactive). However most adaptations being implemented at present are responding to current climate trends and variability (climate change 101). Reactive or autonomous adaptation refers to the capacity of natural and human system to naturally adapt to external shocks. The former therefore includes activities

explicitly aimed at reducing or canceling the negative impacts of climate change (IPPCC, 2001).

2.7.2.1 Purpose of Adaptation

Adaptation is considered an important response option or strategy, along with mitigation. (Frankhouse, 1996; Smith, 1996; Piekke, 1998; Kane and Shogren, 2000). Adaptation strategies became prominent in literature from the 1990s and often associated with climate change by American National Academy of Science. IPCC report 2007 stated that adaptation will be necessary to address impacts resulting from the warming which is already unavoidable due to past emission. Adaptation is necessary because setting limits on emissions will not be enough, or happen soon enough, to avoid all impacts of climate change. Adaptation is imperative because the world climate is changing and will continue to change, at rates unprecedented in recent human history. The risks associated with those changes are real but highly uncertain. Risks are apparent in every area which will affect development goals especially in developing nations. Sadly however these nations have been declared most vulnerable to climate change. Furthermore, adaptation efforts are necessary to reduce both the costs and severity of both mitigation and climate change impacts for decades to come. The IPCC working groups II have suggested that mitigation and adaptation should be complementary. The following recommendations were made:

Adaptation is necessary strategy at all scales:

Those with the least resources have the least capacity to adapt and are the most vulnerable. Adaptation, sustainable development and enhancement of equity can be mutually reinforcing. It is expected that the climate will continue to change as a result of both of natural climatic variation and human activities (Scheraga and Grammbsch, 1998). Therefore while there is uncertainty about future climatic changes, failure to invest in adaptation may

leave a nation poorly prepared to cope with adverse changes and increase the probability of severe consequences. (Smith and Lenhart, 1996).

Adaptive capacity may also be defined as the ability of a system to adjust to climate change, including climate variability and extremes, to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. Adaptive capacity is driven by physical constraints, social drives, economic and political process, and social network within the community. For example a farmer's adaptive capacity will not only depend on access to resources (both physical and social) within the community which allows a crop to be grown successfully but also the effect of macro-scale economic processes on the received crop.

Gender is another factor; women may participate or be hindered by levels of education. There is also temporal and spatial aspect of adaptation Smit and Philifosova, (2001) have suggested that adaptation to climate change and risks takes place in a dynamic social, economic, technological, biophysical, and political context that varies over time, location and sector. They therefore argued that this complex mix of conditions determines the capacity of a system to adapt.

These determinants include the following: economic resources with regards to institutions, technology, infrastructure (with regards to institutions and equity). It is accepted that wealthy or developed nations are better prepared to bear the cost of adaptation to climate change impacts and risks than poorer nations. Goklany, 1995; Burton, 1996; Kelly and Adger, (1999) have been able to prove that poverty influence a region's coping capacity. Moreover from empirical studies it is evident that poorer nations and disadvantaged group within nations are especially vulnerable to disasters (Banuri, 1998; Munasinghe, 2000; Postnote, 2006).

Technology has also been identified to play a significant role in adaptive capacity. For instance, warning system, protective structures, crop breeding, irrigation are all technology

dependent. The lack of technology may seriously impede a nation's ability to implement adaptation options by limiting the range of possible responses (Scheraga and Grambsch, 1998).

Information and skills is imperative in effective adaptation. An effective information dissemination system must be in place (Gupta and Hisschemoller, 1997, Wilken, 1982). This is necessary as Tol, (1998) have suggested, because successful adaptation requires recognition of the necessity to adapt knowledge about available options, the capacity to assess them and the ability to implement the most suitable ones.

Infrastructure: Adaptation capacity is likely to vary with social infrastructure. Availability of good and well planned infrastructure enhances ability to adapt. For instance in the coastal areas of Hong Kong, the capacity to adapt to risk of typhoons differs for existing urban areas, and for new coastal land reclamation (Yim, 1996). In, addition institution hold society together giving it sense and purpose and enabling it to adapt (O' Riordan and Jordan, 1999). Studies have demonstrated that institutional role in adaptive capacity is very important. The presence of or the lack of institutional support could make a great difference in the ability of a society to adapt to climate change. (Kelly and Adger, 1999; Smith and Lenhart, 1996; Huq, *et al* 1999; Ahmed *et al,* 1999; Bathogen, 1997). Smit and Pilofosova, (2001) posits that established institutions in developed countries not only facilitate management of contemporary climate-related risks but also provide an institutional capacity to help deal with risks associated with future climate change

Finally, equity, which guarantees equal access, enhances adaptive capacity. When resources are equitably distributed by the social institutions governing the allocation of such resources, society will participate in adaptation actions (Ribot *et al,*1996; Adger, 1999).

2.7.2.2 Concepts in Adaptation

The following concepts are germane to the understanding of adaptation:

i. **Vulnerability:** Nearly all human societies and activities are sensitive to climate in some way or other. This is because in large measure how people generate livelihood and wealth is influenced by the ambient of climate (Adeger *et al* 2003). Human societies have always and everywhere had to develop coping strategies in the face of unwelcome variation in climate or weather extremes. Vulnerability therefore can be seen as the context in which adaptation takes place. Vulnerability refers to a state of defenselessness, insecurity, exposure to risk and shock (Chamber, 1989) vulnerability is also the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climatic variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity, and adaptive capacity. Magnitude means asking the question about the scale of impact. The change, does it affect a high number of people or species? Is there loss of life? Loss of biodiversity or ecosystem?

Timing: Impacts are explained in short term and unavoidable in the long term if not addressed. The vulnerability or security of individuals and societies is determined, not only by the likely responses of the resources on which individuals depend, but by the availability of resources and, crucially, by the entitlement of individuals and groups to call on these resources. This is well documented across a wide range of political and economic circumstances and development processes (Sen, 1981, 1999; Watts and Bohle, 1993; Ribot *et al*, 1996; Adger, 1999). Vulnerability is therefore a socially constructed phenomenon influenced by institutional and economic dynamics. (Adger, *et al,* 2003). Cannon, (1994) has suggested that poverty and marginalization are driving forces of vulnerability and constraints to individuals in their coping and long-term adaptation. Vulnerability is

conceived simply as a function of exposure, sensitivity and adaptive capacity. V= f (exposure, sensitivity, adaptive capacity (IPPC, 2001). This means that vulnerability is a function of adaptive capacity +potential impacts (sensitivity + exposure)

ii. **Adaptive Capacity:** refers to the potential, capacity, or ability of a system to adapt to climate change stimuli or their effects or impacts. Adaptive capacity greatly influences the vulnerability of communities and regions to climate change effects and hazards (Bohle *et al*, 1994; Downing *et al*, 1999; Kelly and Adger, 1999; Mileti, 1999; Kates, 2000).

iii. Sensitivity: this is the degree to which a system is affected, either adversely or beneficially by climate-related stimuli. It encompasses all the elements of climate change, including mean climate characteristics, climate variability and the frequency and magnitude of extremes. The effect may be direct (e.g. a change in crop yield in response to change in the mean, range or variability of temperature) or indirect (e.g. damages caused in the frequency of coastal flooding due to sea-level rise).

2.7.2.3 Adaptation and Adaptive Capacity

Adaptation has the potential to reduce adverse impacts of climate variability and to enhance beneficial impacts, but will incur costs and will not prevent all damages (IPCC, 2001). IPCC Third Assessment Report states that human and natural systems will, to some extent, adapt autonomously and that planned adaptation can supplement autonomous adaptation (IPCC, 2001). "Options and incentives, however, are greater for adaptation of human systems than for adaptation to protect natural systems" (IPCC, 2001). The propensity of systems (e.g. socio-economic systems) to adapt is influenced by certain systems characteristics that have been called "determinants of adaptation" in the literature (Smit *et al*, 2000). These include sensitivity, vulnerability, resilience, susceptibility and adaptive capacity (Smit *et al*, 2000).

The term adaptive capacity has many definitions. "Adaptive capacity may be described as the ability or capacity of a system to modify or change its characteristics or behaviour so as to cope better with existing or anticipated external stresses" (Adger *et al*, 2004). Therefore, society has inherent capacities to adapt to change. Burton *et al*, (2002) argue that capacities are bound up in the ability of society to act collectively. Individuals, groups within society, organizations and governments on behalf of society, make decisions on adaptation (Burton *et al*, 2002). "The examination of the social dynamics and outcomes of adaptation moves beyond simply accounting for the economic costs and benefits of adaptation to climate variability". Research carried out in the coastal environments, shows that coastal urban communities are particularly at risk to climate variability hence, social capital is an important element for coping with climate variability and hazards in recent time. Adjer *et al*, 2003, for example, carried research in the Caribbean coastal area, and showed that communities find strategies to manage risks through strategic and local networks and interactions. Detailed investigations of social capital illustrate explanations of how individuals use their relationships to other actors in societies for their own and for the collective good, both in material terms and wider spiritual benefits.

Integrating mitigation and adaptation into climate change concerns is not a completely new idea in the African Sahel. The African Sahel is characterized by recurrent droughts, the magnitude and intensity of which have been on the increase over the last 100 years and consequently in the destruction caused by it (Benson and Clay 1998; Brooks 1986). Records show that the region has experienced marked rainfall declines and droughts that exceed those predicted by models of future climate (Hulme *et al*, 2001). The fact that the communities in this region have survived till today with a fast population growth rate is an indication that they have developed traditional mechanisms and strategies to cope with these droughts. Some of these actions combine elements of mitigation and adaptation. Traditional knowledge about

how local populations have cope with previous droughts has the potential of providing guide for addressing current future climatic events.

While the importance of traditional knowledge has been realized in the design and implementation of sustainable development projects, little has been done to incorporate this into formal climate change mitigation and adaptation strategies. Climate change cannot be divorced from sustainable development as sustainable development may be the most effective way to frame the mitigation question and a crucial dimension of climate change adaptation and impacts (Swart *et al*, 2003). Incorporating traditional knowledge into climate change policies can lead to the development of effective mitigation and adaptation strategies that are cost-effective, participatory, and sustainable. However, incorporating traditional knowledge into climate change concerns should not be done at the expense of modern/western scientific knowledge. Traditional knowledge should complement, rather than compare with global knowledge system.

2.8 Theories and Models in Adaptation

There are several theories, concepts and models that have been employed by different researchers in the study of adaptation strategies. These are:

i. Social Capital or Collective Action

Social Capital or Collective Action, use lessons derived from political ecology, and other theoretical insights for present day adaptation processes. Social capital is an integral part of theories of adaptive management in the context of environmental risks. The concept allows for a consideration of social practices and collective action in relation to both other forms of capital, particular natural capital, and the performance of institutions in coping with the variability and uncertainty that are inherent in interactions with the natural world. (Adger, *et al* 2003). Social capital is made up of "the norms and networks that enable people to act

collectively" (Wolcock and Narayan, 2000). Social capital is necessary "glue" for adaptation capacity, particularly in dealing with unforeseen and periodic hazardous events (Burton, *et al* 1993). Social capital describes relations of trust, reciprocity, and exchange; the evolution of common rules, and the role of networks. It gives a role to civil society and collective action for both instrumental and democratic reason and seeks to explain differential spatial patterns of social capital interaction. The major drawback is that it is interpreted differently in social science disciplines and investigated empirically, using different models and data. Adger *et al,* (2003) however argues that social capital has explanatory power specifically in the area of collective action for environmental management. Social capital is central to the lived experience of coping with risk (Zeigler *et al* 1996; Cantor and Rayner, 1994; Platteau, 1994; 2000). Collective action required networks and flows of information between individuals and groups to oil the wheels of decision making. These set of network are usefully described as an asset of an individual or a society and are increasingly termed social capital. Hence social capital captures the nature of social relations and uses it to explain out comes in society. Individuals and societies have been at risk of climate hazards and other factors, and this vulnerability can act as a driver for adaptive resource management.

Agrawal (2001), opined that it is clear that the size of the group undertaking the collective action, the boundaries of the resource at risk, the homogeneity of the decision-making group the distribution of benefits of management, and other factors are all important in determining the ultimate success of collective management. One of the criticisms of this theory is that they confuse cause and effect, particularly when they are used to explain economic performance, educational attainment, or patterns of regional economic growth. (Harriss and de Renzio, 1997; Paladan 2000; Sobel 2002; Durlauf, 2002)

ii. Impact Models

Impact Assessment Models are based on climate scenarios that focus on adaptation to changed average condition. However, attention is not paid to interannual variations and extremes. Mendelsohn *et al* (1999) has suggested that it is easier to adapt to changes in average conditions than with change related to variability.

Integrated assessment models include assumptions about adaptation in the impact components. Some impact models assume "naïve" or "dumb farmer" assumption- This is not unique to agriculture sector. This is a term used for any impacted agent that is assumed not to anticipate or respond to changed climate condition but continues to ,act as if nothing has changed (Rosenberg, 1992). These studies ignores the autonomous and planned adaptations and assume that "farmer" are dumb, or will not be responsive to climate change at all. The studies also do not distinguish between potential and residual new impacts and may not be very useful in assessing vulnerability (Smit and Lenhart, 1996).

iii. Numerical Impact Models

In employing the use of this model, assumptions about perception and adaptation are commonly arbitrary or based on principles of efficiency and rationality and assume full information. (Yohe *et al*, 1996; Hurd *et al* 1997; Mendelson *et al*, 1999). However others yet have noted that actual and assumed behavior do not necessarily match. Tol 1998; Schneider *et al* 2000, questioned whether perfect foresight and rational behaviour are realistic assumptions for predictive models (Tol, 1998). The information available, the rationality of the actor and unconstrained factors all play a major role and this will make reactions to differ. (Yohe *et al* 1996; West and Dowlatabadi, 1999).

The major feature of numerical impact models is that they tend to use rather than generate, information on adaptations to estimate future impacts of climate stimuli, after the

effects of adaptation has been factored in. They indicate the potential of human system to adapt autonomously and thus to moderate climate change damages (Smit et al 2001).

iv. Analogue Models

The analogue models aim to establish how individuals and institutions anticipate or respond to reduce the risks of different types of climate variability and how policy has influenced these actions. Understanding the present-day effects and response to climate variability at all levels of social organization is a prerequisite for studying the effects and responses to future climate change and for identifying the key determinants of successful adaptation in the future. Analogue models may be differentiated into two major types; (i) the spatial analogue model. This model employs the analogue of past climate change contrast with scenarios, derived from climate model experiments in the search for adaptation insights. This involves taking present day behaviour in regions with climate conditions similar to those that might possibly develop in the region of interest. (ii) The temporal analogue; involves taking detailed case studies of past responses of climate variability and extremes.

A scenario is a coherent, internally consistent and plausible description of a possible state of the world. Scenarios commonly are required in climate change impact, adaptation and vulnerability assessment to provide alternative views of future conditions considered likely to influence a given system or activity. The different types of scenario include socio-economic scenarios; environmental scenarios; climate scenario (NEST, 2004).

A major limitation of the analogue approach to climate change assessment is that the characteristics of future climate change are likely to be very different to past climate variability, particularly in terms of the rate and magnitude to change. A major example exists in Africa where the observed rainfall variability is greater than changes suggested by climate models for the next 50-100 years (Hulmes, 1998).

Research on climate change agriculture interactions has evolved from a "top-down" approach to a "bottom-up" approach. The top-down model starts with climate change scenarios, and estimates impacts through scenario analysis, based on which possible adaptation practices are identified. The bottom-up approach, on the other hand, takes on a vulnerability perspective where adaptation strategies are considered more as a process involving the socioeconomic and policy environments, producers' perceptions, and elements of decision-making (Wall and Smit 2005; Belliveau *et al* 2006).

In the top-down, scenario-based approach, adaptation strategies are assumed and are invariably treated as primary technical adjustments (for example, changing to different crops, adopting efficient irrigation systems or altering production systems) to the impacts identified. Most often these adaptations represent possible or potential adaptation measures, rather than measures that have actually been adopted. Indeed, there is no evidence that these adaptation options are feasible, realistic, or even likely to occur. Furthermore, they would only be possible with complete and accurate knowledge of future climatic conditions, which is why they have been aptly named "clairvoyant farmer" scenarios (Risbey *et al* 1999; cited by Belliveau *et al,* 2006). This approach can be found in spatial analysis, climate impact modeling, and Ricardian studies. For example, studies on climate impacts using the top-down approach carried out in South Africa (Schulze *et al* 1993; Erasmus et al 2000; du Toit *et al*, 2001; Kiker 2002; Poonyth *et al*, 2002; Deressa 2003; Gbetibouo and Hassan, 2005) predicted adverse impacts on the agricultural sector with significant adverse effects on crop yields and marginal crop areas in the western part of the country, which would become unsuitable for the production of maize, the main staple crop.

Vulnerability studies have shifted the focus of research from the estimation of impacts to the understanding of farm-level adaptation and decision making. This work explores actual adaptation behaviour based on the analysis of farmer decision in the face of variable

conditions through survey data analysis, in-depth interviews, and focus group discussions with farmers and other experts. According to Bryant *et al*, (2000), such studies that raise research questions regarding how farmers perceive climate change and variability; have identified those climatic properties that are of most importance to farmers in their decision making; and do suggest the types of adaptive responses that can be anticipated.

Agricultural changes do not follow a simple linear relationship between changes in a farmer's decision-making environment and farm-level change. One important issue in agricultural adaptation to climate change is the way and manner in which farmers update their expectations of the climate in response to unusual weather patterns. A farmer may perceive several hot summers for example but rationally attribute them to random variation in a stationary climate.

This present work chooses to adopt the bottom-up approach that seeks to investigate actual adaptation at the farm level as well as the base factors seemed to be driving them, based on the case of farmers from six (6) selected LGAs in Kano state. This work seeks to capture the extent of farmers' awareness and perceptions of climate variability and change, and the type of adjustments they are making in their farming practices in response to these changes.

2.8.1 Adaptation Frameworks

There are several established framework often employed in adaptation studies to determine vulnerability and adaptation. These are in two categories; (i) those referred to as 'first generation, developed in the mid 1990s. These frameworks are based on climate scenarios generated through general circulation models, applied to ecological or biophysical environments. (ii)The second generation' models developed latter, which focus on more holistic impact assessment with adaptation decision-making contexts. In recent times

however, V & A is rapidly evolving and the approach often employed is a blending of the merits of both the first and second generation approaches. These include emphasis on socio-economic scenarios; stakeholder participation and strengthening adaptive capacity. The UNDP, (1994), employed the top down approach; U.S Country Studies Programme (USCSP) 1996 also employs the top down approach. The UNDP, (1998) employs the top-down and bottom up approach. NAPAs 2001 (national adaptation programme of action) uses the bottom up approach. UKCIP, (2003) Uses both the top-down and bottom-up approach. UNDP (2004), top down and bottom-up approach. Australian Greenhouse Office on Climate Change (2006) uses top-down and bottom-up approach. United States Agency for international development (USAID), 2007, uses the bottom-up approach. In all these frameworks, the direct empirical analysis of adaptation processes tend to start with the systems of interest, then asses its sensitivity and adaptability to climate change and other stimuli. This is consistent with vulnerability assessment (Downning *et al,* 1999; Adger, 1999; Handmer *et al,* 1999; Kelly and Adger, 1999). A direct climate condition prompts adaptation, less often than the economic and social effect or implications of the climatic stimuli that are fundamental in triggering adaptive responses (Smit et al 2001, IPCC 2007, Sunbald 2008). Two types of framework is shown below. The UKCIP and an adaptation of it to China's agriculture system. It must be noted that each of these V.& A framework is worth considering. The 'first generation may appear out of date, they retain methodological rigour and can be useful in particular circumstances, especially if resources (including data) are limited (UNFCCC, 2008). The framework used in the Ningxia region in China is an adaptation of the UKCIP, (2009).

The framework consists of six steps;

Step (i): Assess climate work

Step (ii): Integrate regional development and adaptation goals

Step (iii): Identify adaptation options

Step (iv): Priotise options (in terms of cost effectiveness considerations adaptive flexibility, knowledge level)

Step (v): Implementation and demonstration

Step (vi): Monitoring and evaluation

The steps above could be depicted by a flow chart as shown below:

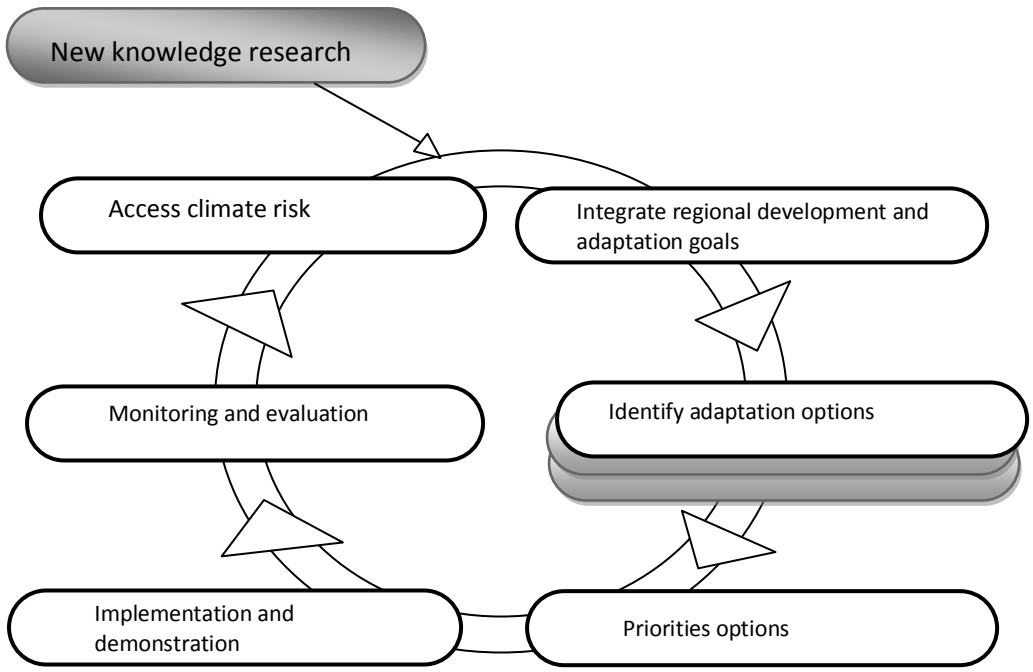


Fig:2.1 **The adaptation framework – each step may require elements of capacity building**

Source: **ICCCA, (2008)**

Below is the United Kingdom Decision-Making framework for climate adaptation strategies. These frameworks point to the following facts, adaptation must be seen as ongoing; climate risks and adaptation priorities vary across regions; opportunities for adaptation lie in reducing vulnerability to existing climate hazard; consultation with all stakeholders is crucial; moving adaptation into main stream of policy local content is critical for its success. The main features of the UKCIP framework include the following: provide

guidance to those engaged in decision-making and policy processes; it lays out an approach to integrating climate adaptation decisions and more generally climate-influenced decision in the broader context of institutional decision making.

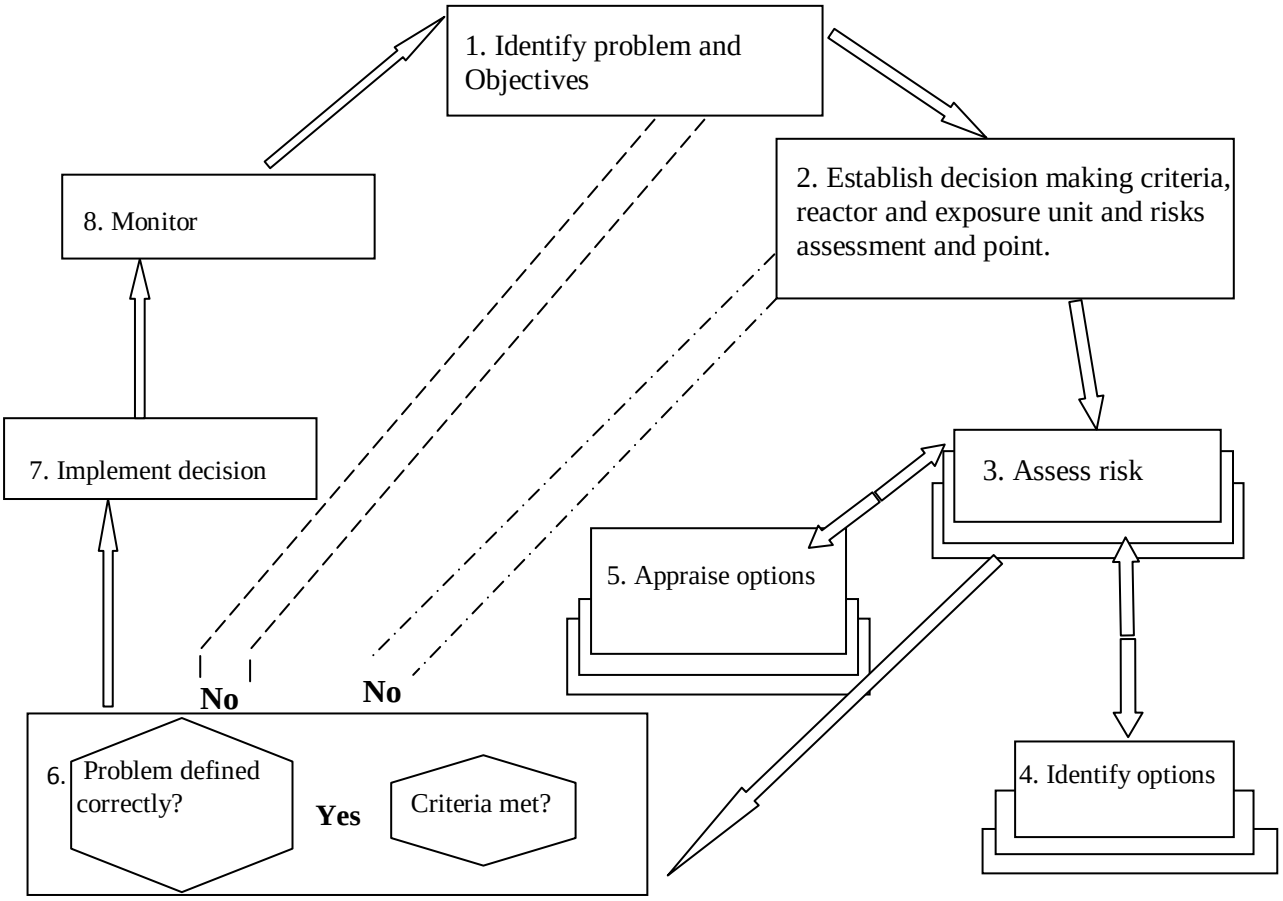


Fig: 2.2 Decision making framework for climate adaptation strategies (U.K. CIP)

Source: Willies, R.I and Connell, R.K, 2003

2.9 Barriers to Adaptation

When people become aware of the changing climate they will become aware that they will adapt their behaviour to reduce the potential costs as well as take the advantage of any opportunities. Stern, (2006), identified some barriers to adaptation, which suggests that there are factors that hinder adaptive capacity.

i. **The first is uncertainty and imperfect information.** Without a proper understanding about the likely consequences of climate change, it is difficult for individuals or businesses to weigh the cost and benefits of investing in adaptation. They must be provided with a more robust and reliable evidence.

ii. **The second barrier to adaptation is missing and misaligned market:** when people are not well educated on the benefits of adaptation, they may not want to invest in adaptation, because they cannot capture the full benefits of the investment. In the case of the misaligned market, if home buyers do not value resilient homes differently from non-resilient home, then home developers might have little incentives to provide resilient houses.

iii. **The final hindrance identified by Stern is financial constraint:-** This is most felt by the most vulnerable in society, and might exacerbate existing inequalities. Social and economic inequalities might limit the ability of certain section of society to effective adaptations. For example, if disadvantaged groups are not able to afford insurance products or measures. Others have recognized five barrier, these include;

   (a). Financial/ market (uncertain pricing, availability of capital, lack of credit).

   (b). Institutional/legal (weak institutional structure, institutional instability)

   (c). Social/cultural (rigidity in land-use practices, social conflicts)

   (d). Technological (existence access)

   (e). Informational/ educational (lack of information, trained personnel) (Smith, 1996; IPCC, 1998;).

These may still fit in into Stern's earlier three categories. The UKCIP, (2009) also recognized additional barriers to include: Limited understanding of climate change risks and vulnerabilities-current and projected; lack of supportive polices, standard regulations and

design guidance encouraging status quo or presenting impediment to progress; existing legal or regulatory restrictions; Cost of identified adaptation options when budgets are limited; social/cultural/ financial rigidity and conflicts; short-term nature of planning horizon-necessity of realizing return on investments; uncertainty and confidence for the long-term mismatch between business planning horizons and time frame of projections of climate change; not seen as a big problem yet, so temptation to wait for impact to react: Belief that the uncertainty is too great to take action now; lack of useful precedents or evidence of adaptation actions; lack of acceptance/ understanding of risks associated with implementation. Overcoming these barriers may need understanding and updating institutional and legal framework.

2.9.1 Barriers to Adaptation Preparedness in Nigeria

Like many developing countries, Nigeria faces a number challenges in its preparedness to anticipate and implement adaptation to reduce the impacts of climate change and minimize their human and environmental toll in its development process. Major handicaps for designing and implementing adaptation strategies include:

- Absence of a National Climate Change Policy or Strategies
- Inadequate funding
- Limited human and institutional capacity to deal with climate change uncertainty and model impacts
- Poor understanding of adaptation and inadequate data for evidence-based analysis.
- Limited practical guidance on adaptation, which could support national adaptation processes to protect and enhance human well-being in the face of climate change.

- Poor integration of climate change adaptation into the national development planning and process.
- Low level of awareness of the dimension of contemporary environmental problems. Particularly climate change and the urgency to address them as a means of achieving development goals. This is the situation at all levels of governance in the country (Federal/State/LGA).

All these and other potential barriers must be overcome in order to increase the country's adaptation preparedness.

2.10 Adaptation in Semi-Arid Regions

The semi-arid region is not immune to the climate change phenomenon. There are various researchers that have focused on the region albeit scanty. Barbar *et al*, (2003) suggested that semi-arid regions are subjected to continued accelerated soil erosion. In their study "Projecting future land degradation under changing climates in the Swartland, Southern Cape, South Africa" Although the region is already liable to accelerated soil erosion and land degradation, mainly due to bad farming practices and the replacement of natural vegetation with crops, this region has become climatically vulnerable to further change. The major issue here is the threat of climate change in the ever changing earth system. They employed the use of the GCM regional downscaling exercise in order to explore the impact of climate change on the Swartland and in terms of potential soil erosion and land degradation. Nordeamlak, (2008) in his study in Ethiopia revealed that the country's is vulnerable to environmental change, mainly due to decline in water resources availability and this further exacerbated by poverty. This study employed vulnerability indices for regional states of Ethiopia, using the method of principal component analysis, based on vulnerability. It was discovered that the relatively developed semi arid and arid regions where drought is frequent are most

vulnerable. Important adaptation options include the use of irrigation and making higher yielding and drought-tolerant crop varieties available to farmers. Odingo, (cited in rose Hurd, 1997) concluded that for savannah and semi arid ecological zones a rise of 1.5^{0c} will be accommodated smoothly with little change. This of course does not take into account changes due in variation in precipitation regime. Most dry ecosystems are already moisture limited and would therefore suffer from any reduced moisture availability. Warming may encourage further "savannanization" conversion of woodland to grassland. The arid areas of Africa could experience temperature increase of up to 6^{0c} by the middle of the next century (Magadza, 1992). The mean rainfall for a double carbon dioxide atmosphere is about 90 percent of current mean. The combination of elevated temperatures and reduced rainfall in the region is likely to lead to more severe aridity.

In conclusion water is fundamentally important for livelihoods and economies, especially in dry lands regions that rely on agriculture and other water dependent activities. Inhabitants of dry land areas are often challenged by the demands of existing climate change will have further implications for management of water resources in these regions.

2.11 Mainstreaming Adaptation to Climate Change in the Development Process

The inherent link between climate change and development continues to be ignored in many African countries. However, as seen above, the problems impending development in these poor countries are the same problems that increase climate change vulnerability. Mainstreaming climate change adaptation into the development process means including climate change vulnerability considerations in all development policies. Such an approach will have additional benefits within other sectors such as water, health, agriculture and poverty.

2.12 Cognitive Heuristics and Climate Change

Social psychologists have shown that people are poor estimators of risk and probability (Kahneman *et al*, 1982), Tversky and Kahneman, (1973) found that three common heuristics– representativeness, availability, and anchoring can result in cognitive biases. These biases can in turn, result in inaccurate perceptions and poor decision making.

The representativeness heuristics is used by people to judge the probability of a little known events or situation by comparison to other similar and better known events. People using this heuristic, assess the probability of an uncertain event by the degree to which it is "similar in essential properties to its parent population; and eflects the salient features of the process by which it is generated" (Kahneman and Tversky, 1973). Common questions about an event might be the likelihood that event A belongs to process B, or that A originates from B, or that B will cause A to occur. In answering these types of questions people incorporate the representativeness heuristic by evaluating the degree to which A is representative of, or resembles, B (Tversky and Kahneman, 1974).

The closely related availability heuristic is the process by which people will assign higher probabilities to events that can more easily be recalled (Riesbsaem, 1986, Tversky and Kahneman, 1973). These associative bonds are often based upon experience and salience of the event. The availability heuristic can be split into two general classes: the construction of instances and associations, and the retrieval of association and instances. This construction and retrieval process can be biased by highly salient data, by an unrepresentative data base, and by beliefs and values (Taylor 1982). For example, a farmer who had recently experienced one moderate drought would be less likely to believe that drought frequency is increasing, than a farmer who had recently endured two major droughts, because the latter event presented easier recall and higher salience.

These cognitive heuristic processes may influence environmental perception and decision making. Riebsame (1986) showed the vital role of these heuristic devices in the endurance of the "Dust Bowl" image, and the implicit guidelines the image sets forth for agricultural policy and land use planning. Whyte (1985) discussed numerous examples where heuristics affect the perception and response to hazards, especially beliefs in patterns. She also demonstrated that these heuristics works in close conjunction with one another.

The research in social psychology has mainly addressed the impact of heuristic biases on probability assessments. But what about the influence of these biases on the qualitative aspects of environmental perceptions? Will people use representativeness and availability heuristics to form qualitative judgments on climate change? The availability heuristic is the mechanism by which farmers retrieve examples of memorable, salient climate events and then construct a scenario of the future climate. But this retrieval and construction process may not be enough to convince a farmer that the climate is changing. Representativeness should provide the link from extreme event to long-term change. Does a farmer's perception of climate change 'A', resemble the future climate scenario B (which, according to media reports and many experts, may be warmer and drier)? If 'A' is roughly similar to 'B' then representativeness is at work. The farmer then should be more likely to believe that the climate is changing, see the change as anthropogenic, and view recent events as being caused (in part) by anthropogenic forces.

2.13 Perception and Climate Change

Environmental perception is the means by which we seek to understand environmental phenomena in order to arrive at a better use of environmental resources and a more effective response to environmental hazards. The processes by which we arrive at these decisions include direct experience of the environment (through the senses of taste, touch

sight, hearing and smell) and indirect information from other people, science, and the mass media. They are mediated by our own personalities, values, roles and attitudes. The study of environmental perception has to encompass all these means of processing environmental information and to place the individual psychological processes of prediction, evaluation and explanation into a relevant social and political framework.

The focus of a perception approach to environmental management is to analyze decision-making and choice of adjustment from the inside-out, or from the perspective of the decision-frame (that is, the decision and its context) as it appears to the decision-maker, with all its imperfections. Indeed, it is often the limitations and inconsistencies in subjective decision-frames that become the focus of attention in perception research.

Thus, research has shown that choices are made within the framework of perceived alternatives and available information. Alternatives and information are profoundly affected by people's attitudes and values and the roles they play in relation to the decision to be made.

The major problem in adopting a perception approach is not so much in finding appropriate techniques to measure specific variables, but in knowing what variables to measure. The issue of knowing where to bound the system to be studied is one familiar to all scientists. It is a particular intractable problem for environmental perception research because human response to the natural environment is everywhere mediated by strong social forces.

2.13.1 Climate as Perceived

A useful breakdown of climate in relation to human response is to consider it in terms of variability from normal, expected values and in relation to thresholds of direct human perception. In terms of the three classes of events often studied in environmental perception. It can be hypothesized that extreme interannual events and natural hazards are likely to produce the greater behavioural response because they are above the perceptual threshold of

direct human experience and are easily recognizable as extreme events. Long-term climatic events such as CO_2 warming of the atmosphere cannot be directly perceived by individuals, and although short-term seasonal and annual variability can be felt, they are not usually regarded as extreme enough to be significant, decadal variability appears to be below both the level of expected variability and direct perception.

Table 2.3: Climatic Variability and Direct Experimental Perception

	High	Low
Above	Extreme events Natural hazards	Seasonal variability Annual availability
Perceptual threshold of direct experience		
Below	Long term trends ($C0_2$ warming, ozone depletion)	Decadal variability

Drawing from the diverse literature on risk, hazard and decision-making, it can be further hypothesized that varying characteristics of climate processes affect the salience of climate for human perception and response. For example, the public and policy-makers alike tend to disregard future risks and put resources instead into responding to more immediate problems. They are prone to attach greater importance to events which are likely to occur and about which there is some experience, or at least agreement, about what will happen. Thus, scientific uncertainty and controversy become translated into public apathy in a world where problems compete for attention and resources.

2.13.2 Risk Perception

Risk perception is the process whereby risks are subjectively, or intuitively, understood and evaluated. The term is often used in relation to lay people's assessment of

risk. But studies have shown that statisticians and other scientists also estimate risks according to intuitive 'rules' when they are outside their area of expertise of familiarity Tversky and Kahneman, 1974). The risk perception equation includes more components than the commonly used definition of risk as simply probability X' consequence, with consequence usually measured in deaths, currency lost, or person-days of work lost. Specifically, the following elaborations of the consequence expression become significant in risk perception.

1. The *case* of the consequence (whether 'natural', Act of God, managerial incompetence, etc.);
2. The *type* of consequence (e.g. long, painful death *vs* quick 'heart attack'; great physical incapacity producing a burden on the family *vs* death);
3. The *victim* of the consequence (old, infirm person *vs* breadwinner of family, *vs* child);
4. The type and scale of the *worst case scenario* that is *possible*, however improbable.

How humans perceive, respond, and adapt to long-term climatic change are questions of fundamental interest to nature and society researchers. A consensus has emerged in recent years in the scientific community that major anthropogenically-induced climate changes could have cumulative and fundamental effects on the earth's natural systems over the respond and adapt to global warming.

2.13.3 Perception, Uncertainty, and Climate Change

To comprehend potential or even probable responses by agriculturalists to global warming requires understanding how farmers form their perceptions of climate change from the influences of actual climatic shifts, scientific information, and socio-cultural factors.

Perceptions of the environment appear to be affected by the magnitude, frequency, and temporal aspects of environmental change (e.g. Burton *et al*, 1978; Kates, 1962). These

perceptions may mediate human interaction with the environment (Burton *et al*,1987). Perceptions of the environment and apparent climate modification influenced early settlement patterns and public policy in most society of the world (Kollmorgen, 1969; Kollmorgen and Kollmorgen, 1973; Blouet andLawson, 1975). Farmer's experience, perception, and behaviour have been interlinked during twentieth century drought and have been described elsewhere (Taylor *et al,* 1988). For example, drought onset is slower and its impacts are more protracted than such hazards as tornadoes, hail, and floods. Drought might, therefore, be more difficult to perceive, but because it plays a crucial role in economic survival, most farmers probably have strong opinions on its magnitude, frequency, and timing (e.g. Kirkby 1974; Taylor *et al,* 1988).

Some drought perceptions have been shown to have no impact on decision making and are considered 'nonoperational' (Kirkby, 1974). Other evidence, however, suggests that farmers' awareness and perceptions of living in a semiarid environment affects their management style. Parry, (1985) noted that farmers in marginal regions are cognizant of climatic variability. They are concerned more with survival than wealth, and therefore emphasized avoiding risk over maximizing outputs.

Lack of clarity about spatial boundaries, occurrence, and perceivable impacts hamper perception of climate events. Gradual changes in climate and climatic variability, as involved in potential global warming, may then be almost impossible for people to perceive. In the St. Louis metropolitan area, for example, a 30% increase in perception over 30 years was not noticed by most people (Farhar-Pilgrim, 1985). Whyte, (1985) hypothesized that "extreme interannual events and natural hazards are likely to produce the greatest behavioural response. Whereas longer-term climatic events such as …CO_2 warming…cannot be directly perceived by individuals."

The resulting impression may be that attempts to measure people's perceptions of long-term environmental change are fruitless. Previous studies, however, do not provide any insight into how the perception of distinct identifiable episodes, such as major droughts, floods, field pest invasion are related to more subtle long-term phenomena. Brooks, (1986) noted a tendency for "sociotechnical systems to respond preferentially to 'fast variables' in the environment, as compared to 'slow variables', especially when the latter are less familiar or predictable". But does this respond to 'fast' change in any way affect or alter the perception or response to 'slow' change, such as climate change?

A major event, such as drought for instance, can influenced future judgment of the probabilities of the same events. A recent event can galvanize people to seek information on protection against that hazard (Kunreuther and Slovi, 1986). Changes in flexibility, reliability and resilience of adjustments selected, and perception of the probability of future events should result. But because of the time scale involved, people have no direct experience with climate per se. thus, judgments of the probabilities of future long-term climate change cannot be determined from past experience. Without real experience of the magnitude and impacts of climate change, could people use more recent short-term climate experiences, such as drought, to aid in the assessment of future climate change?

2.13.4 Public Perception and Climate Change Awareness

There is significant body of literature on public perceptions and awareness of climate change particularly in developed countries of Europe and America, especially from 2007 to date (Lorenzeni *et al* 2007). Results of some of such studies show that awareness levels and people's perception of climate change have been rising over the past two decades, with a sharp increase from 2003.

The relationship between awareness of an issue and action to address it is not a direct relationship. The fact that people are aware of climate change does not automatically mean

that they may be willing to take action to address it. Understanding the nature of this relationship is a prerequisite to developing an effective coping strategy to climate change. Similarly, the way people find out about an event can heavily influence their perception as to whether they feel they can do something about it or not. It is not enough for people to know about climate change in order to be engaged, they also need to care about it, be motivated and able to take action (Lorenzoni *et al*, 2007, Sumbald 2008). Whether individuals will want to act given that climate change is a psychologically, spatially and temporally distant phenomenon remains a key question in climate change perception study. People are not likely to support initiatives addressing climate change unless they consider the issue as serious problem affecting them personally therefore, only climate change images which make the issue directly relevant coupled with practical ways to make a differences are likely to induce behaviourial change of the public.

The picture or images people have about climate change also related to where they get their information. Newspapers or print media are one of the most widely use sources of information. Other sources of information include informal chats with friends, family or colleagues agricultural extension officers, etc. All these are significant in influencing on people's perception of climate change.

2.13.4.1 Understanding Individual Responsibility and Impacts

Research have shown that there is limited level of understanding of the role of individuals in controlling climate change (IPSOS 2007, Sunbald, 2008). Closely linked to this is the fact that people are expecting more actions to be taken by the government rather than at the level of the individuals especially in developing countries (Nigeria inclusive). People generally do not want to change their life style if others are not doing the same. According to Howes (1980), it is not a rational decision for most individuals to take actions to reduce risk from climate change in the absence of collective action. The people will not act or take action

if they do not see the government doing so. Therefore more publicity needs is required to implement actions which governments is already taking in order to ensure consistency of the messages sent the population.

Research has shown that people do not simply change their behaviour is response to information and awareness raising, important though that is. Information need to be linked to government policy measures that draw attention to the issue and which reinforce the information message i.e. knowledge is not enough to trigger individual action. Similarly, there are situational barriers that often prevent individuals from taking action (particularly in developing countries). These include directcost, lack of a practical alternative etc.

CHAPTER THREE: THE STUDY AREA AND RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the study area and methodology employed in data generation and analysis. Statistical analysis use were more of simple descriptive statistics.

3.2 Origin of Kano

The antiquity city of Kano was formed on the high plains traversed by the Jakara stream more than a millennium ago (Olofin, 1987). Many other places in the state are believed to be occupied by people much earlier than Kano City itself. It is difficult to state when people started living in Kano. A thermoluminiscent dating of some man-made relics conducted in the United Knigdom for Bayero University's history department suggest that man was actively engaged in iron smelting culture in Kano at about 320 – 380AD. Thus, he must have been there for more than one thousand years to develop such skills of iron smelting. Another dating from River Challawa reads 2400 years BC, one other from Wawan Rafi in Wudil shows 1000+ and relic from the Dala hill suggest 635AD. Between 10^{th} and 11^{th} centuries the '*Seven Hausa States'* were formed under Bayajida dynasty from Daura. Two of the seven Hausa states, Kano and Rano are all in the soil of Kano state; thus Kano singly forms the largest part of the antiquated Hausa nation-state. With the arrival of Wangarawa people from Mali (and Islam) in the 15^{th} century, the ancient city of Kano became the terminus of the two pre-colonial Trans-saharan trade routes, one to Egypt and the other to Libya. With the inception of Danfodio Islamic reforms in the West African Savannah between late 18^{th} to early 19^{th} centuries, the system of government was reformed to suit Islamic teachings. And Kano became part of the Sokoto caliphate (confederation).

By the time Europeans made an influx into Kano (1903), it became a huge province controlling places like Daura, Katagum and other places in the present day Jigawa, Bauchi, Kaduna and Kastina states. In 1967 Kano had become a state of the Federal Republic of

Nigeria, and only in 1990 nearly more than half of its landmass was slashed for the new state Jigawa. (Olofin, 1980, 1987)

3.2.1 Location of Kano

Kano state covers an area of 21,000 square kilometers. It is located between latitude $10^0.30$-13^000N, and longitude 7^030-9^030E. (see fig 3.1 & 3.2). It is some 900 kilometers from the edge of the Sahara desert and some 1,140 kilometers away from the Atlantic Ocean. The state shares a boundary with Jigawa state from the North and East, from the West and Southwest it borders Katsina and Kaduna states respectively. From the extreme Southeast it borders Bauchi state (Fig 3.1 and 3.2).

Fig. 3.1 show the map of Nigeria showing Kano, while Fig. 3.2 show the map of Kano showing the selected local government areas for the study.

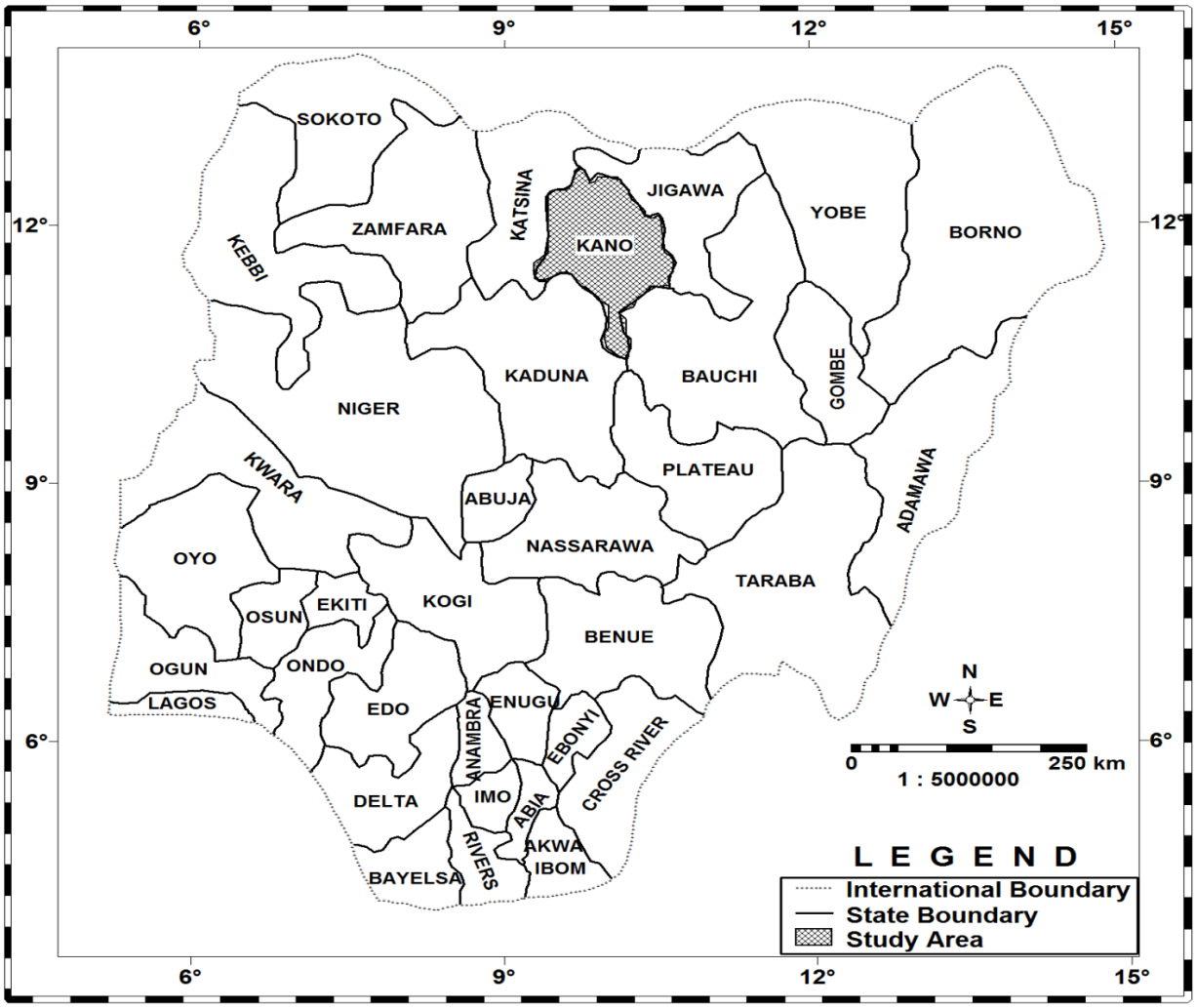


Fig 3.1: Nigeria Showing Kano State.
Source : Department of Geography, Federal College of Education, Zaria.

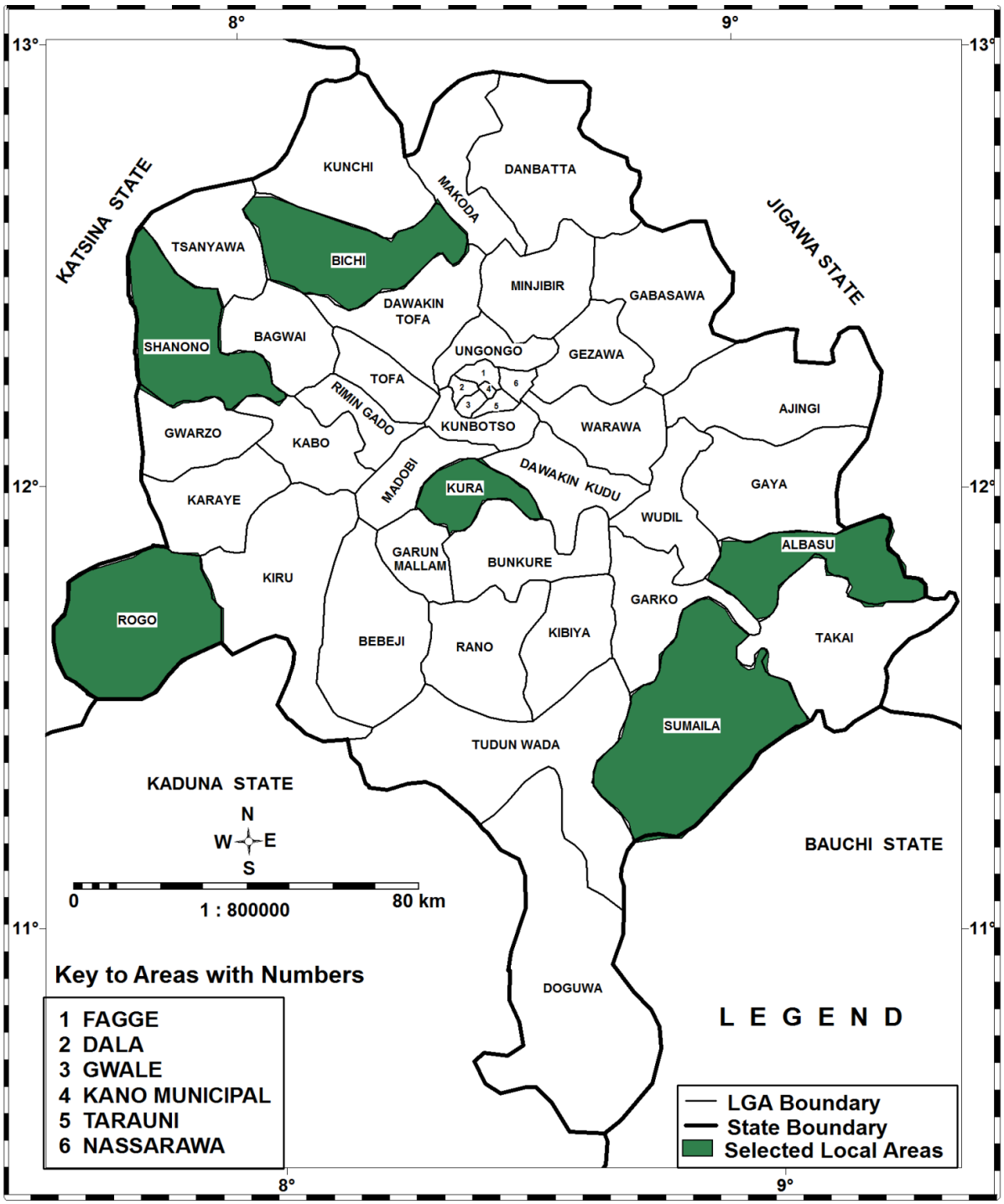


Fig.3.2 : Kano State Showing Select Local Government Areas.
Source : Department of Geography, Federal College of Education, Zaria.

3.2.2 Relief

Topographically speaking, Kano is located on the 'high plains of Hausaland' with occurrence of rock out-crops predominantly in southern Kano. The highest raised land being in Doguwa Local Government Area with a peak reaching up to 1230 meters above sea level. Towards central Kano and its North lies a plain with group or ungrouped hills or only residual hills like Dala and Goron Dutse in urban Kano. The terrain is flatter towards the northern part of the state. Olofin (1980)

3.2.3 Drainage

The natural drainage of Kano constitutes two major rivers, Kano and Challawa and their numerous tributaries, the former rises from extreme South and latter from Southwest. They make a confluence and drain eastwards to Hadejia-Nguru wetlands and ultimately to the Lake Chad. However, the drainage system has been modified through dams and barrage constructions for multipurpose uses and flood control. Olofin (1980)

3.2.4 Population and Traditions

The 2006 Nigeria national population census revealed that Kano is the most populous state in Nigeria, with 9,383,682 million people (NPC 2006). The majority of the population is Hausa/Fulani, but Hausa language is the vernacular spoken by all. Hausa is spoken in many parts of West Africa and Sudan, and according to some authorities in African history the Hausa people are believed to originate from Ethiopia. Hausa language is broadcast in BBC, VOA, Deutsche Welle, Radio Beijing, Radio Iran, Radio Egypt, Voice of Africa (Libya) and others. Nonetheless, Kano is a cosmopolitan settlement comprising significant number of other Nigerian ethnic groups, West Africans and few Sudanese, Lebanese, Syrians, Indo-Pakistans and Europeans. More than 90% of the people of Kano are Muslim of Sumi sect.

Christians make the non-muslim community with a significant number following several denominations. The rendezvous of churches is Sabon Gari area in the municipality testifies to this. The traditional religionist are found in the remote village of rural areas (Olofin 1980, 1982).

3.2.5 Description of the Study Area

The dry land areas of Northern Nigeria of which Kano state belong have insufficient rainfall to support agriculture without irrigation. These regions are characterized by long dry season and a short but often intense, wet season. The wet season is variable and unreachable. The onset and the end of the rains, and also total rainfall vary considerably from year to year (Beets, 1990).

The study LGAs are selected from the existing food security programme (SPFS) of the state. They are chosen across each SPFS.

The Study LGAs are:-

Zone I – Kura LGA and Albasu LGA

Zone II – Suamaila LGA and Rogo LGA

Zone III – Shanono LGA and Bichi LGA

The selected villages within the LGAs are typical of indigenous farming community of northern Nigeria. They are all far away from major road or any large town and not under the direct influence of both.

3.2.6 Choice of the Study Area

The dry land area is one of the most fragile ecosystem in Nigeria, because of its frequent drought and unreliable rainfall regimes. Agriculture in the area is described as complex, diverse and risk prone**.** It is an area often heat by desertification and land

degradation and the sustainability of the farming system is under serious debate. In this area, despite the harsh climatic condition (occasioned by increasing temperature and deterioration of land quality occasioned by erosion events), human and livestock population are on the increase at an alarming rate. Yet there have been no major shift (out migration) of population from the state despite the fact that the food production system of the state (agriculture) have not received major changes in the past few decades (Olofin 1980 and Mortimore 2000). The question is, are the agricultural activity sustainable to the resource base of the state? Can the various agricultural sub-sector/system complement each other and strengthen the existing system in the face of present climate change epoch in the state.

3.2.7 Agricultural Production in the study Area

Agricultural production in Kano area like most areas of dry part of northern Nigeria is a rhythm one centre on the passage of the season**.** For most of the dry season, secondary operations are practiced, except for few who utilize available irrigation/fadama sites.

Agriculture broadly speaking is of subsistence type and land holding are characteristically small and fragmented. It is based on extensive land cultivation. About 70% of the area are brought under cultivation in any one year (KNARDA, 2003). Due to the high climatic rhythm of the area, there is much dependence on manure and, recently, chemical fertilizer to prevent soil fertility loss. The arrival of the first rains is a signal of tremendous activity. Generally, it starts (June/July) with the application of organic manure by distributing it in the furrows between the previous year's ridges and subsequently filling them with soil. Farmers who can afford the inorganic nutrient (fertilizer) apply them around the feet of the growing plants. The harvest period starts at the end of August and last until mid November. Most of these activity fluctuates greatly in recent time with increasing uncertainty in the rainfall rhythm.

The prominent species of crop is grain, particularly millet (Maiwa-gero in Hausa). It is a crop of the driest regions and matures faster than most sorghum. The species maturity depends on the length of the dry season. It requires less moisture than almost any other crop and is often grown in areas with rainfall as low as 280mm per annum and generally needs less than 310mm of rainfall. Excessive rains (especially within a short period) causes harm to it and the fruit needs to set in hot, dry weather. It thrives better in the environment than any other crop under poor or hash weather condition (Rosenberg, 1992, Adejuwon 2006, Adefolalu 1998).

3.2.8 Farm Labour in the Study Area

In a farming community of the sub-saharan African region, the population of an area determines the carrying capacity and affects the farming system of that area. Similarly, the population and its technology determines its vulnerability to climate change.

Disparity in population is one of the reasons for selecting the LGAs/villages. The population and agricultural density in terms of farming intensity follows the rhythm of the rain in the study area, i.e. a decrease from the south to the north. The sense in taking this comparative phenomenon is because population further determines other factors such as: land per capital, agricultural intensity, labour availability and land use in general.

For purpose of comparison in the present work, the study area is divided into two broad demographic areas:

i. The high population and cultivation densities area, in case of most areas within the southern food security zones based on the 2006 population census.
ii. The low population and cultivation densities areas which comprise most of the local governments in the northern fringes of the state.

1. **High cultivation Density Areas of Kano:** These areas are mostly found too far from the Kano. Closed settled zones(i.e. the central food security zone) and the southern food

security zone with high amount of rainfall. Here the rural population density reaches up to 500 persons/km^2 (Mortmore, 1991). They are rural community where intensification of small scale agriculture is highest in the whole northern Nigeria (Yusuf, 1996) and the average arable land per capital was found to be 0.24/ha(Mortmore, 1991). Moreover, as the natural population growth rate is high (above 3.2%), there is ever increasing pressure on agricultural land and plot fragmentation is increasing annually. These and high uncertainty in the rainfall regime form major challenges in the agriculture of the study area.

The high cultivation density areas is different from the low cultivation areas of the northern food security zone. It is higher than the low cultivation area in terms of population density, cultivated land per capita, rainfall amount and farming intensity, thus it is regarded as high cultivation density area.

2. **Low cultivation Density Areas:** These are areas north most of the state. They are low population density areas compared to the southern areas. This drier Sudan and Sahel zone are lower in population, with an average rural population range, less or equal to 100 persons/km^2 to 50 persons/km^2 (Mortmore, 1991). In these areas the land per capita is very high and this indicates that labour will likely to be a constraint next to climate.

3.2.9 Labour Management

Due to the disparity in land availability, technology and ethnocultural differences, amount of rainfall etc. the labour management of the local people differ from one local government to the other in the study area. This is more real when compared between the local governments in the south to those in the northern Kano area. The main source of agricultural labour as elsewhere in northern Nigeria is the male members of the family aged from 15 to 60 years who perform most of the farm preparations while the female members, especially the young married age 15 to 40 are mostly confined to domestic house work (Yusuf, 1996).

Finding also holds that, some married older women do work on their own farms. The head of family (Gandu) household controls the labour of each member, deciding on what task to be done especially in the morning activities. There is high mobility of labour within the village communities. Labour shortage for the big farmers are filled by hiring, labourer for weeding and community help during harvesting. In recent time, the introduction of ox-plough disburdens the shortage during riding and ox-weeding. The introduction of ox-plough disburdens the labour shortage during ridging and ox-weeding.

In some areas among the Hausa indigenes all members of the household above 9 years participate in farm operation. In areas of high land per capita, land is extensively cultivated and labour is always a limiting factor next to climate and soil. For Fulani (pastoralists) who live outside the village, farming operation and most of livestock rearing are male affairs. Labour is equally limited for their dual activities of crop production in Fulani households.

3.2.10 Water Resources of the Study Area

The region is drained by two major rivers – Kano and Challawa and their numerous tributaries, with the former rising from extreme south and latter from southwest. The two rivers make a confluence and drain eastwards to Hadijia– Nguru wet lands and ultimately to the Lake Chad. Most of the tributaries are perennial water bodies. Most of the water bodies have little or no water in them during the dry season but are usually flooded during the rainy season when the surrounding countryside is converted to fresh water swamps. These seasonally flooded lands (Fadama lands) are highly priced as valuable agricultural land and are cropped with onions, sugar-cane and rice.

3.2.11 Soil and Vegetation

The factors of soil formation in the region are not different from the factors elsewhere i.e. like any other place in northern Nigeria. However, the role of parent material is very great in the region. Parent rock appears to pull a greater influence than climate. Thus the variety of soils occurring in the Basement Complex area is different from the variety occurring in the Chad Formation zone. Another factor of great significance is topography. Climate gives a zonal stamp, even though the mature soils of the regions are more intrazonal than zonal. Climate has only a generalized influence, parent rock creates meso-social spatial differences. The "natural" vegetation of Kano region is the savanna type. Most of the region is contained within the Sudan savanna variety. The exceptions include the southernmost area which is characterized by the northern Guinea Savanna and the northernmost section (north of Gumel and Hadijia) which is characterized by the dryland thorn shrub. Olofin (1980)

The Northern Guinea Savanna: The northern Guinea savanna occupies areas south of Tudun Wada, particularly the hilly areas of Dadi Plians and Rishi Hills. This is a woodland type of vegetation composed of numerous medium trees and grass undergrowth. Most of the vegetation here is a secondary regrowth in forest reserves (Yusuf, 1996).

The Sudan Savanna: The Sudan savanna can be said to be the typical vegetation of the Kano region. It is composed of a variety of trees scattered over an expanse of grassland. The trees are usually characterized by broad canopies and they are hardly taller than 20 meters. The baoba is peculiar tree, taller and larger than others, which is common all over the landscape. There are various types of acacias (albida, nilotica and seyal, among others), occasionally forming woodlands. Most of the tree species are adapted to drought conditions through long tap roots, leathery leaves and tiny leaves. They retain their greenness throughout the year, others shed their leaves during the dry season (Olofin, 1987, Yusuf, 1996).

The Sahel Thorn Shrub: According to Olofin (1980, 1987) the vegetation is characterized by thorny shrub and turfts and grass. Complete ground cover is never achieved, even at the height of the wet season. Other plants include those that store a lot of water in their stems and leaves. These "sappy" plants include the shrubs and creepers.

Gallery Woodlands: Gallery woodlands fringe the floodplains of major rivers, especially in the area of Guinea savanna and the wetter sudan. In the guinea savanna, such woodlands are actually forests. Naturally gallery woodlands are no longer common in the drier Sudan savanna where man has already removed them (Olofiin, 1980).

Cultural Vegetation: It is pertinent to state here that the consideration of natural vegetation, as contained above, is an academic exercise in the Kano region. Over almost all the region, natural vegetation has been removed and replaced by varieties of cultural vegetation, known together as "farmed parkland". Remnants of natural vegetation may be found only in parts of the Sahel and in the secondary regrowth of forests reserves.

Three major types of cultural vegetation can be identified. These are: cropped land where food or cash crops are grown usually on permanent basis: afforested land, where exotic plants are grown for one purpose or the other and parkland fallow, which is farmland left in fallow. Some portions of the forest reserves are afforested land, and annual bush fires and illegal grazing, are fast turning the other part of the forest reserves into cultural vegetation types. (Olofin, 1980, 1987)

3.2.12 Climatic Elements

According to Olofin (1980, 1987) the present climate of the Kano Region is the tropical wet-and-dry, coded as *Aw* by W Koppen, although climatic changes are believed to have occurred in the past. The characteristics of the major elements of the present climate are described in table 3.1.

The mean climatic characteristics of Kano are given in Table 3.1 below;

Table 3.1: Average Climatic Conditions in Kano Area

Month	mean Temp(^{0}C)	Range (^{0}C)	Rainfall (mm)	Et (mm)	S'shine (h/d)	RH/* (%)
January	21.2	17.8	0.0	133.3	9.0	28
February	23.7	20.9	0.3	141.1	9.0	25
March	27.7	18.5	1.8	182.5	8.6	23
April	30.5	16.4	8.9	195.5	8.4	36
May	30.4	13.6	70.2	187.9	8.8	51
June	28.1	13.0	132.7	156.3	8.7	65
July	25.7	10.7	210.9	126.4	7.5	78
August	24.9	9.0	314.0	112.7	6.0	83
September	25.9	10.9	132.8	126.5	7.9	79
October	26.8	16.5	12.8	144.0	9.5	58
November	24.6	19.7	0.0	139.9	9.8	37
December	21.7	18.7	0.0	127.4	9.2	32

Source: Olofin (1980), Kano State Integrated Rural Development Plan, Preparation Report (1979)

3.2.12.1 Rainfall

Rainfall is very critical element in the region because of its deficiency during the dry season (Olofin, 1980, 1987). In a normal year, the mean annual rainfall in the southern parts of the region is about 1000 mm, decreasing to about 800mm around Metropolitan Kano, and about 600 mm in the north and northeast. Great temporal variations occur in the amount of rainfall received anywhere in the region. No two consecutive years record the same amount, and average calculated for any two periods are never the same. For example, table 3.1 shows the average annual rainfall over a long period (more than 50 years) for the Kano Airport to be 884 mm. However, calculation based on the period 1965 – 1974 result in an average of 729 mm, while the next five years (1975 - 1979) recorded an average of 748 mm. variations of up

to 30% on either side of the mean value are considered normal. Wider variations occur under drought conditions. Thus, during the 1972/75 drought, the Kano Airport received only about 48% of its long-term mean annual rainfall.

According to Olofin (1980), the variations in the amount and other aspects of rainfall result in three rainfall regimes.

a). There is a wet regime when the amount of rainfall received is larger than the long-term mean, the duration of the wet season is longer than normal, and the pattern of rains is steady

b). There is a moderate regime when both the amount and the duration of rainfall are approximately normal, and the pattern of rains is steady.

c). There is a dry regime when *either* any of the amount and the duration of rainfall is less than normal with erratic rain pattern, or both of the amount and duration of rainfall are less than normal with, or without, erratic pattern of rains is steady.

The regimes occur at random. The occurrence of the dry regime for two consecutive years means a major drought.

3.2.12.2 Temperature

The temperature regimes is warm to hot through the year, even though there is a slightly cool period between November and February. The mean annual temperature is about 26 degrees centigrade (^{0}C), but mean monthly values range between 21^{0}C in the coolest months (December/January) and 31^0 C in the hottest months (April/May). The long-term mean conditions at the Kano Airport are shown in Table 3.1. The values for areas south of the station are less by one or two variations from one year to the other are very marginal (Olofin 1987).

3.2.12.3 Evaporation

The combination of evaporation and transpiration (evapotranspiration) is very high in the region. The potential evaporation for the Kano airport is shown in table 3.1 to be about 17.72mm mean evapotranspiration for the station, by sunken pan method, is about 2538 mm per annum. These mean values decreases slightly to the south and increase towards the north of the station. However, actual evapotranspiration, estimated at about 60% (south) to 75% (north) of the annual rainfall, is not as high as the potential one. In terms of the amount, the actual evapotranspiration is higher in the south than in the north. However, an increasing proportion of a decreasing rainfall is being lost from the south to the north, creating an increasing amount of water deficit northwards, i.e. aridity increases northwards (Allan 1973 in Olofin 1980).

3.2.12.4 Other Elements

Other climatic elements of importance include the duration of sunshine, relative humidity, and winds. Table 3.1 contains some data on sunshine and relative humidity. The mean sunshine hours shown in table 3.1 represent fairly accurately the sunshine conditions all over the region. However, marginal spatial variations exists in the relative humidity which increases by up to two per cent southwards and decreases by the same value northwards. Temporal variations in the amount of sunshine are very marginal, but wide temporal variations (reflecting those in rainfall) occur in the values of the relative humidity.

3.2.12.5 Climatic Controls

According to Olofin (1980) the climate of the Kano region is controlled by the interplay of the tropical marine (mT) air mass which originates over the Atlantic Ocean to south, the tropical continental (cT) air mass which originates over the Sahara Desert to the

north, the Inter-Tropical Discontinuity (ITD), and the prevailing winds. The ITD (also known as the Inter-Tropical Convergence zone: ITC) is the dividing zone between the cool and dry, sometimes dusty, cT air mass and the warm and wet mT air mass. The ITD itself is a zone of tropical, weak frontal weather conditions which, in West Africa, swings from latitude 5^0 N at the lowest-sun period (December) to latitude 18^0 N at the highest-sun period (June), and back from 18^0 N to 5^0 N during the other half of the year. It is believed that the ITD advances northwards at about 160km/month, resulting in a relatively gradual onset of rains from the south to the north; but it retreats southwards at about 320km/month to cause a more rapid end of rains. The northward advance is associated with southerly winds while the southward retreat is associated with northerly winds, known locally as the Harmattan.

Altitude is not an effective control of climate in the region, but latitude and the continental location of the region are greatly reflected in the temperature characteristics.

3.2.12.6 General Effects of the Climatic Controls

The interplay of the air masses, winds and the ITD exerts the greatest control on the weather and climatic conditions of the region. The overall effects of this interplay include a decrease in mean annual rainfall in the same direction, and the seasonal variation in the climatic elements of Kano (Olofin, 1987).

In particular, the movement of the ITD determines the onset and end of rains, and the weather conditions (seasons) at particular times of the year. Over Nigeria as a whole, four weather zones are identified in relation to the location of the ITD.

Zone A, situated immediately north of the ITD, is a region of dry air and little cloud, with a lot of dust.

Zone B, situated immediately south of the Discontinuity to a distance of about 200 to 300km, is zone of isolated showers, moist lower layer, and dry upper air.

Zone C, extending from Zone B to a distance of 700 to 1000km south of the ITD, is zone of moist air up to a height of 6000m; sporadic rains and disturbance lines with thunder storms near Zone B; and widespread and steady rains towards its southern margin.

Zone D, extending from Zone C to a distance up to 3000 km south of the ITD, is a region of high humidity, relatively low and constant temperature, and little rains.

Kano Region is in Zone A, between November and April, in Zone B in May and most of June, in Zone C in July and August, and back to Zone B in September and October. It is believed that Zone D does not reach as far north as the Kano Region.

3.2.12.7 Seasonal Effects of the Climatic Controls

The general effects of the climatic controls and the temporal variations in rainfall and temperature conditions according to Olofin (1980) give Kano Region, not just a dry and a wet season as commonly believed, but four seasons which are:

a). a dry and cool season

b). a dry and hot season

c). a wet and warm season

d). a dry and warm season

The Dry and Cool Season (*kaka*): starts around mid-November and ends in February in Metropolitan Kano. It starts about ten days earlier and ends some ten days later than this to the north of the station. In the south, the season starts ten days later and ends about ten days

earlier than it do in Metropolitan Kano. Thus, the duration increases from south to the north. The period is characterized by cool and dry weather conditions, with occasional dusty harmattan haze. Other weather conditions, in addition to a predominance of northerly winds, are reflected in table 3.1 for the appropriate months.

The Dry and Hot Season (bazara): Is a short transitional period between the harmattan season and the wet season. Winds are very variable, but the region still lies north of the ITD. The season starts from the end of the cool season and ends about mid-May in Kano (add ten days for the north, and take away ten days for the south). This is the hottest season of the year when mid-day air temperature can be over 40^0 C in a Stevenson's Screen.

The Wet and Warm Season (*damina*): Follows the hot season, and ends in Kano around mid-September (plus ten days to the south, and less by tend days to the north). This is the proper wet season is in the region when over 90% of the annual rainfall is recorded and southerly winds prevail. The temperature is warm and fairly steady, resulting in the lowest diurnal and monthly ranges of temperature for the year.

The Dry and Warm Season (rani): Starts at the end of the rains, and ends about mid-November in Kano (+10 days north and south) with the onset for the harmattan. It is the second hottest period of the year when the relative humidity is still sufficiently high to make sensible temperature almost unbearable. Winds are very variable, and the season records the highest number of calms in the year. The weather in October is very representative.

Normal or Seasonal Variation: Temporal variations occur at different scales in the amount and duration of rainfall in the region. The normal or seasonal variation occurs annually and it is believed to be in the order +30% about the mean value in this tropical wet-and-dry climate. Thus a mean value of, say, 864mm implies the receipt of any value in the range 605mm (dry) to 1123mm (wet) in the station concerned, and an average duration of 4

months means any length between 3 and 5 months. Most of these 'normal' variations are reflected in long-term records, but probability calculation based on such records must be used cautiously. Short-term records, are not suitable for any probability calculation because the effects of the extreme 'normal' variations may either be over or underemphasized in such records. In any case, it should be realized that any probability calculation for this type of climate relates to a very lengthy time-span.

3.3 Methodology

3.3.1 Types of data

Problem of research of this nature is that of data collection especially when the objective is not to generate a voluminous data base for every locale that will be randomly sampled and covered (Gopal 2010, Megha 2010, Atteh, 2005). Both primary and secondary data were collected for this study using different methods including structured questionnaire, informant interviews, Focused Groups Discussion and Field Observations.

3.3.2 Sources of data

3.3.2.1 Primary source

One major primary data were obtained from the farmers or rural people through structured questionnaires, prepared by the researcher based on the set objectives. The questionnaire sought information among other things on socio-economic characteristics of the respondents, source of climate change information in the area, their knowledge of global and local climate change, their coping strategies etc. In addition to the questionnaires, discussions/interviews were held with vital groups as district head/community leader to source information on climate change and their coping strategies in the study areas and barriers to adaptation strategies.

3.3.2.2 Secondary Data

The secondary data source, especially on the population size of the study area, was obtained from the national population commission documents while data on farmer's population, farmers farm size, etc. for the LGAs were obtained from KNARDA. For observed inconsistency in available data from the NPC on the LGA's the study relied more on data provided by KNARDA staff. Meteorological data covering the study area (rainfall and temperature was obtained from NIMET office, Kano)

3.4 Sampling Procedure

This study used both systematic and purposeful sampling techniques in the selection of the LGAs and villages for questionnaire administration. In order to minimize as much as possible urban influence criteria such as farmers population, farmers farm size, distance from urban influence etc. were considered primarily in choosing sampling points. The selected six Local Governments were systematically chosen to conform to at least 10% of the total forty-four LGAs in Kano, picked from the three existing food security zones in Kano state (i.e. two LGAs per each food security zone based purely on simple ratio or proportion) as shown in table 3.2.

Table 3.2 shows the food security zones and number of LGAs in Kano State.

Table 3.2 Food Security Zones in Kano State

FSP Kano	Number LGAs in the zone	Number of LGAs selected
Zone 1	14	2
Zone 2	13	2
Zone 3	17	2
Total	**44**	**6**

Source: Field survey, 2014

Table 3.3 shows the selected LGAs from the food security zones selected for questionnaire administration.

Table 3.3 Selected LGAs for the Study

FSP Kano	Selected LGAs
Zone 1	Kura
	Albasu
Zone 2	Sumaila
	Rogo
Zone 3	Shanono
	Bichi

Source: Field Survey, 2011

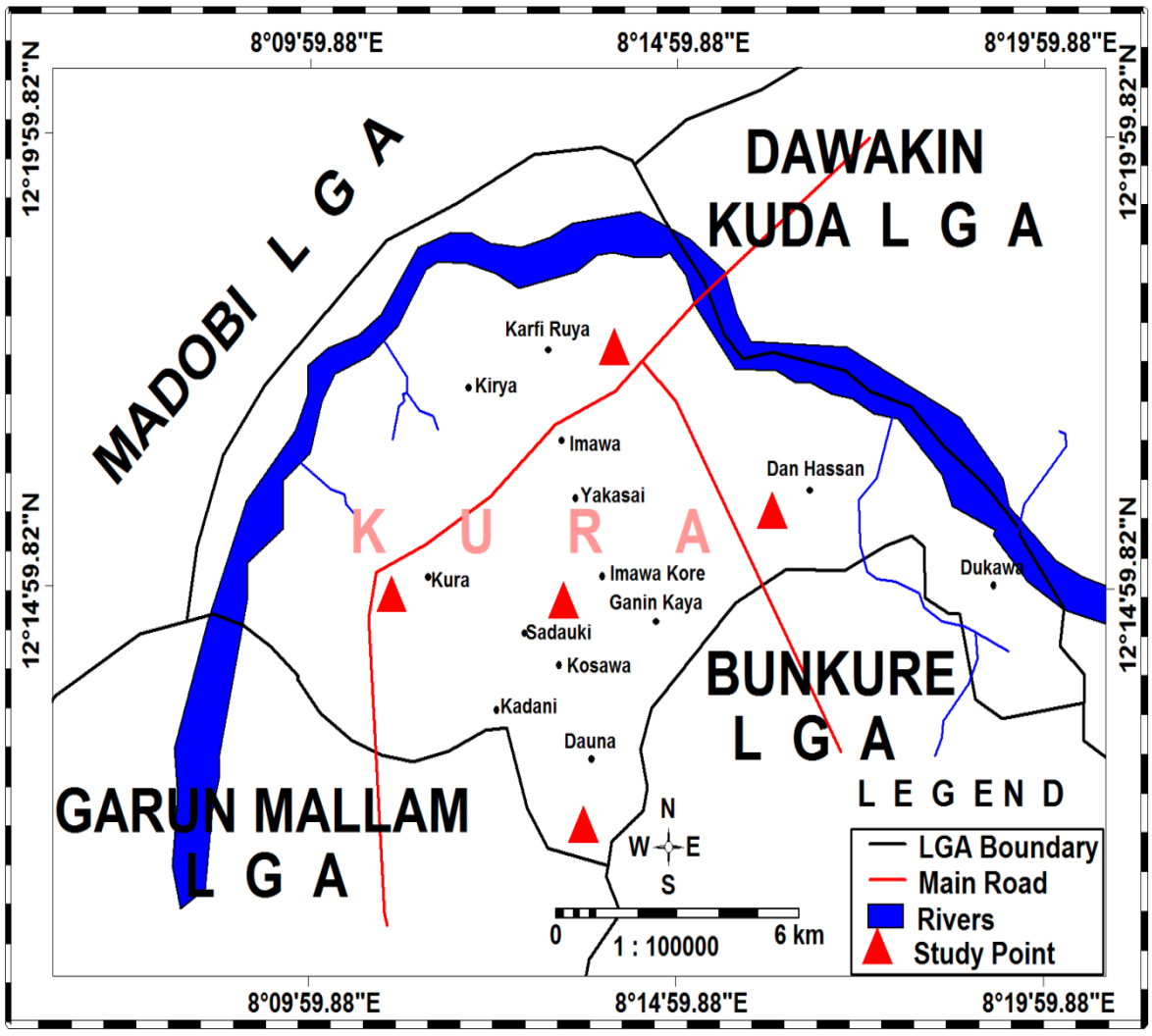


Fig. 3.3: Kura Local Government Area Showing Study Points.
Source : Department of Geography, Federal College of Education, Zaria.

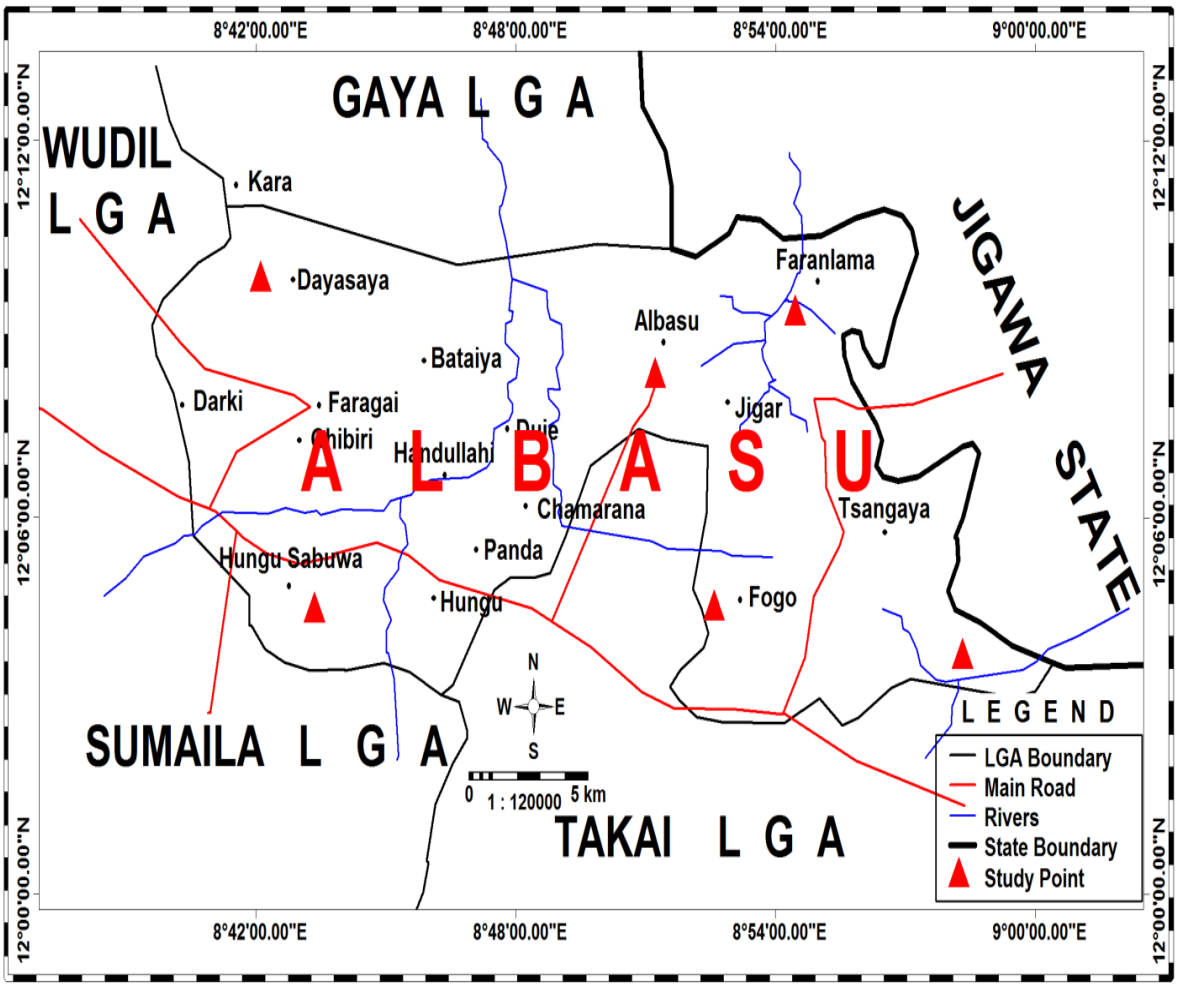


Fig. 3.4: Albasu Local Government Area Showing Study Points.

Source : Department of Geography, Federal College of Education, Zaria.

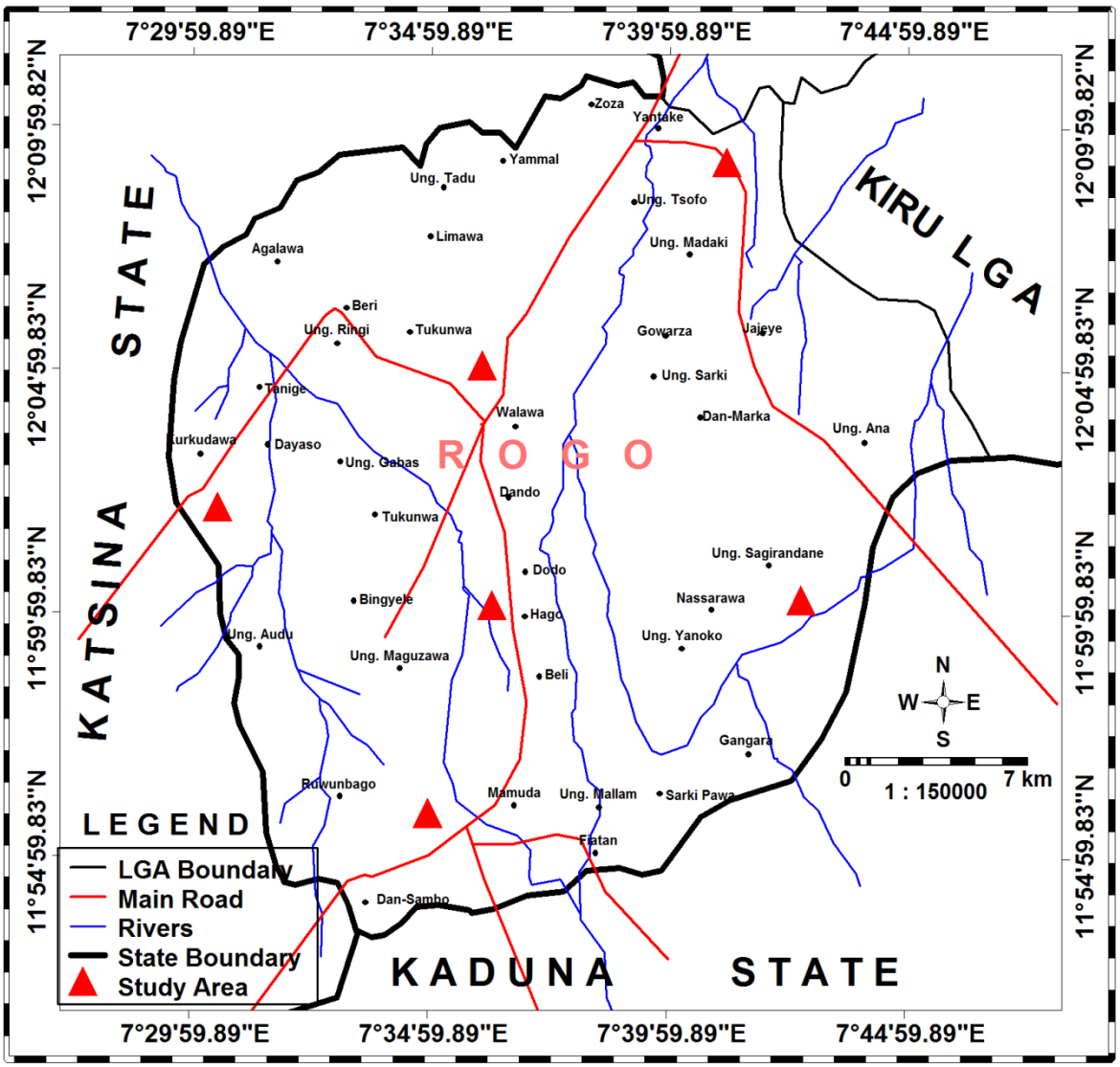


Fig. 3.5: Rogo Local Government Area Showing Study Points.
Source : Department of Geography, Federal College of Education, Zaria.

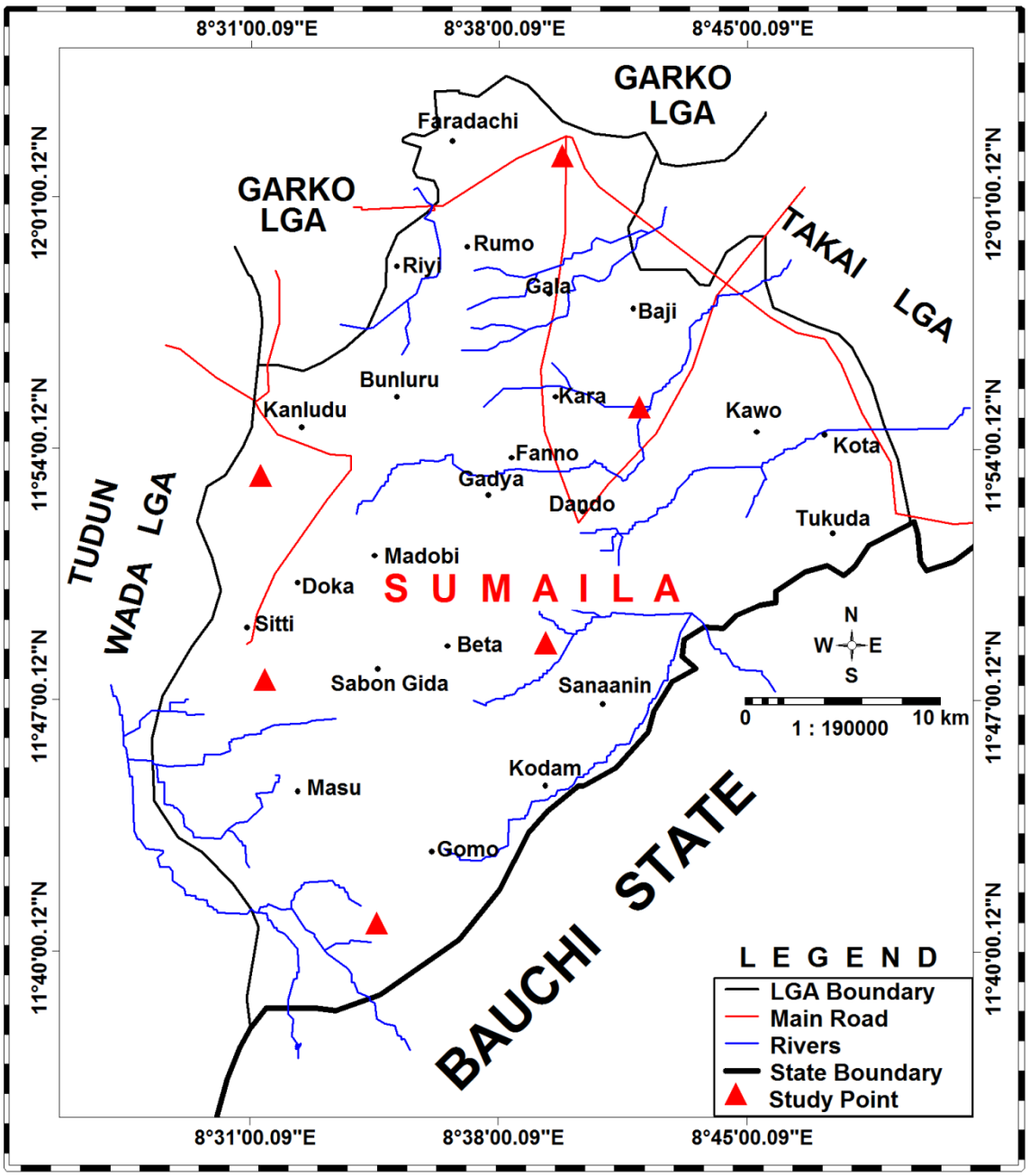


Fig. 3.6: Sumaila Local Government Area Showig Study Points.
Source : Department of Geography, Federal College of Education, Zaria.

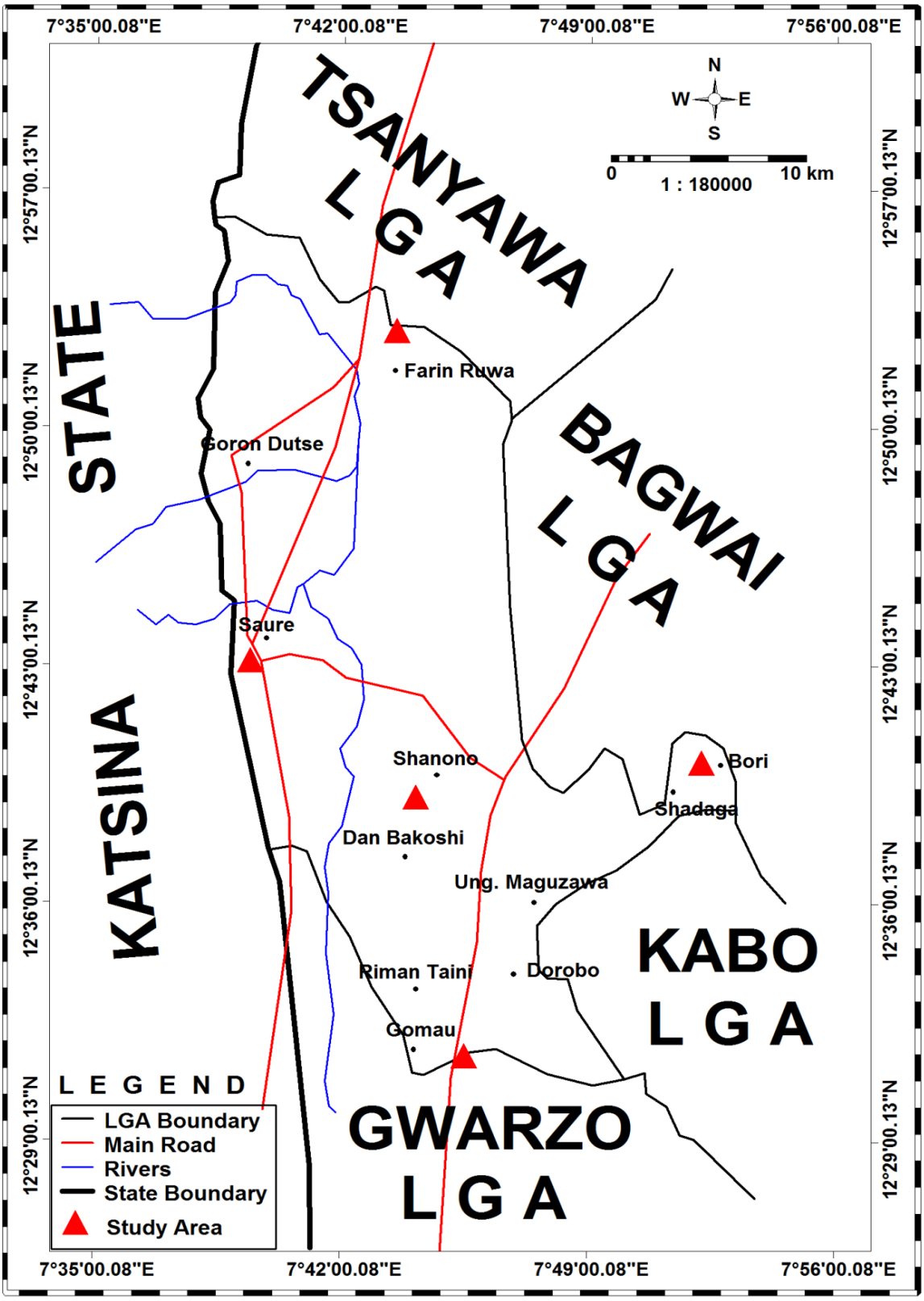


Fig. 3.7: Shanono Local Government Area Showing Study Points.
Source : Department of Geography, Federal College of Education, Zaria.

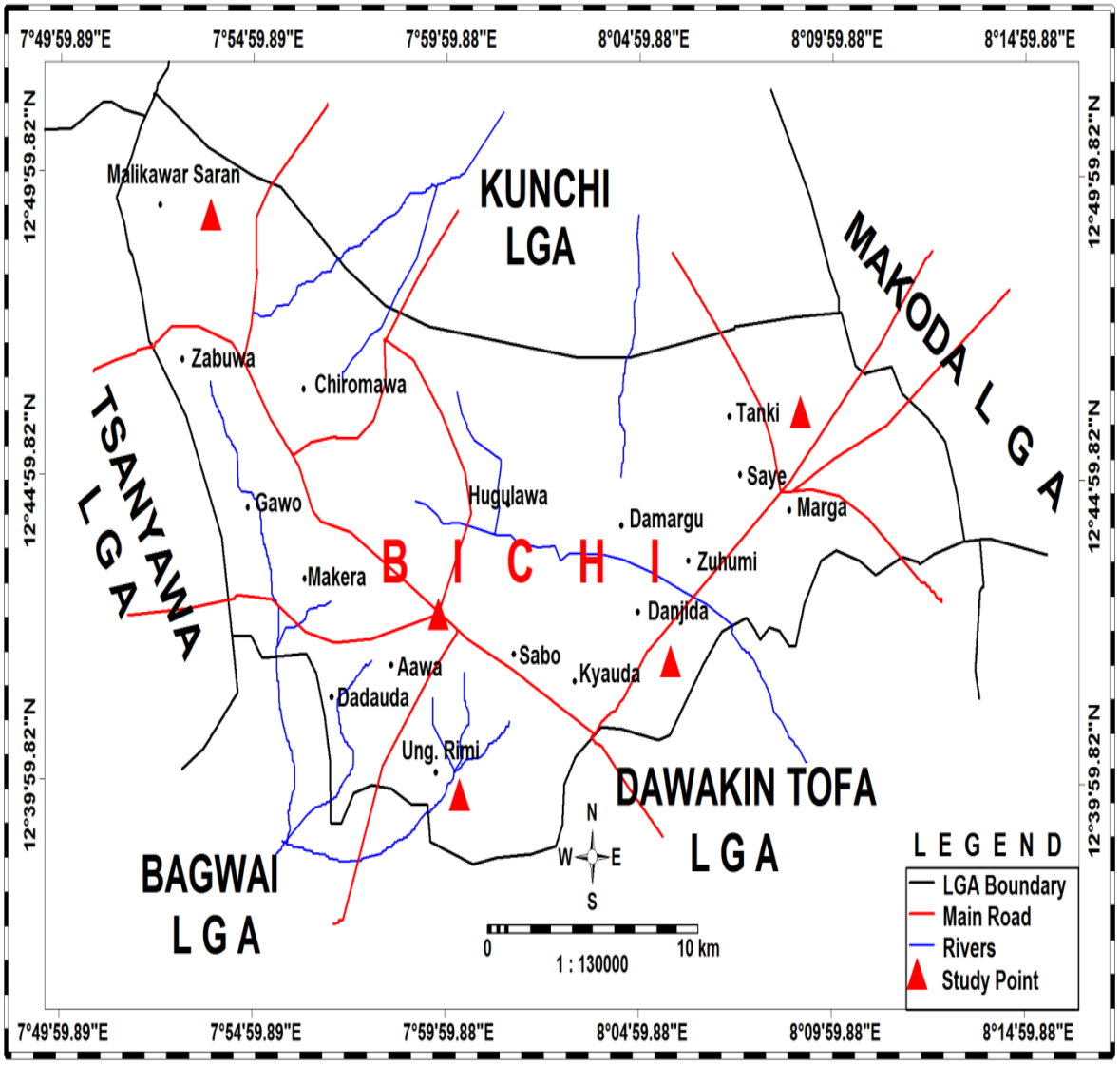


Fig.3.8: Bichi Local Government Area Showing Study Points.

Source : Department of Geography, Federal College of Education, Zaria.

The selected LGA from the zones were done using simple ratio and systematically by picking the first and the last, after arranging them alphabetically. The same principles as above were applied in selecting the villages under the LGAs chosen for questionnaire administration.

The one thousand seven hundred and fifty (1750) sampled respondents were chosen on the bases that they fulfill the criteria of being part of the farming community. This was to ensure that visitors or strangers to the communities are avoided as much as possible. A sample of 0.9% of the estimated population of the selected LGAs were adopted in the questionnaire administration/distribution.

This sample is considered adequate for the study of this nature because researches of this nature do not accommodate large samples due to complexity of completing the questionnaires, the time and cost involved in administering the questionnaires and monitoring the respondents. The selected LGAs across the FSPs across the ecological zones of the state provide the spatial frame work.

3.5 Questionnaire Design

The questionnaires used for this study were designed having some background knowledge of the study area. A previous literature and interaction with KNARDA staff were carried out to familiarize with information and issues. The questionnaires were separated into sections, inquiring about the perceptions, manifestations and adaptation to climate change. All questions were relevant to the research. However, some questions have been important to understand the general context and are not necessarily leading to a conclusion in some occasions, questions have led to discussion which have given a different perspective and added important information to the research. The questions the farmers were asked were

some time repeated or explained differently if the interviewees had doubts (especially in the FGDs questions).

3.6 Questionnaire Administration

The questionnaire was administered through the help of the staff of KNARDA who are trained Field Personnel of the institution. The researcher spends some time to train the field supervisor and enumerators on the questionnaires. They in turn interacted with the farmers/households/ community leaders under the supervision of the researcher. They also facilitate the interviews and discussions with the community leaders. The questionnaires were administered systematically, i.e. every third house to the left or right of a street or road, the house holder and his adult farming population were interacted with.

Table 3.4 shows the distribution of questionnaires to the selected LGAs for administration.

Table 3.4 Distribution of questionnaire LGA by LGA

S/N	LGAs	Estimated population	No of questionnaire administered	No of valid returned questionnaire	Percentage
1	KURA	46,333	417	362	86.8
2	ALBASU	28,333	255	233	91.4
3	ROGO	40,778	367	339	92.4
4	SUMAILA	38,889	350	264	75.4
5	SHANONO	40,556	365	325	83.4
6	BICHI	31,445	283	227	80.2
	Total	**226,334**	**2037**	**1750**	

Source: Field survey, 2010

The above population figure is based on estimated farmer's population given by staff of KNARDA. 0.9% sample is a bit large sample. This is arrived at so as to avoid errors in sampling and to make for expected invalid or unprocessable questionnaire. The villages and

communities selected and questionnaire administered to, were chosen systematically for reasons of simplicity and to prevent biases. Because most farmers were frequently out of their houses, it was better to go around knocking doors rather than making appointments. If farmers were not home, they were sometimes interviewed in their nearby farms. The use of translators, and field assistants (staff of KNARDA) was needed because of the non fluency of the researcher in Hausa language. The criteria for the selection of the LGAs and communities has to do with the major occupation of the people and their remoteness from the urban activity of Kano metropolis. One LGA (Kura LGA) was chosen because it has both rain fed and irrigation system which can be altered by climate change. The selected villages visited were at one (1) to two (2) hours away from the metropolitan Kano depending on the availability of transport, on the average. The pre-field surveys to the villages were done to recognized and meet village/community leaders and members for the purpose of the research.

Depending on the time of arrival of the field assistants to the village and on availability of peasants, interview could be made. Due to the remote nature of most of the villages, most of the trips first needed transportation by public bus and then with a motor cycle *(Okada)*. Interviews including (FGDs) were held between 7am – 9am and 2pm – 4pm when the farmers could be founded in their houses for breakfast and launch. Some were conducted in late evening by field assistants who live among them. If farmers were found in their fields, interviews and questionnaire interactions was carried out there.

The interviews with the supervisors and other field assistants took place at KNARDA head office in Kano. Luckily, most of them have motorbikes which facilitated movement between houses, crop (fields) and communities. All the interviews were recorded by the Field staff of KNARDA for analysis. Notes were also taken, secondary information were also picked up while interviewing the different supervisor of KNARDA.

For objectives I to V, there was a survey involving the administration of structured questionnaires. This questionnaire aim at eliciting information on how the ordinary rural farmers/person perceive climatic experiences in his/her local environment, its dynamics and possible reasons for changes. The questionnaire is to reveal the farmers or rural people's adaptation strategies in the face of changing climate, in term of farming practices: determining planting time, duration of present rainy season, choice crop etc. To this effect, apart from information on social and demographic characteristics of respondents, questions were formed to address, among others, the following:

i. Consciousness of prevailing climatic conditions of the farmers
ii. Level of knowledge about climate variability and change on local scale
iii. Respondents' perceptions of climate change
iv. Local adaptation strategies
v. Determination of onset, planting date and cessation of the rains
vi. Practices in the study area contributing to the GHG

Note:

The questionnaires were distributed based on information on the following:

- Farming population within the selected Local Government/Villages
- Accessibility of the farming community in terms of road and their religion by research assistance
- Farmer's farm size from KNARDA

3.7 Data Analyses

Data collected on each parameter and items in the questionnaire were expressed as percentage respondents. Farmer's perceptions on changes in long-term temperature and precipitation as well as various coping strategies being used by farmers were analyzed and presented using simple descriptive statistics. Statistical test such as mean comparison and principal component analysis (PCA) were also employed in the study. The PCA was used for objective four (iv) to manage the various items of constraints to reduce the items to manageable size (i.e. to see which is the strongest ranked adaptation strategies in the study area).

CHAPTER FOUR: RESULTS PRESENTATION

4.1 Introduction

This chapter is concerned with the presentation of the results obtained from the analysis carried out. Results presented include socio-economic characteristics of the respondents, and awareness and perceptions of farmers in Kano on climate change, their coping and adaptation strategies, climate change hazards in the study area etc.

4.2 Socio-Economic Characteristics of the Respondents

The socio-economic characteristics of the respondents in the selected LGAs were identified to have an understanding of their social and economic strength to cope with impacts of the changing climate of the study area. The socio-economic status of the respondents also expanded the scopes to view their roles in responding to climatic disaster.

4.2.1 Occupational Pattern

Fig 4.1 shows the primary occupation of the respondents in the study area.

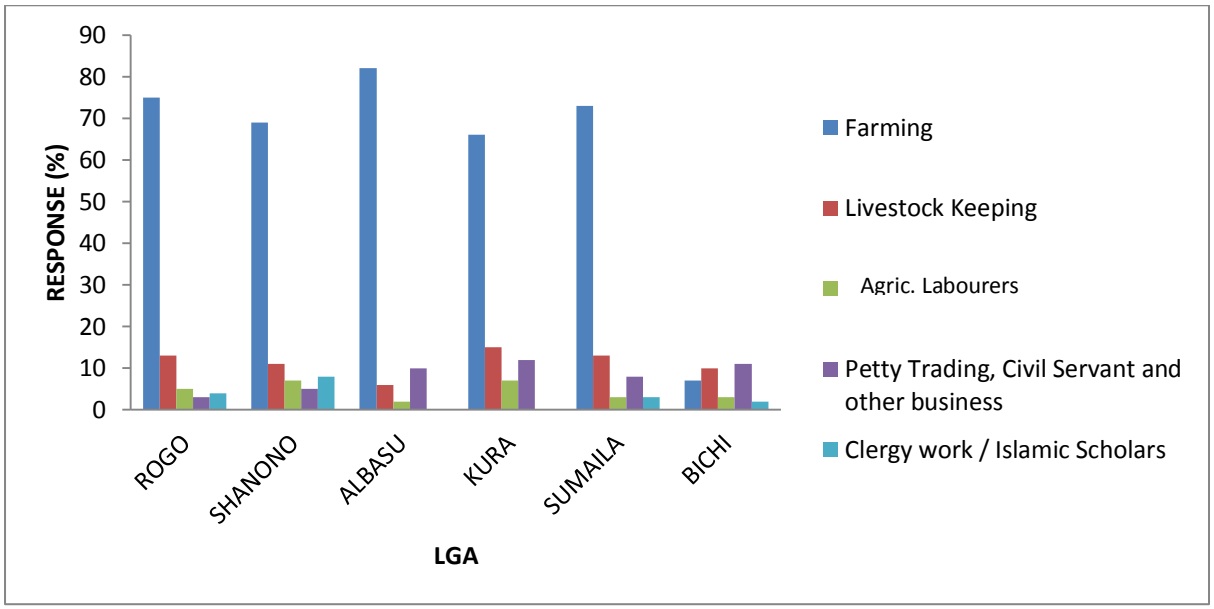


Fig: 4.1: Percentage Proportion of Distribution of Respondents Primary Occupation.

Farming is the major economic activity or occupation of the respondents in the selected LGAs. According to Fig 4.1, farming is the major economic activity for majority of the respondents throughout the selected LGAs (75%, 69%, 82%, 66%, 73% and 74% respectively). The status of primary occupation of the respondents varies largely within the selected LGAs. Although livestock keeping is the second major economic activity in all the LGAs, most livestock keepers are also farmers, as very few of them keeps livestock alone. Agric labourers ranked third (4.5%) followed by petty traders (4%).

Other minor economic activity included hawking of water and selling of crop stocks and firewood (were observed in Rogo and Kura) by women in particular and young men. Most young men in almost all the LGAs migrate to the urban centre off-season to engage in menial job as part of coping strategies.

4.2.2 Farming System in the Study Area

Figure 4.2 presents the percentage distribution of the most common farming system in the study area.

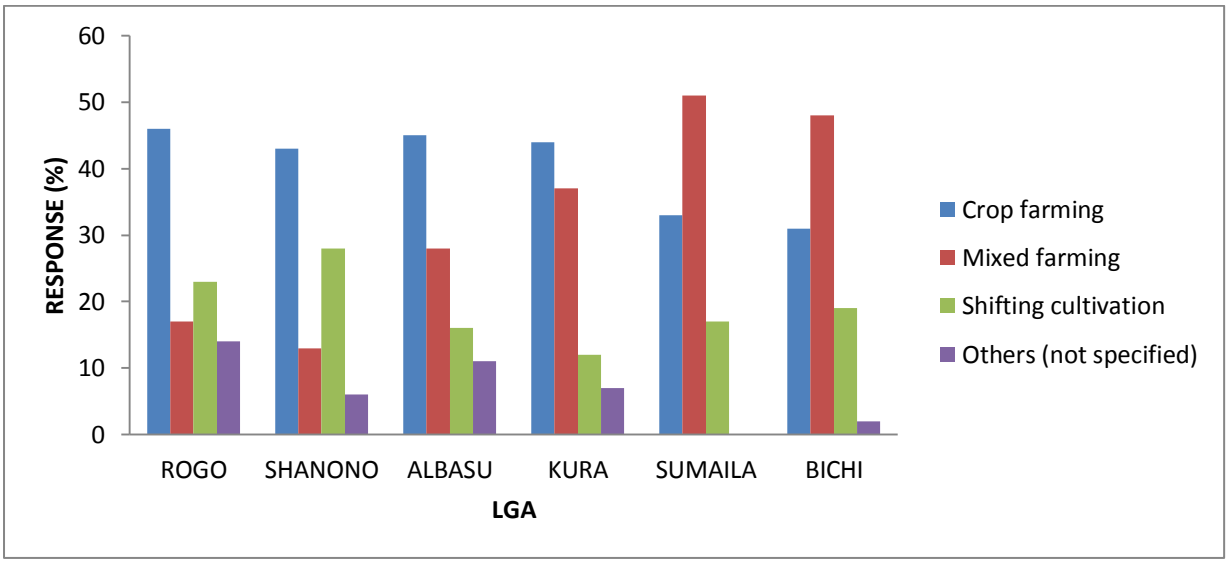


Fig: 4.2: Farming Systems by Percentage Proportion in the Study Area

Fig 4.2, presents the most common existing farming systems in the six selected LGAs in the study areas which is a reflection of the farming systems in the state.

The farming systems in the area include crop farming, mostly grain crops (i.e. production of crops alone, mixed farming; i.e. the keeping of livestock and crop farming) and shifting cultivation. Much of these activities are greatly on subsistence level with little mechanization.

4.2.3 Gender and Marital Status of the Respondents

The gender and marital status of the respondents are shown in fig 4.3a and b.

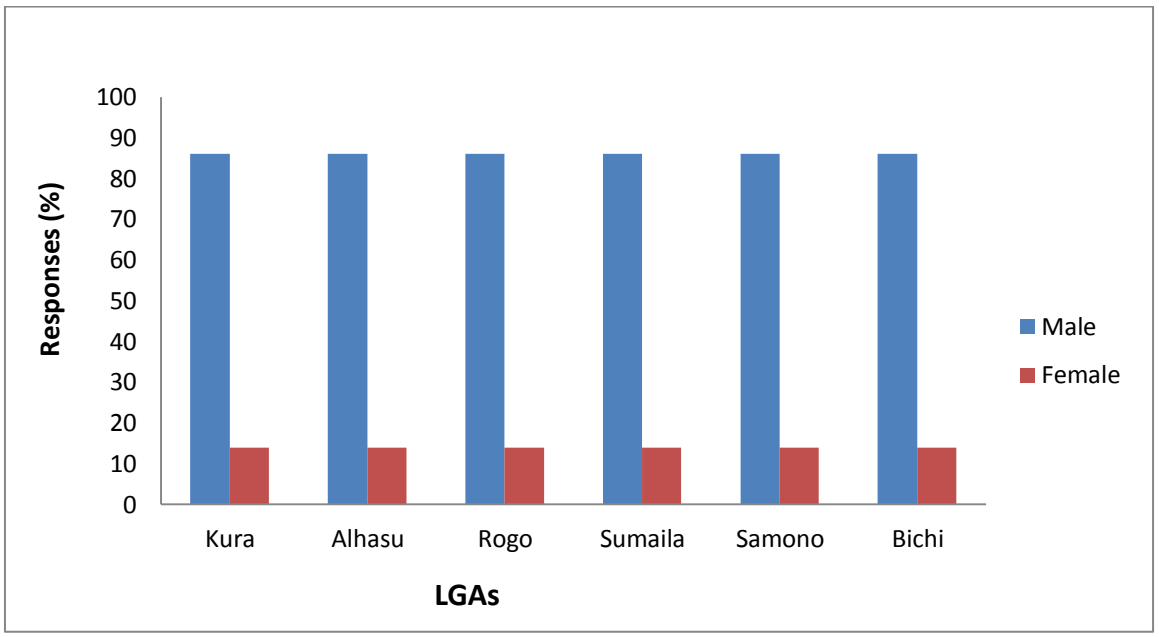


Fig: 4.3a: Gender Status of Respondents across the Local Government Areas

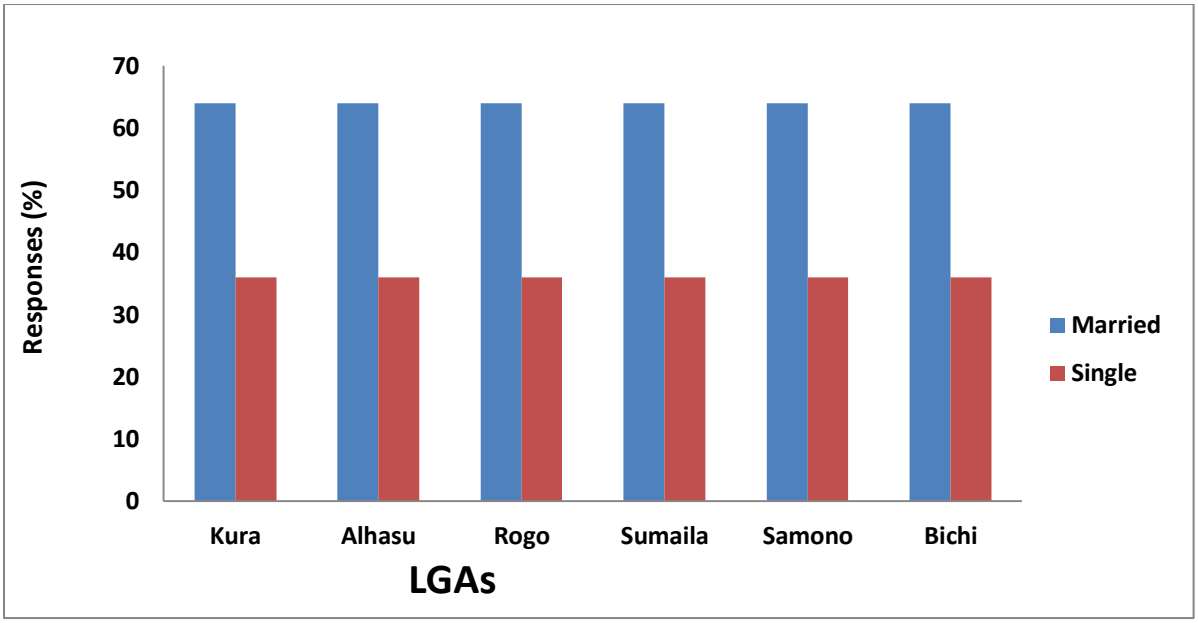


Fig: 4.3b: Marital Status of Respondents across the Local Government Areas

The sampled population is more tilted towards the male sex both in the administered questionnaire and the FGDs. This largely is due to the influence of the religion of the people in the study area which discriminate against women in certain social activities. Male respondents accounts for 85.9% (1505) of the valid 1750 across the state. While female respondents accounts for 245 (14.1%). Also, out of the 1750 respondents, across the state 1120 (64%) were married while 630 (36%) were single.

4.2.4 Age of Respondents

Figure 4.4 presents the age characteristics of the respondents in the study area.

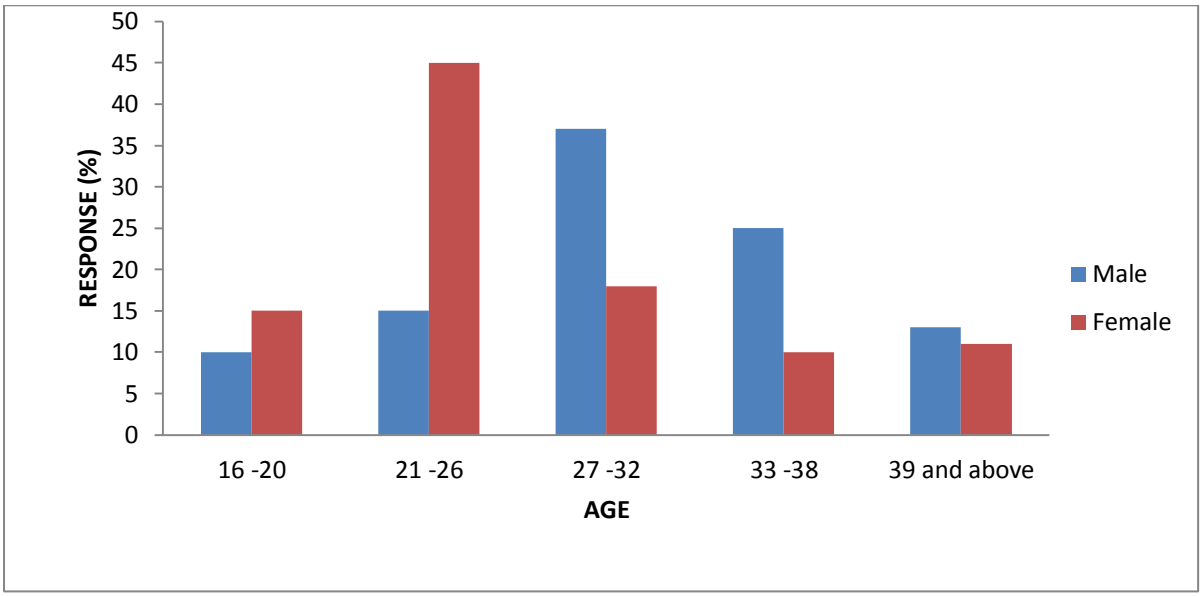


Fig: 4.4: Age Distribution of Respondents

The age categorization was not strictly based on the fact of Nigerian minimum work age of 18 years, since the respondents are mostly farmers,(i.e., as a rural set up, ages less than 18 are involved in farming for a living) the categorization is a reflection of the economically productive (labour force of the area) sequent of the sampled population.

Fig 4.4 shows that out of the 1750 of the valid respondents, only 1628 (93%) indicated their age. From the 1628 (93%), 1416 (87%) were between the ages of 16 – 38, while only 212 (13%) were above 39 years. The implication of the statistics of the respondent's ages shows that the respondents are within the economically active population involved in farming and can serve as a vehicle of controlling GHG generation if properly informed. i.e., through good and adequate enlightenment programme on appropriate cultural practices that minimizes GHG generations (e.g. zero tillage, non-burning of grasses after clearing, minimal grazing, etc.)

4.2.5 Religion of the Respondents

The religion of the respondents is presented in fig 4.5.

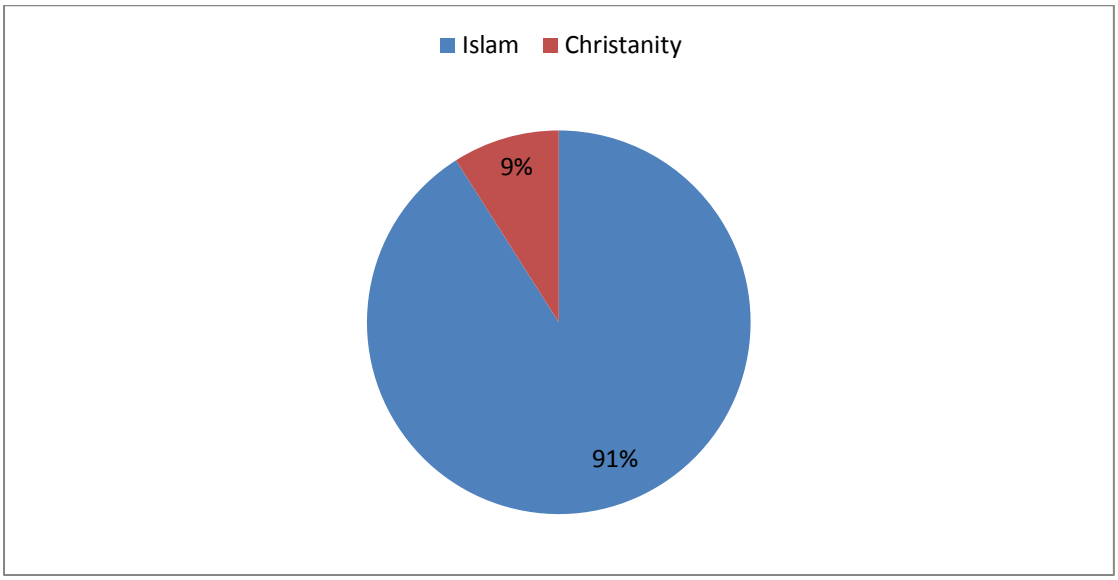


Fig: 4.5: Religion of Respondents

Fig 4.5 indicates that the respondents from the study area were predominantly Muslim. This is the reflection of the entire LGAs selected. 91% (1592) respondents were Muslim. While only 158 (9%) were Christian. None of the respondents indicated to practice any of the African traditional religion.

4.2.6 Educational Qualification of Respondents

The educational status of the respondents are shown in fig 4.6

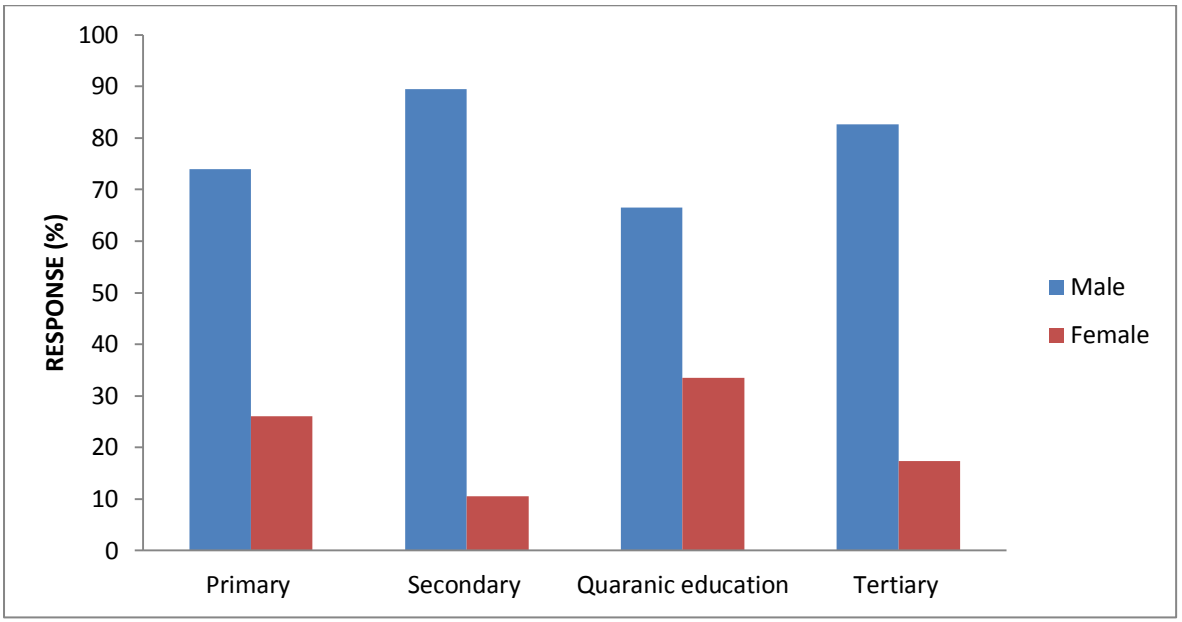


Fig: 4.6: Highest Education Qualification of the Respondents

The shows that a large proportion of the respondents are of the quaranic school background. This is closely followed by primary education in both sex and tertiary. This indicated that almost all the respondents have the basic academic qualification to be able to complete the questionnaire.

4.2.7 Income Sources and Status of the Respondents

Figure 4.7 shows the major income sources of the respondents

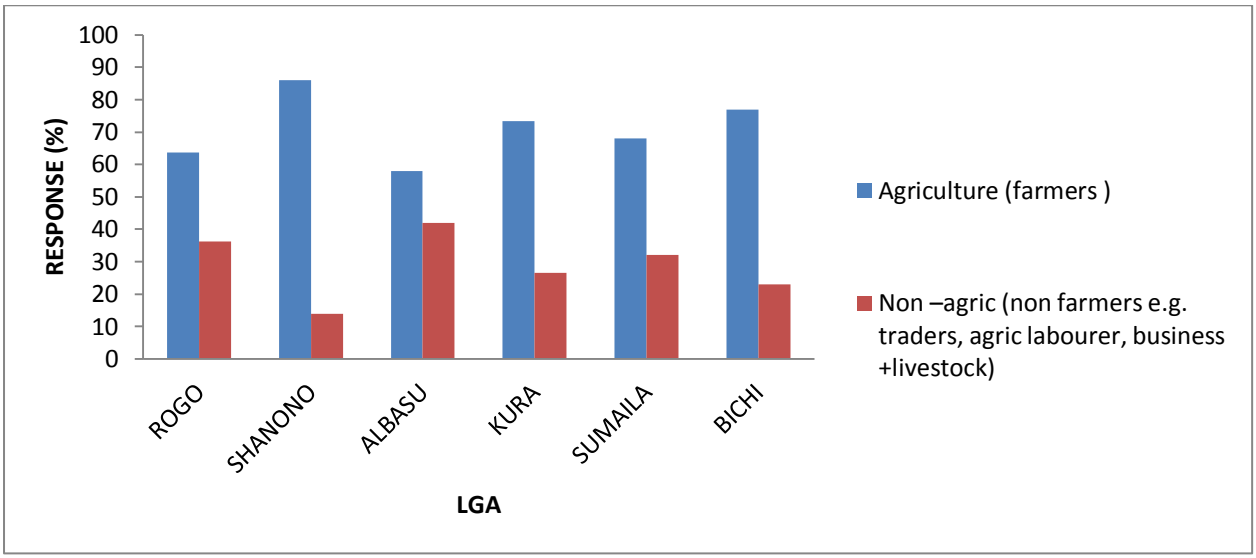


Fig: 4.7: Percentage Sources of Respondents Income

According to fig 4.7, the sources of income of the respondents can be broadly grouped into agriculture (farming) and non agriculture (petty trading/ business, livestock keeping agric labour etc.). Incomes from agriculture dominate the sources of income of the respondents. This is so because most of the respondents are farmers. Even those who claimed other sources (livestock keeping, trading etc.) are still involved in farming. Only in Rogo and Albasu are the sources of income almost equally split. Income from farming or agriculture are predominant in the rest of the sampled LGAs.

4.2.8 Famers Income Per Year

The distribution of farmer's income per year is shown in fig 4.8

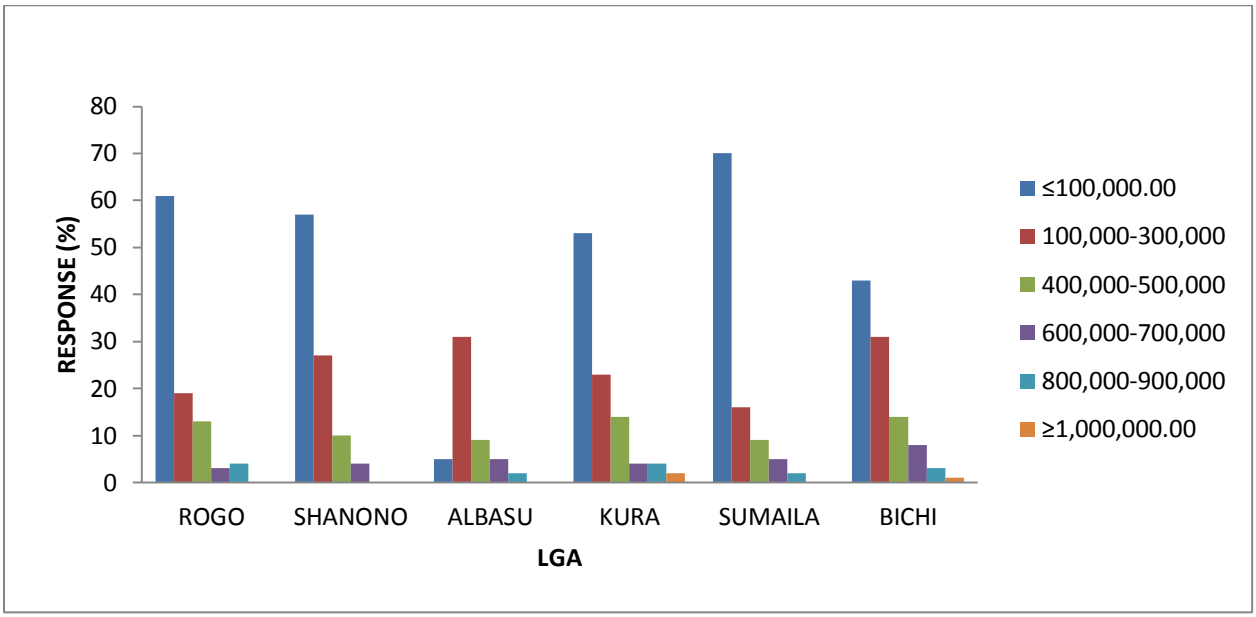


Fig: 4.8: Income Distribution of Respondents

The figure reveals that, most of the farmers earn less than one million naira (1,000,000.00) per annum. This may be due to the nature of farming in the area (mostly peasants). This level of income may be responsible for poverty in the area, it can also be responsible for the low capacity of people to cope with climate hazards occasioned by climate change in the area. It is only in Kura LGA and Bichi LGA that is, 2(7%) and 1(2%) respectively, that the respond indicated having an income equal or above one million naira per annum.

4.2.9 Farmers Yearly Excess Expenditure Over Income

The excess yearly expenditure over income of farmers in the study area is shown in fig 4.9

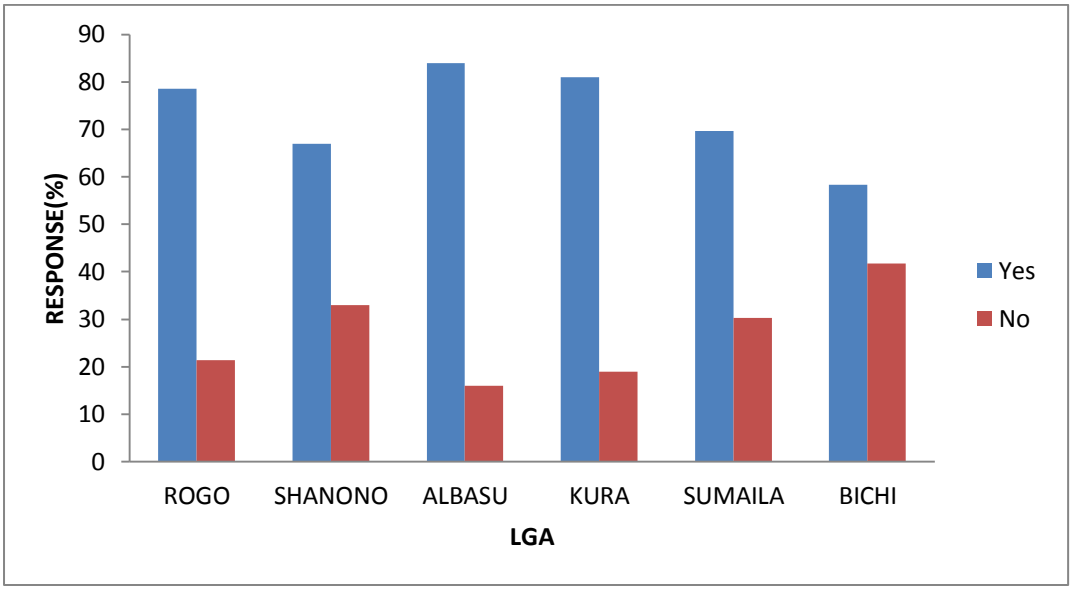


Fig: 4.9: Farmers Annual Excess Expenditure Over Income

From fig 4.9, responses of the farmers reveal that the yearly expenditure of the farmers in the study area is above their annual income. In all the sampled villages/settlements in all the LGAs the expenditure of the farmers far outweighed their income per annum. (based on responses of those who answered Yes or No to question on whether their income is less than their expenditure). Only in Bichi, Shanono and Sumaila were the respondent income and expenditure almost equal 41.7%, 30.5% and 30% respectively.

4.2.10 Strategies to Overcome Income Deficit

The most common strategies used to overcome income deficits in the face of climate change episode is shown in fig. 4.10

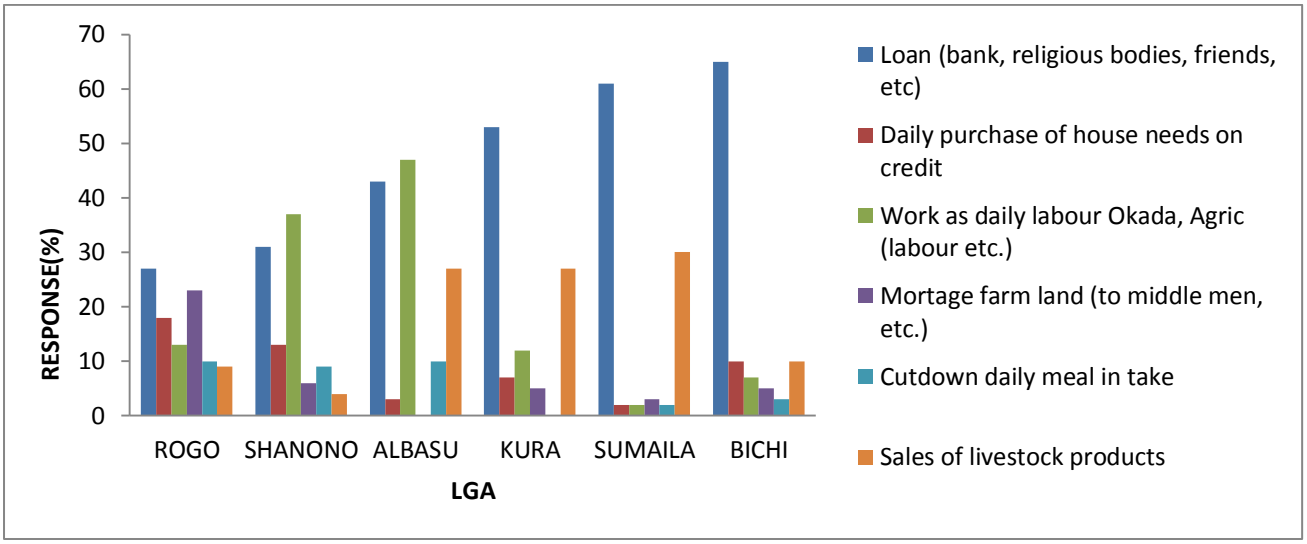


Fig: 4.10: Farmers strategies to over income deficit in times of crop failure or off season

The deficit in annual income and expenditure especially during crop failure, climate disaster are managed differently across the selected local government areas. Fig 4.10 reveals that this is done through loan from banks, religious bodies, neighbors, and mortgaging of farmland to middle men who buys products from the farmers. Also, some of the farmers result to working as daily labourers as agric labourers, Okada riders, etc. and sales of livestock and livestock products.

4.3 Awareness and Perception of Climate Change in the Study Area

4.3.1 Farmers Awareness and Understanding of Climate Change

The level of awareness of the respondents by age and level of education on trends of changes in temperature and rainfall is shown in table 4.1- 4.3

Table 4.1: Farmers Awareness by Level of Education on Climate Change Indicators in the Study Area

Level of education	Changes in Rainfall pattern	Increase T^{0c}	Humidity i.e. general dryness	Increased flood	Storming or windy rains
Primary	13.1	50.7	48	63	58.6
Secondary	23.1	35.3	38	56	69
Quaranic education	36.5	43.5	40.2	28.6	65.3
Tertiary (NCE, Poly, Uni)	96	76	69.4	85	84.3

Source: Field Survey, 2011

Note:

The above table is mutually exclusive (i.e., multiple entry). It is based on those respondents who responded "Yes" on the indicator.

Table 4.2 Farmers Awareness by Age Group on Observed Temperature Trends for the last two (2) Decades

Status of temperature	**15-20**	**21-26**	**27-32**	**33-38**	**39 +**
T^{0c} is getting hotter	37.6	48	67	58	63.5
T^{0c} is moderately hot	4.3	26.7	13.8	21.6	13
T^{0c} is hot	25	20.3	16.1	12	19.5
Do not know	33.1	5	3	9	4
Total	**100**	**100**	**100**	**100**	**100**

Source: Field Survey, 2011

Table 4.3 Percentage Distribution of Farmers Perception on Trends of Rainfall over Kano State (not based on meteorological data)

Trends of rainfall	**Kura**	**Albasu**	**Rogo**	**Sumaila**	**Shanono**	**Bichi**
R/F is decreasing	57	47	27	19	50	34
R/F is increasing	17	60	57	60	45	16
R/F is not changing	5	38	18	31	40	28
R/F is untimely	67	78	58	72	60	60
R/F is heavier within a short period	74	73	63	59	79	76
Do not know	2	20	14	-	10	19

Source: Field survey 2011

Climate change is perceived differently at different levels of perception or conceptualization (Diggs, 1991; West *et al,* 2007). Results of the questionnaire survey, Focus Group Discussion and key informant interviews revealed that there is varied understanding on climate change depending on the level of education, age, livelihood activity, etc. (table 4.1 & 4.3 are mutually exclusive, i.e., multiple responses)

Farmers from the different age group related differently changes in temperature condition of the area. While the older ones 39+ indicated that the temperature is getting hotter, most of the younger ones could not relate clearly temperature condition (table 4.2). However, in all the selected local government areas, it was agreed that there have been continuous fluctuation in rainfall pattern over the years (Table 4.3). The level of education in perception of local climate was reflected by the respondents awareness of climate change (table 4.1) while those with higher or tertiary education showed better knowledge of climate change, those with lesser qualification were on the contrary.

4.3.2 Farmers Extent of Awareness of Local Climate Change Issue

The extent of awareness of local climate by the farmers presented in table 4.4

Table 4.4 Percentage Distribution of Farmers Extent of Awareness of Local Climate

Variable	**Respondents**	**%**
Aware to a great extent	184	10.5
Aware to a reasonable extent	201	11.5
Know little about climate change	192	11
Do not know at all	1173	67
Total	**1750**	**100**

The study sought to know the level of local farmers' knowledge of climate in their immediate environment. Table 4.4 reveals that majority of the farmers are not aware of local changes in the climate of their area. Only 10.5% (184) said they are aware to a large extent of local climate change in their environment. 11.5% (201) are aware to a reasonable extent. While 11% (192) knows little about local changes in their climate and 67% (117) do not know at all about changes in their local climate.

The local farmers understanding on climate is that climate is continuously changing especially with regards to pattern of rainfall and that it is getting worse all the time (from FGD/Interviews). Bad years with regards to rainfall are becoming more frequent than before, resulting in poor performance of crops. On the other hand, with regard to other weather elements e.g. temperature changes, the result of the questionnaire survey reveals that the level of awareness of the local farmers of climate change and its impacts were still low.

4.3.3 Farmers Understanding of Global Climate Change Phenomena

Table 4.5 presents the extent of respondent's awareness of global climate change.

Table 4.5 Percentage Distribution of Farmers Extent of Awareness of Global Climate Change

Variable	%
Extent of knowledge	
Knowledge of climate change impact on farming activity.	
Yes	89.7
No	10.3
Understand of climate change.	
Excess rain fall within a short period	67
Untimely rainfall pattern	79
High wind and stormy rains	53
Frequent and prolonged dry spells.	61.5
Crop failure (drought)	53
Shorter Harmattan period	35
Longer Harmattan period	56.3
Change in local weather condition	63
Continous poor yield condition.	16
Ozone layer depletion	09
Change or increasing temperature condition	3.5

**Multiple responses*

The study sought to elicit the understanding of farmers on global climate change or global warming. Surprisingly, 89.7% of the respondents indicated that they were aware of global climate change impacts on the farming activity and general environment. Their knowledge of the global climate change or global warming was high as against their low level awareness of their local climate change.

Interestingly, 63% of the farmers indicated they understood climate change as change in local weather condition, (table 4.5 above). These responses probably represent the basic understanding of the term “climate change”. 16% related climate change to “poor yield”, while 9% refers to it as “ozone layer depletion. Some of the respondents (8.5%) sees it as “heavy rainfall condition” while 3.5% understand it to be “change or increasing temperature condition”. Furthermore, table 4.5, reveals that 67% understood climate change as excessive rainfall within a short period, while 79% sees it as a case of frequent prolonged dry spells, and 53% understood it as a case of drought or crop failure.

4.3.4 Farmers Perception and Description of Local Climate Change in the Study Area

Table 4.6 shows the varying description of local climate of the study area by the farmers

Table 4.6: Farmers Local Knowledge or view of Climate Change

Description	LGA 1	2	3	4	5	6
Decreasing rainfall	53	47	68	59	72	18
Weather is getting drier every year	76	69	83	88	69	75
Rains are not supporting crop as before	62.6	59	62.7	47	59	60
Cost of crops rising increase of CC	60	48	70	63	80	51
Rural –urban migration because of CC	53	60	80	69	70	70
Change in general livelihood due to CC	47	53	37	59	49.1	50
Increasing flood frequency during rainy season	75	69	73.1	65	70	73
Increasing incidence of drought	55.7	81	50	70	78	70
Excessive devegetation because of CC	60	59	70	62	68	51
Decline in crop yield	75	60	51	64	53	67
Increase new pest & disease infestation of plant and animals	68	72	53	60	60	82
Increasing episodes of wind erosion	49	57	70	65	70	71
Desert encroachment	41	70	69	70	75	81
Dryness of streams	67	59	70	61	73	62
Fragile human health especially during harmattan	70	73	69	72	80	85

***Multiple Responses (i.e., mutually exclusive)**

Climate change episodes manifesting in terms of increasing flood frequency, incidence of drought, decline crop yield, dryness of streams, high wind activity, the rains not supportive to crops as before etc, are observed by the farmers as evidence of climate change in their local environment (table 4.6). In all the local government areas, at least 50% of the farmers have the above events as climate change challenges to their farming activities (table 4.6).

Table 4.6 shows the percentage distribution of farmers perceived and observed changes resulting from climate in the past 3 (three) decades in the study area. Drier weather year by year, increasing flood events during rainy seasons, decline in crop yields, increase in new plant pest and diseases and fragile human health were identified by the local farmers as major problem from climate change, in the six (6) selected local government areas of Kano states. It was only in Rogo and Kura LGAs that the respondents did not really see desert encroachment, wind erosion episode as a major problem of climate change. Dryness of stream or surface water body was also highlighted as an extreme weather related problem. For example, from the FGD, one Murtala Mai Alubosa, in Sumaila describe the situation as follows:

> "…we do not know what the world is becoming today, everyday is becoming hotter and hotter. It was not like this when we were coming up as children in this place. Harmattan period use to be sweet, but in present day, it is now harsh… Murtala/ male/ Sumaila LGA Kano state 2011."

Extreme and irregular weather conditions were also identified in the study area has been responsible for fragile health problems in the area e.g. malaria, meningitis, etc. Other problems identified to be associated with climate change in the area, relates to agricultural produces. e.g. millet, sorghum, tomatoes, onions, lettuce, pepper and beans. These crops are

very sensitive to weather conditions. The weather impacts is described as low quantity and quality of the crops.

From one of the informant interview with one of the field officers of KNARDA in Bichi LGA

> "…the dry season farming in this environment some 20 years ago do last from November to March, but presently this has change, it do start earlier in August/ September and last till around April/ May interview/ Bichi LGA/ Kano state 2011."

From the above, there is no pretence of the impacts of climate change in the study area. The people of the area are feeling the effect of climate change as hunger and begging have increased in the last 10 years (as attested to in the FGDs).

4.3.5 Sources of Information on Climate Change

Fig 4.11 reveals the major sources of climate change information to the farmers in the study area

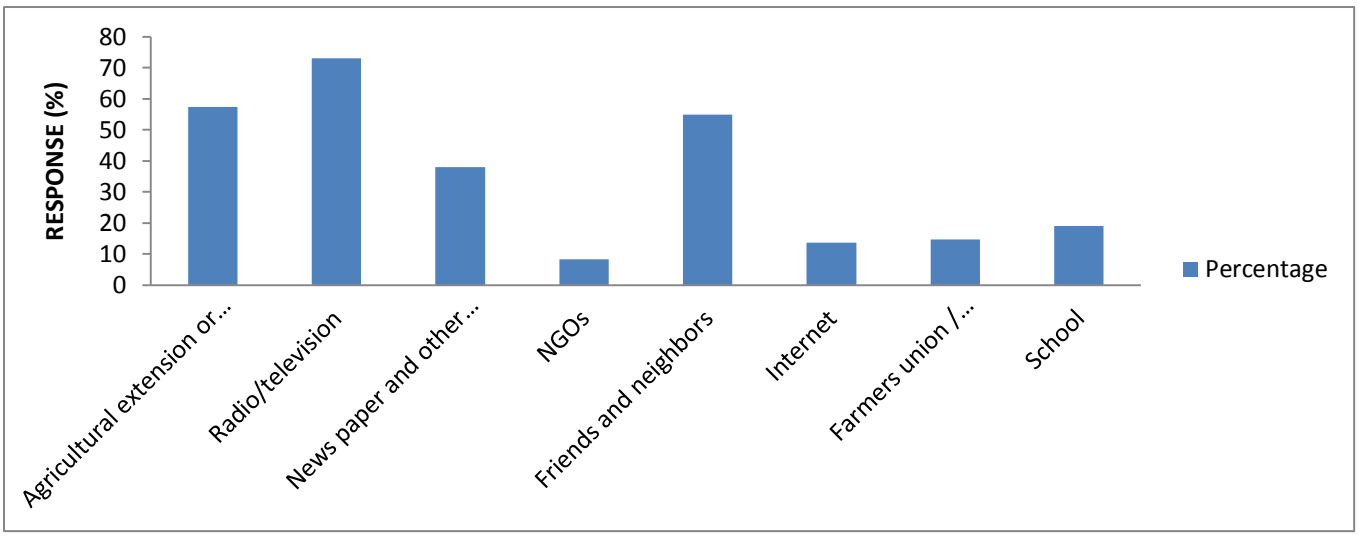


Fig: 4.11: Source of Information on Climate Change to FARMERS in the study Area

Generally, knowledge of climate change impacts is related to availability and accessibility of information on the climate change extent. From the questionnaire administered it was found that radio/TV, agricultural extension or field officers and interaction with friends form the largest sources of information on the climate change phenomenon in the study area. Fig 4.11 reveals that the farmers received information on climate change from the following three major sources: Radio/Television (73.1%), agricultural field officers (57.3%), and friends (55%). Other sources include other print media (38%), school (19%) farmers' union/cooperatives (14.7%), and internet (13.6).

In almost 80% of the villages sampled in Bichi, Shanono, Albasu and Sumaila, elderly and religious/clergy household heads beliefs and insisted cultural and environmental signals and signs can be taken as indicators for climate warnings systems. Their argument is that the knowledge of knowing, interpreting and predicting future weather and climate conditions belong to God and is only given by God. Anyone who attempt to predict it through other means is magic. This finding agreed with Dejene, (2011). This belief by the elders and religious leaders have an impact on adjusting traditional practices to adapt to the ever changing climate in the study area. The implication of this is that, since such a social milieus has power to prevent new ideas for change, there has to be an effort to influence the attitude and perception of such people for improvement of the society without necessarily ignoring the vital positive role of existing social setting of the community i.e. for any meaningful effort of adaptation practices to mitigate climate change, there may be need to integrate new indigenous technology to those existing cultural believes.

In this sense, some of the interviewees believed that climate hazards such as delay in onset of the rains, prolonged dry spells or droughts, floods, pest and disease invasion can be overcome when prayers are offered to God by the community. This is because some climate

events are believed due to people having done something wrong to upset God and this is why climate is changing. Similar finding was reported by Titto, (2011). However, it was observed that most of the younger generation are still in an ambiguous position as to whether to stand by these elders and religious leaders for advice for climate prediction and explanation. The generation seems to have found other references to obtain information and give reasons for climate changes in the study area. Among these sources are: information from NGOs, Extension and Field Officers (especially those from KNARDA) etc. Some of these younger peasants feel they do not have to consult the clergies for prayers to bring the rains or avert climate hazards.

4.3.6 Perceived Causes of Climate Change in the Study Area

The perceived major causes of climate change in the opinion of the farmers is presented in fig 4.12

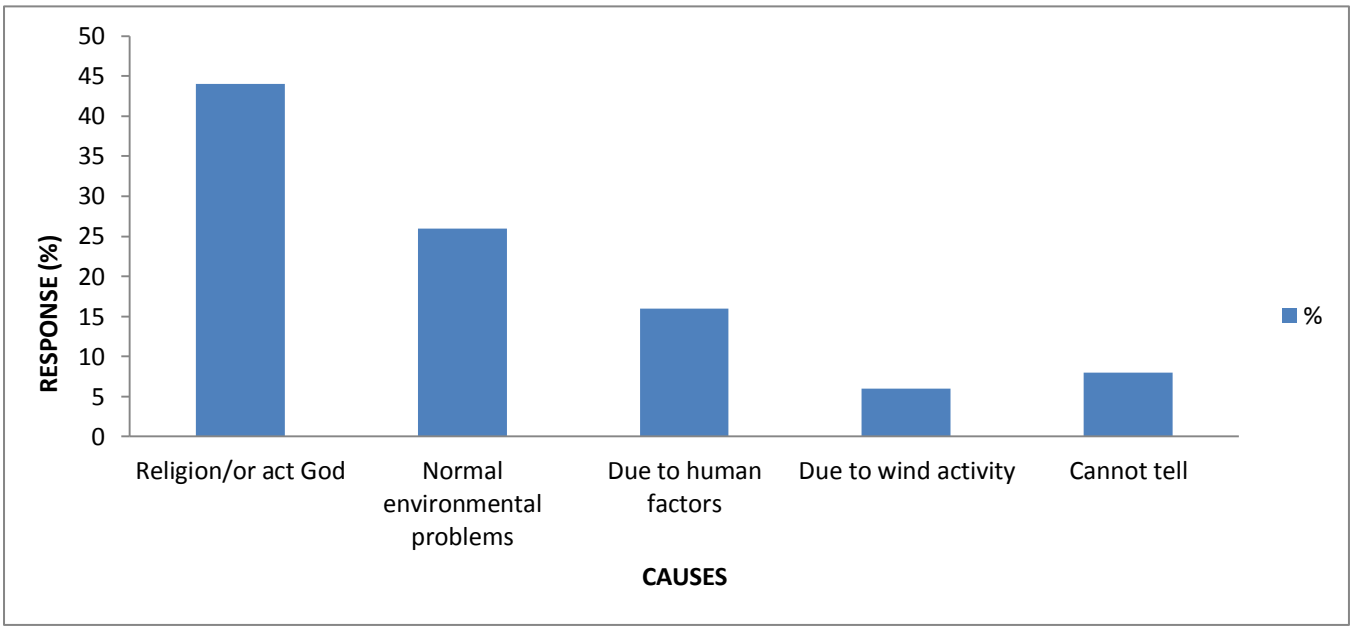


Fig: 4.12: Perceived Causes of Climate Change in the Study Area

The people of the study area are predominantly religious ones with very few open minded literates. Hence climate extreme events such as prolonged dry spells or drought and excessive floods are perceived from the religious perspective. The effect of religion was such that 44% (770) of the respondents attribute climate change events to the act of God. 26% (455) respondents view climate change episodes as normal environmental experiences while only 16% (280) blamed the occurrence of climate change on human factors. Further still 8% (140) cannot tell possible reason of climate change and 6% (107) respondents blamed it to wind activity. The implication of fig 4.12 is that mitigation and adaptation efforts maybe difficult as the belief and perception of the people may constitute a barrier.

Surprisingly, much of the population sees the situation of climate change as a phenomenon that will change positively with time in their community, (83.6%). This claim is based on high level religious Fanaticism. For example, in some of the FGD's and reconnaissance interview it was observed that some of the people believed that there is strangely nothing wrong with the situation in their community. They said that "with prayers the situation often come to an end. For example,

> "…the heavy heat and dryness, being experience have happened before. In those days during the time of our fore fathers, prayers were made and the situations do come under control…" FGD/Male/58/Bichi.

For another farmer in Shanono:

> "…lately we hear through jingles and discussions on radio and television that there is something called climate change. We do hear that government will come to help us as crops failure is getting more and more worsen. Till today, there is nothing tangible to show by the government…"

This belief and ignorance of the farmers contribute to the ever increasing state of poverty in the study area. Their enslavement to superstition has hindered the acceptance of modern farming techniques.

4.3.7 Perceived causes of new insect pests and plant diseases in the study area

Farmers in almost all the FGD's center observed that of late (5-10 years back) that there have been an increase in certain insect pest and plant diseases due to rising temperature. For examples, stalk borers (Calidea dreq:) which attacks maize and sorghum and rice were not originally a common insect pest of the area. Also, certain ants were reported to have become a major problem of nursery crops today due to warming in some communities selected except in Rogo and Sumaila. Similar findings has been reported by Shao, (1999), in semi-arid areas.

The two major climatic elements determining the occurrence and localization of pests and diseases appears to be temperature and moisture (Mendelson et al 1999 & Megha 2010). Generally, pest and disease vectors thrive better when temperature is under optimum water supply. However, climate change and vulnerability may increase the incidence of pests and disease. According to the FAO, (2010), changing temperature and rainfall in drought prone areas are likely to shift population of insect pest and other vectors and change the incidence of existing vector-borne diseases in both crops and animals.

The overall incidence of agricultural pest and diseases has increased in recent times in the Kano area. There was an increase in the number of crops affected by pest and diseases in the state. This view was the same in all the LGAs. The severity of infestation has also increased in recent years, such that people were of the opinion that local variety of some crops may no longer be feasible for cultivation in future.

4.3.8 General Perception and Awareness of the Local Farmers.

There is a growing realization by the people that climate change is happening. Their understanding and awareness is partly from media sources but is largely influenced by their observation of weather events around them. These observations are in the form of temperature change, erratic rainfall pattern over the last two decades, and poor performance of crop due to fields pest and diseases. Although all the observations may not be directly attributed to climate change alone, the correlation between changing pattern in weather events and many environmental attributes e.g. crop production will established this**.**

4.3.9 Observed Weather/Climate Factors

There has been noticeable change in weather elements such as temperature, rainfall, and seasonal durations in the last two decades as observed by the respondents during the FGD's interviews. The discussion with the community leaders reveals that during the last decades (Post 2006) there has been higher temperature, more variability /irregularity in rainfall both in time and quantity, more fluctuations in seasonal duration than earlier decades (see table 4.7)

Table: 4.7 People's Perception and Observed Environmental Change at Local Level

Observed decades	Observed changes		
	Temperature	Rainfall	Seasons
1960s-1980s	There was change but not very pronounce	Change was more in decrease in rainfall amount	No distinct change
1990s-2000s	High fluctuation with high hamarttan cold and high heat during heat period	Experienced less rainfall amount generally	Late arrival of the rain with prolonged dry period
Post 2000	Increasing high temperature /heat wave	Sharp variability in high intensity and time of rainfall	No distinct break between the arrival of the harmattan and end of the rains

Source: Field work 2011

4.4 Adaptation and Coping Strategies

4.4.1 Adaptation Options in the Study Area

4.4.1.1 Farmer's coping strategies to Adopt to Climate Change in the Study Area

This part of the work centres on the various adjustments farmers make in their farming activities when they perceive changes in climate of the study area.

Table 4.8: Farmer's reaction in the Face of Climate Change

Reaction	No of respondents	%
Yes /i.e. undertake major remedial action	403	23
No (do not undertake any remedial action)	1347	77
Total	**1750**	**100**

Source: Field work 2011

From the questionnaire and interviews of FGD's and informant interviews conducted, it was observed surprisingly that, even though a large number of farmers in the study area noticed changes in climate, over 77% did not undertake any major remedial action(s).

Though, this may not be strictly scientific, farmers in the area responded differently to changes in temperature and rainfall. A number of adaptation measures or options are identified in the study area. These adaptations are farmers different on-farm responses in the face of increased variability in rainfall pattern. Major responses or adjustments by farmers in the area include:

i. planting of different varieties of crops
ii. shortening of crop growing season
iii. changing /adjusting extent of land put into crop production
iv. sourcing irrigation or Fadama farming
v. uses of chemical fertilizer

vi. water maximization

vii. mulching with crop residues

viii. adjusting planting dates

ix. wider spacing of crops on row

x. on farm selection of seeds

xi. adjusting farm land clearance /weeding time

xii. thinning of crops

xiii. mixed cropping

4.4.1.2 Perceived Hindrances to Modern Adaptation Strategies to Climate Change

Hindrances to possible modern adaptation techniques in the study area is presented in figure 4.13.

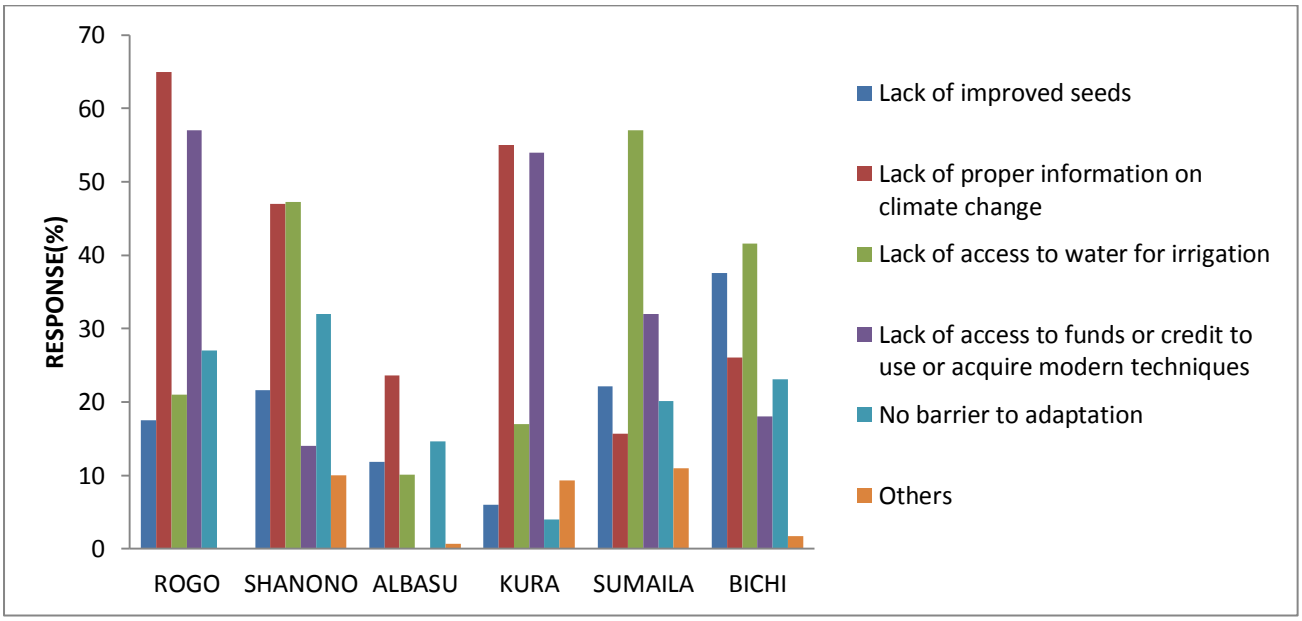


Fig: 4.13: Perceived hindrances to adoption of modern techniques in combating climate change.

More than 65% of the respondents cited inadequate information on climate change in Rogo LGA and 55.03% and 47% in Kura and Shanono respectively. 57% of the farmers in Sumaila cited inadequate access to irrigation or Fadama as a hindrance to proper adaptation

to climate change in the area. Inadequate access to fund to acquire and use modern techniques was cited by the farmers generally in the area as a barrier. Few farmers indicated lack of improved seeds as a barrier.

4.4.1.3 Farmer's Response to Temperature Challenges

The reaction of farmers in the face of rising temperature and rainfall fluctuation is presented in fig 4.14 and table 4.9 respectively for the study area

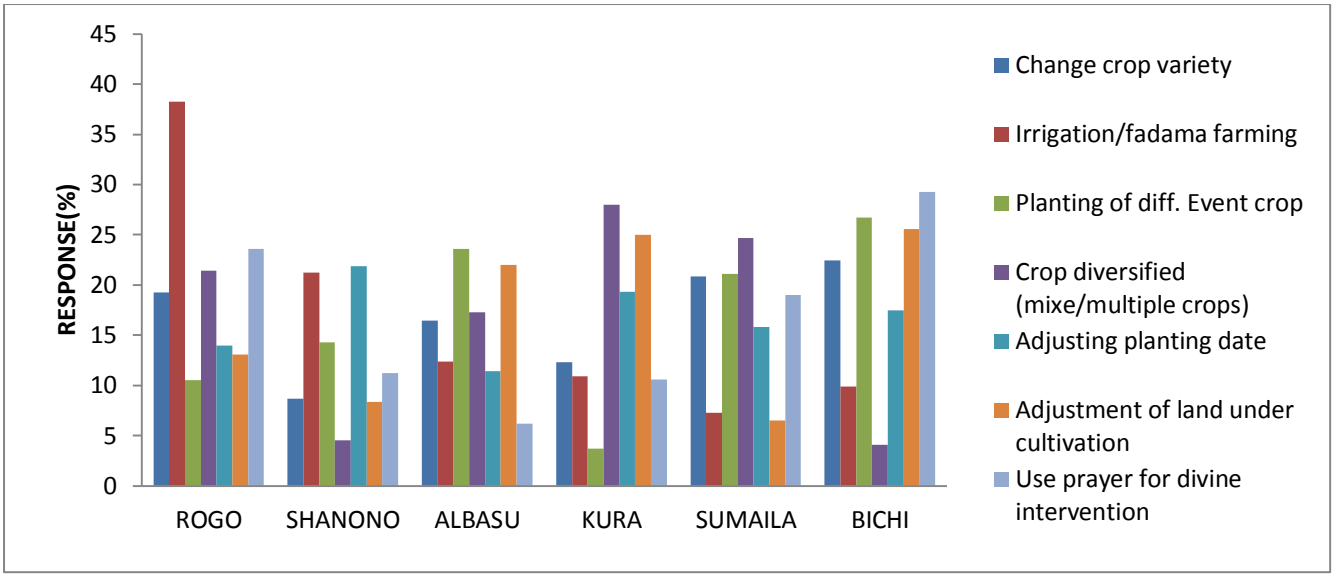


Fig: 4.14: Farmer responses to increased temperature

4.4.1.5 Farmers Responses to Changing Rainfall Pattern

Table 4.9 Adaptation in Response to Change in Rainfall (Distribution of Respondents)

	Change crop variety		Irrigation/fadama farming		Planting of diff. Event crop		Crop diversified (mixe/multiple crops)		Adjusting planting date		Adjustment of land under cultivation		Use prayer for divine intervention	
LGA	Respondents	%	Respondents	%	Respondents	%	Respondents	%	Respondents	%	Respondents	%	Respondents	%
Kura	83	24.5	42	12.3	51	15.0	80	23.6	89	26.3	23	6.63	261	77.1
Albasu	22	6.8	24	7.5	61	18.7	39	12.0	137	42.3	24	7.4	49	15.1
Rogo	25	11.2	36	16.3	49	21.8	9	4.2	24	10.8	17	7.4	16	7
Sumaila	57	15.6	16	4.4	53	14.7	78	21.5	13	3.5	108	29.7	62	17.1
Shanono	58	21.9	31	11.9	44	16.6	87	33.0	18	6.8	92	35	26	10
Bichi	45	20.0	108	47.6	30	13.2	13	5.8	223	10.3	8	3.5	42	18.3

***Multiple responses (mutually exclusive)**

Source: Field work 2011

From the numerous adaptation measures in the area, 7 (seven) most highlighted was used to test farmers responses to increase temperature and rainfall pattern in the area (table 4.9 and fig 4.14). From the table, in the face of increased temperature farmers in Rogo LGA cited irrigation/fadama (38.26%), use of prayers (23.6%), mixed cropping (21.4%) and use of crop variety as most adaptive measures in the area. In Shanono irrigation (21.26%) and adjusting planting date (21.9%) are the most cited measures. While in Albasu, planting of different crops (23.60%), mixed cropping and change of crop variety are most practiced measures. In Kura LGA mixed cropping (27.93%), prayers 10.6%, use of crop variety and irrigation are cited the most practice measures. In Sumaila LGA planting different crops (21.12%), prayers 20%, and use of crop varieties (20.87%) respectively are the most cited measures. And finally in Bichi LGA. Prayer (29.3%), planting of different crops (26.7%), use of crop varieties are the most practice measures.

In terms of rainfall increased amount and variability, in Rogo LGA, farmers cited prayers (27.1%) adjusting planting date (26.3%), mixed cropping 23.6% and use of crop variety (24.5%) respectively as the most practiced adaptation measures.

In Shanono LGA adjusting planting date (42.3%) prayers (15.1%) and mixed cropping are the most practiced measures. In Albasu LGA planting different crops (21.8%), irrigation/fadama and use of crop variety are the most widely practiced. Furthermore, mixed cropping 21.5%, adjusting land under cultivation (29.7%), prayers are the most practiced measures in Kura LGA. While in Sumaila LGA adjusting land under cultivation (35%), mixed cropping (33%) and use of crop variety (21.9%) are cited as most adapting measures in the area. In Bichi irrigation/fadama farming (47%) use of crop variety (20%), prayers (18.3%) are the most practiced adaptation measures in the area.

The adaptation strategies induced by perceptions of changing rainfall patterns seems to differ from those induced by perception of changing temperature. While adopting a new crop variety, with mixed farming and planting dates are major strategies under temperature increased, use of water maximization, prayers, planting different crops are the most practiced schemes in terms of rainfall variability.

4.5 Climate Change and General Potential Adaptive Measures Practiced by Farmers in the Study Area

Adaptation to the adverse effects of climate change is a key issue for all society, especially those in sub-Saharan Africa who are often the most vulnerable and least, equipped to defend themselves. Studies have shown that without adaptation, climate change is generally detrimental to the agricultural sector, but with adaptation, vulnerability can be largely reduced (Easterling *et al,* 1993; Mendelson, 1998). The degree to which a community or group of people is affected by climate change depends on its adaptive capacity. Adaptive

capacity is the ability of a person or group of people to adjust to climate change (including climate variability and extremes) to moderate potential damages to take advantage of opportunities or to cope with the consequence (IPCC, 2001; Gbetibouo, 2009). This include efforts to adjust to ongoing and potential effects of climate change (Mani *et al*, 2008).

Farmers adaptation to climate change requires that farmers first notice that the climate have changed, and then identify useful adaptation measures and implement them (Madison 2006).

Varying strategies where observed through the questionnaires and FGD's interview results to have been adopted by farmers in the study area for climate change adaptation.

Table 4.10 presents the general traditional adaptive practiced by the farmers in the study area.

Table 4.10 Percentage Distribution of General Traditional Adaptation Strategies to Climate Change in Dryland Kano Area

S/N	Indigenous adaptive measures	% Yes	% No
1	Use of organic manure (measures)	75.6	24.4
2	Use of inorganic fertilizer (measures)	69.5	30.5
3	Use of wind breakers (trees) on the farm	47.8	52.2
4	Planting pest and disease resistant seeds	49.6	50.4
5	Use of acclimated crop varieties	23.3	76.7
6	Staggered seed crop planting	57	43
7	Mixed cropping or crop diversification	69.1	30.9
8	Make of contour build around farmland (more with fadama/irrigation farming)	39.1	60.9
9	Use of minor tillage (zero tillage)	28.3	71.7
10	Varying farmland clearance or preparation date	74.2	25.8
11	Cover cropping (legumes, lemon etc.)	83	17
12	Use of water storage (small scale on farm water harvesting)	4.4	85.6
13	Reforestation /afforestation	37.1	62.9
14	Use of early maturing crop variety	68.3	31.7
15	Mulching of moisture protection practices	54.3	45.7
16	Seed preservation /plant seedling for next planting	78	22
17	Use of weather tolerant/resistant seeds	59.4	40.6
18	Mixed farming practices	83.2	16.8
19	Adjusting planting date	71.2	28.8
20	Planting of crop with early rainfall	63.1	36.9
21	Use of recommended planting distance (wider crop spacing)	41	59
22	Listening to information about climate change	33	67
23	Adjusting harvesting date	73.6	26.4
24	Out migration from climate risk area	28.3	71.7
25	Processing of crops to minimize post harvest pest and disease attack	73	27
26	Indigenous adaptive measures	70	30
27	Inter cropping	63.3	36.7
28	Planting before the rain	71.8	28.2
29	Cross ridging	67.1	42.9
30	Reclamation of wet lands or river valleys	19.6	80.4

Source: Field Survey, 2011

**Multiple responses:*

Note: Most of the responses depend greatly on types of crop the farmer plants.

The above table 4.10 shows the percentage distribution of respondents adopted different strategies for climate change adaptation in the study area to cushion the effects of climate change. For example, 63.1% planted now with early rainfall /onset, 83.1% planted mixed farming practices (possibly for economic purposes) 69.1% practice crop diversification, while 68.3% use early maturing crop variety, 73 process crop against post harvest pest and moisture changes. 74.2% adjust land preparation based on prevailing condition and 83% adopted practice of planting cover crops to prevent soil erosion and inorganic fertilizer respectively. The practices of water harvesting in the area is low 14.4%. also use of information on climate change is low 33% among the framers. Similarly, use of minimum tillage or zero tillage to minimize GHG contribution is low 28.3%.

Strangely, on the other hand, result of the FGD indicates that farmers are adopting the "spiritual approach" or "prayers" to cushion the effect of climate change. They noted that, "the current changes in climate of the area are brought about by God and that they can only pray for mercies of God. This is more of the views of the older ones (39 years and above). Some of the widely adopted adaptive traditional measures during the FGDs in the area include:

i. Mulching used for organic manure
ii. On farm seed preservation and selection for coming season
iii. Mixed farming
iv. Mixed cropping
v. Use of wind breakers on the farm '
vi. Use of early maturing crop variety
vii. Use of recommended planting distance
viii. Inter cropping

ix. Planting before the rains

x. Staggered seed crop planting

xi. Crop diversification

The farmers indicated that while they noticed the manifestation of climate change in their environment they adopted these measures and there have been improvement in their farming activities.

When asked on the sources of these innovative strategies for climate change adaptation, about 73% of the respondents (FGDs respondents) remarked that they did not copy or learn the practices from anywhere and that they are indigenous to them. Some of them opined that, these measures have helped them well in soil conservation and management. Although the farmers could not easily indicate a local term for climate change they noted that the above measures and many others have been practiced for so many years because of the peculiarity of their environment even before climate change became a major issue of discourse in recent times.

From the foregoing, it is evident that farmers in the study area have been practicing traditional adaptation measures even before the more recent concept of climate change became a topical issue of discourse. The finding that these innovative practices are indigenous to farmers in the area have some implications for climate change and development policy in the State. Policy makers and other stakeholders in the State can involve farmers and learn from the adaptive measures they are already practicing and integrate some to modern techniques for maximum result.

4.6 Community Identified Critical Climate Change Challenge(S) in the Study Area

The most critical climate change challenges in the study area (according to the respondents during the FGD are listed in table 4.11)

Table 4.11 Perceived Climate Change Challenges

Perceived challenges	Experienced impacts on farmers' livelihood	Action taken
Increasing temperature (heat stress)	- Health problem -reduced agricultural production - Beneficial in crop or fruit ripening	No major action is taken
Drying up of streams and surface water	Decline in agricultural productivity	-No major actions taken - prayer
Erratic rainfall pattern	Decline in agricultural productivity - total crop failure	- altering of agricultural calendar e.g. early sowing, or delay sowing etc. - change of crop variety - resowing of crop, etc.
Increase in field pest and disease	- Decline in agricultural productivity - health problems	- prayer or religious ritual -local pest management e.g. use of ashe, intercropping, rotation etc. - use of pesticides -planting resistant crop varieties etc.
Severe wind storms	-loss of harvest - destruction of crops -damage to houses	-practice of mixed cropping e.g. planting of maize and beans on a plot -protecting house roofs -prayer or religious rituals
Heavy flood	-loss of field -loss of properties -etc.	- prayer or religious rituals -making of side drains to drain off excesses water -no major actions taken
Drought/longdry spells	Decline of agricultural productivity	- reswoing of crops - use of irrigation (where available), planting of resistant crop variety.

Source: Field work 2011.

Farmers in the study area attested to climate change manifestation in the area. Most of the farmers interviewed in the FGD. Selected local governments identified among other climate changes challenges in the area, erratic rainfall pattern, heat stress (increasing daily temperature), floods, severe wind storm etc. (see table 4.11).

This agrees with the findings of Agrawal and Perrin, 2009; FAO, 2010, Machi, 2011.

Their responses to these identified critical climate change challenges in the area rang from altering of agricultural calendar (planting or sowing date), use of new crop varieties, traditional or local pest management, prayer or religious rituals, and resowing of crops during the long dry spells or total crop failure.

Farmers who have access to irrigation water (e.g. farmers in Kura or Fadama sites are not too affected by long dry spell drought). Their constraints are more in form of cost of pumping machine (as most of them hires the machine). The cropping and adaptive capacity of the farmers is weak because of their low income level. This is why impacts of climate change episodes or challenges on these farmers when they occur is high.

4.7 Vulnerable Groups in the Study Area

Vulnerability of individuals or regions actually depends on their adaptive capacity, sensitivity and exposure to changing climatic patterns. The ability of individuals to adjust to actual or expected climate impacts or to cope with consequences of climate change varies to various degrees.

Results from both the questionnaire survey and FGDs shows that in the Kano area, the disabled, children, elderly and poor farmers were rated as most vulnerable groups of the society, while landless and petty traders (mostly Igbos, or non indigenes) were classified as medium vulnerable groups. Rich or wealthy farmers, farmers with a second occupation (Government workers) who have access to credit and other resources are assumed less vulnerable. This result is almost similar in all the selected LGAs. Similar findings of this nature have been reported elsewhere by Teshome et al (2008); Shewmake (2008); DFID (2004); Dejene (2011). The implication of such understanding of the local dimension of

vulnerability is necessary to develop appropriate adaptation strategies that will mitigate adverse consequences of climate change.

In the same way, three major social or income groups were identified within the study area, these are:

i. The high income farmers

ii. The middle income farmers

iii. The low income farmers

Based on the opinion of the farmers, the wealthy groups in the study area can broadly grouped into three (3) major groups as presented in table 4.12

Table 4.12 Distribution of Wealthy Groups in the Study Area

LGA	High income farmers		Middle income farmers		Low income Farmers		Total	
	No of respondent	%	No of respondent	%	No of respondent	%	No of respondent	%
Kura	62	17	77	21.3	223	61.7	362	100
Albasu	16	7	82	35.1	135	57.9	233	100
Rogo	71	21	61	18	206	61	339	100
Sumaila	11	4	37	14	217	82	264	100
Shanono	101	31	90	27.6	134	41.4	232	100
Bichi	25	11	43	19	159	70	227	100

Source: Field work 2011

Generally, the stratification of wealth based on the farmers income in all the LGAs indicate that the poor group constitute the largest number of the population. With exception

of Sumaila where the percentage of the poor is less than 50% (41.4%) in the rest of the LGAs the percentage of poor farmer is above 50% of the total population (fig 5.8)

4.8 Identified Climate Change Impact and Challenges in the Study Area

One of the major targets of this research was to determine the effect of climate change on agricultural practice and on the rural farming population of Kano. Respondents were asked through FGD's and informant interview to identified and rank extreme climate events in the locality. Among the major hazards highlighted by the respondents to be directly or indirectly linked to climate change for the last four decades are presented in fig 4.15.

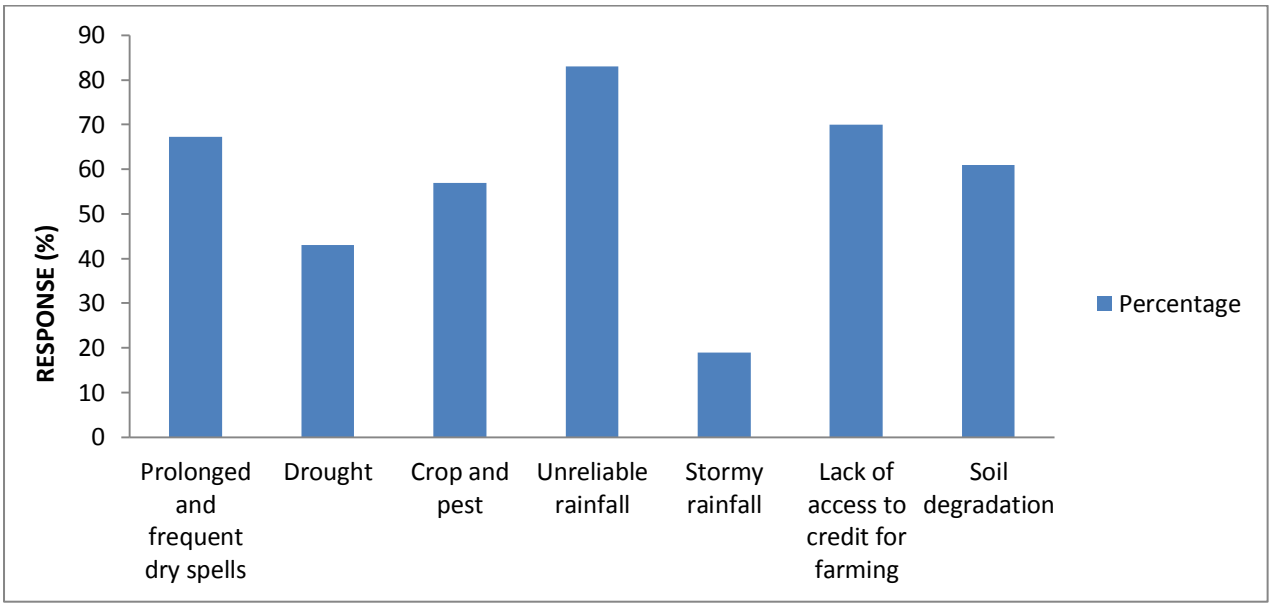


Fig:4.15 : Farmers Identified Climate Impact and Ranking in the Study Area

Majority of the farmers ranked frequent and prolonged dryspells, unreliable rainfall as the most related or threatening extreme climate change events in the study area. This is followed closely in almost all the LGA's by crop pest and diseases, drought and lack of access to credit facility for farming purposes. Similar result has been reported by Dejene

(2011) Teshome *et al* (2011). Unreliable rainfall, soil degradation and stormy rainfall were also identified climate change hazards in almost all the LGAs.

4.9 Comparison of Farmers' Perception of Change with Meteorological Data in the Study Area

Aggregated monthly rainfall and temperature data over Kano was obtained from NIEMET and the Aminu Kano International airport NIMET office of Kano, for about ten (10) decades. Data for temperature were available for only about forty (40) years. The temperature and rainfall graphs are shown in appendix 4. The meteorological data covering Kano show existence of strong inter annual variability in rainfall and temperature, especially rainfall pattern. The fluctuation in recent years in rainfall and temperature shown by the meteorological data is in line with the local perception of the farmers.

4.9.1 Precipitation

Results of meteorological records over the state shows a marked inter annual variability in the rainfall both in terms of annual total and monthly total for the 100 (one hundred) years analyzed.

The onset, cessation and length of growing season calculated for the one hundred years (100) rainfall data over the study area is shown in figure 4.16a-c.

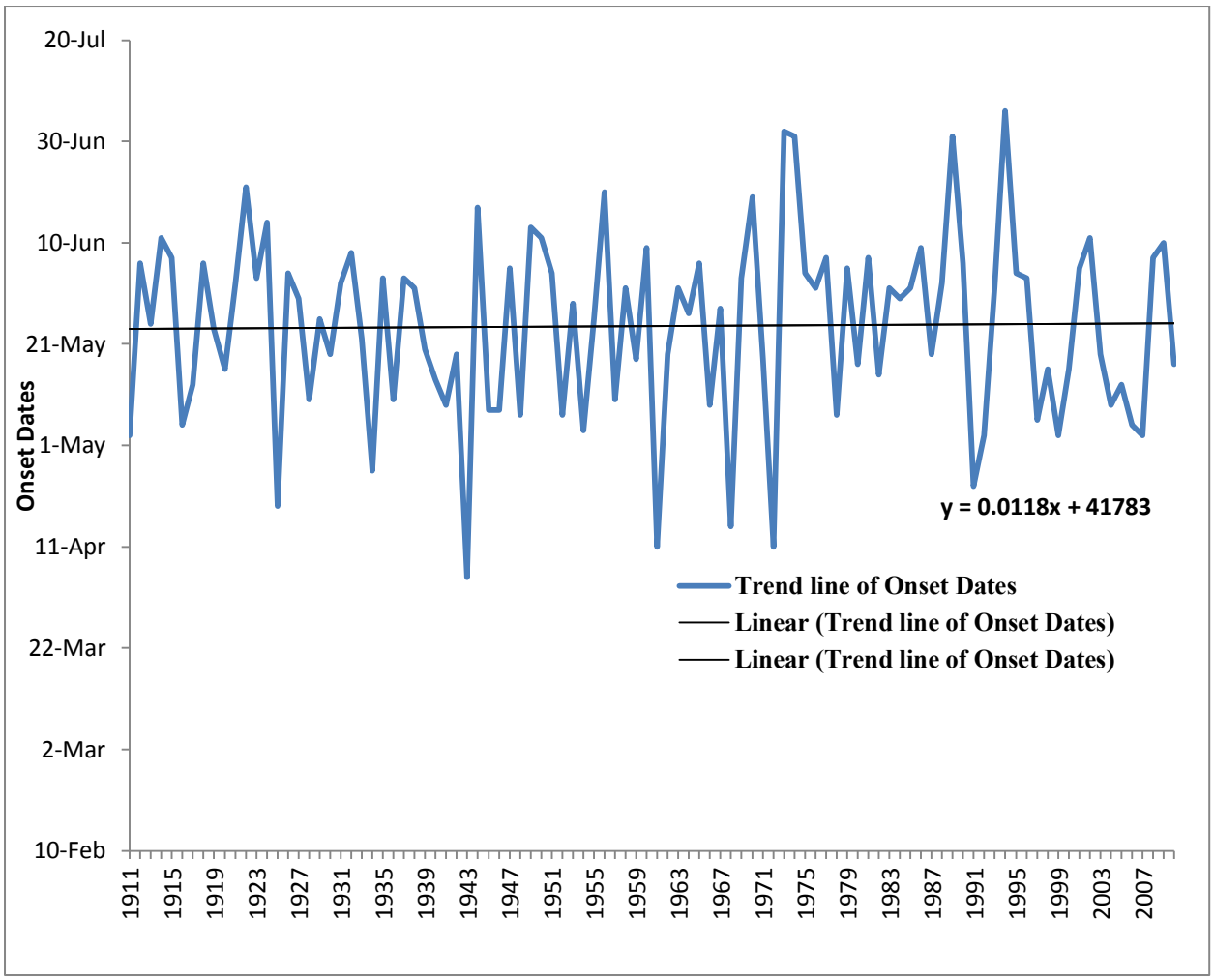


Fig. 4.16a: Onset Dates of Rain Over the Study Area

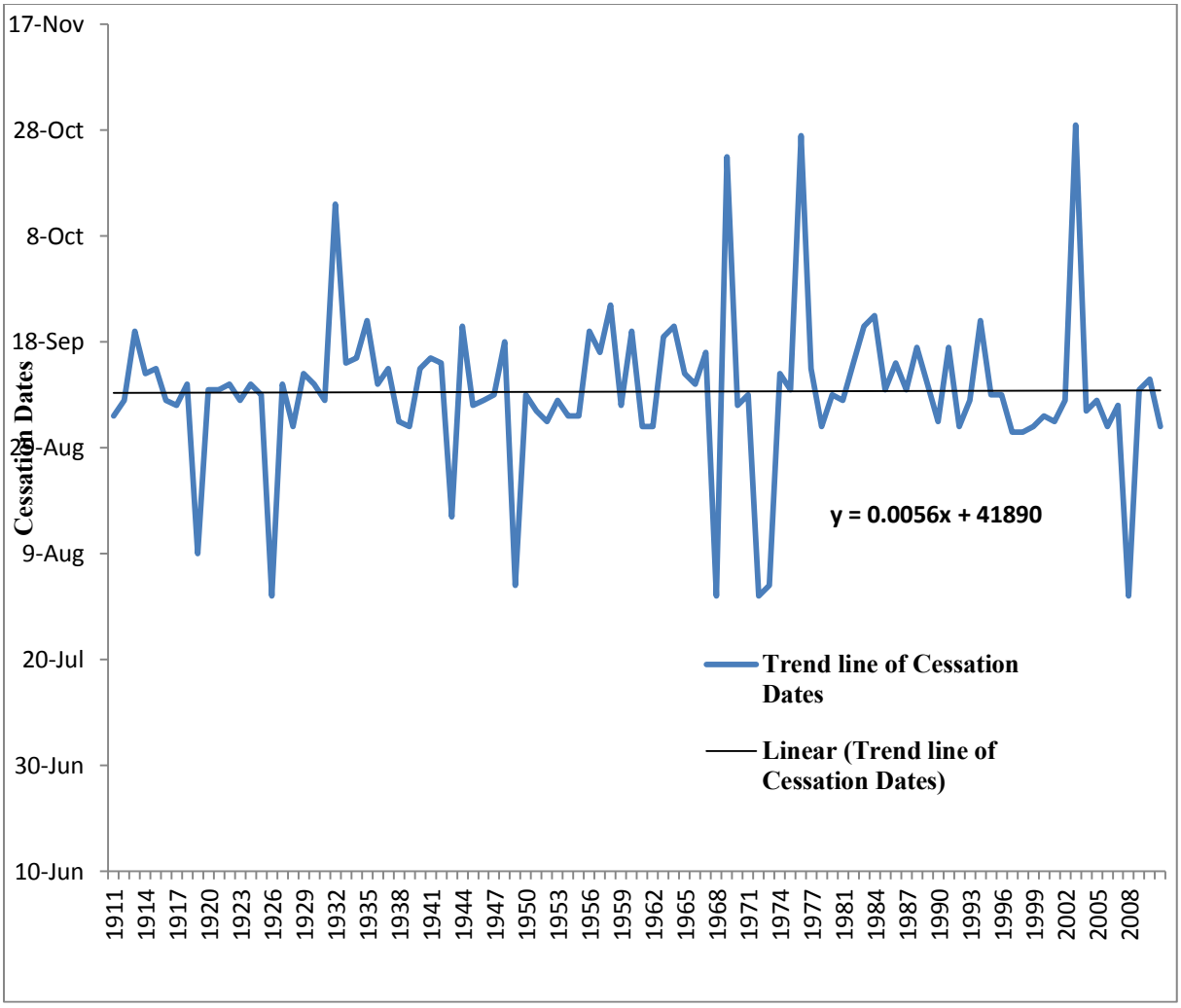


Fig. 4.16b: Cessation Dates of Rain Over the Study Area

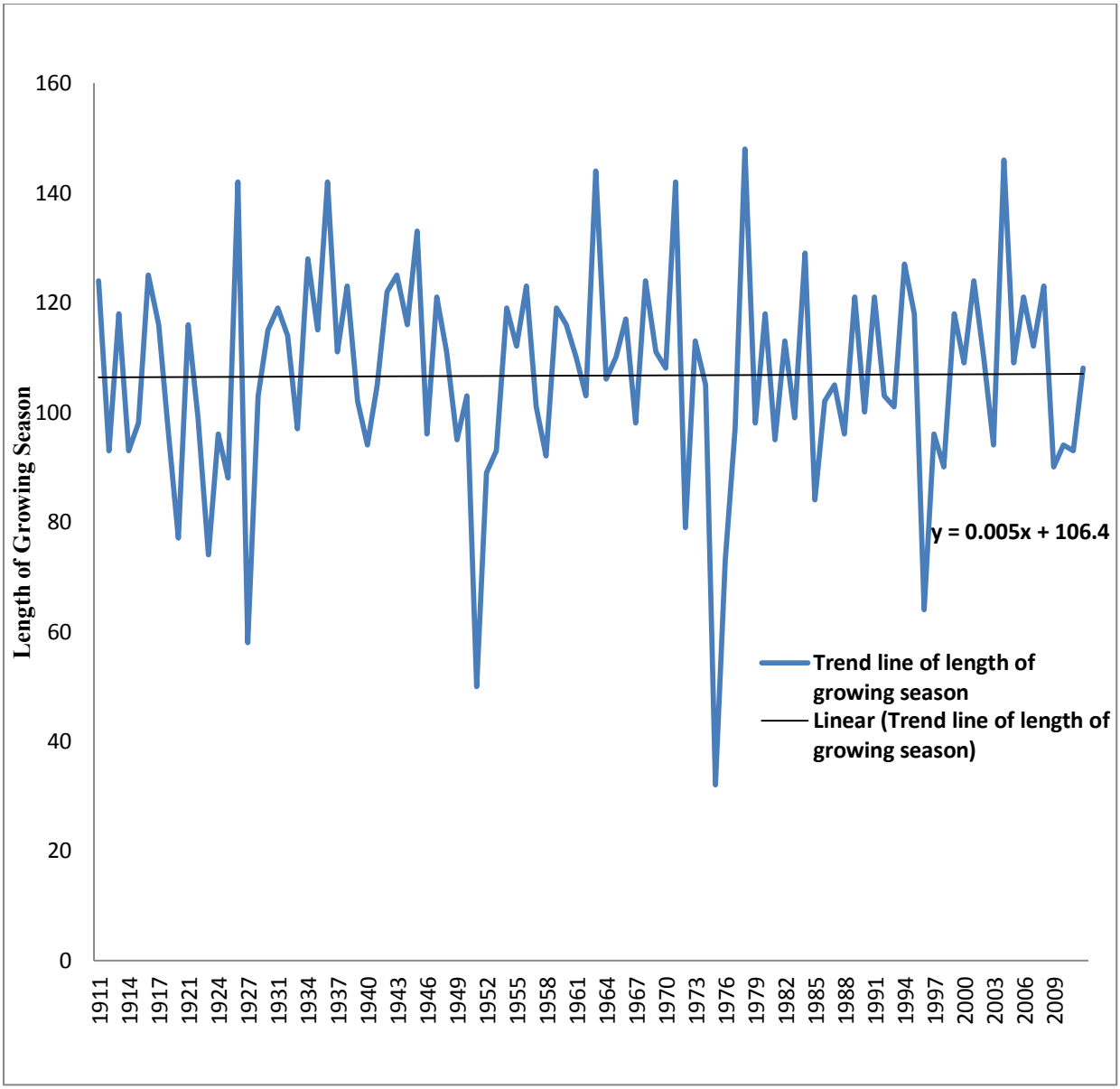


Fig. 4.16c: Length of Growing Season over the Study Area

Particularly, in recent years (10 years), the rainfall total fluctuates greatly in between the years which agree with the perception of the farmers.

Using Walter, 1968 method onset and cessation of rains also indicate significant inconsistence in between the years (i.e. cessation vis-versa between the year). The Walter method also shows a longer length of growing season in recent years with higher amount of total rainfall.

4.9.2 Temperature

Temperature data were only available for forty (40) years. The mean annual maximum and minimum temperature over the forty (40) years were 29.6^0c and 19.3^0c respectively. There was a slight increase in mean annual temperature for the period, a range of about 2^0c year and 1^0c year in the maximum and minimum temperature respectively, were observed.

The above meteorological data analysis is based on generalized weather record across the state. Without weather data from the selected LGAs/communities, without Long-Term data analysis of inter-annual differences, it will be difficult to make proper comparison of the farmers observations with climate records. But there is strong indication that the farmers response mainly reflect comparison with the most recent years, rather than long-term observations.

CHAPTER FIVE: DISCUSSION OF RESULTS

5.1 Introduction

This chapters the full discussions on the results obtained from the analysis.

5.2 General Perception and Awareness of Local Farmers

There is a growing realization by the locals in the study area that climate change is happening. Their understanding and awareness of climate change is largely from media sources and observation of some weather events around them. These observations were based on erratic fall regimes, temperature variations and poor performance of field crops. Although all these observations may not be completely attributed to climate change, the correlation between changing pattern in weather events and other environmental attributes such as crop failure is well established.

5.2.1 Perception of Farmers on Temperature Change

Most of the farmers, particularly adult farmers (ages 39 years and above) perceived significant change in temperature condition in the last two (2) decades (table 4.2). Almost 80% of the elderly interviewed in the FGD felt the changes in the harmattan season. Some of the respondents are of the view that onset of the hamarttan has shifted from late weeks of September to early and late weeks of October. They believe temperature is getting hotter with cold conditions now more pronounced in the months of late November to February. The respondents also reported that hottest months has increased in duration in the area, its onset has now advanced to the months of April/May in recent times which were traditionally months of rainfall onsets. This finding agrees with that of Ashutash, 2010, but at variance with Mihemachhema et al (2007).

The condition of temperature changes may be responsible for episodes of increasing wind erosion especially in the far northern part of the state, dryness of streams in the

environment (table 4.6). The above is in agreement with, Shrestha *et al* 1999. The FGD and questionnaire survey results show that local peoples perception appear to be in accordance with other empirical studies on the subject matter. (Ati, 2006; Ati *et al*, 2007).

5.2.2 Farmers Perception of Rainfall Trends

Results from the FGD and questionnaire survey, reports farmers perceiving changes in the trends of rainfall in terms of intensity, duration and general variability (table 4.3). the farmers believe that rainfall in recent time is increasing in amount, untimely and heavier within a short time as compare to decades back i.e. amount of rainfall seems to be increasing in the area). This is at variance with Ashutosh, 2010, but in agreement with Rahman *et al* 2011. Although, no major shift has been reported in the rainfall regime in the area, but farmers perception indicated alternative rainfall (i.e. one year good or timely onset, and the next year late or delayed onset). The local farmers believed that the rain season in recent time last till about September and October due to delay in the onset of the monsoon rains. This is not too friendly to most grain crops of the area.

Water related impacts of climate change is likely the most critical for farmers in the Kano area. The effect of increased flooding resulting from climate change (particularly in Kura LGA), is one of the greatest problems farmers face in the area. Among the effects of flood in the area are lost of farmland and crops, loss of life through drowning, loss of access roads in the rainy seasons, prevalence of pest and diseases and sustenance of stubborn weeds that often affects yields of crops.

In terms of awareness and perception, local farmers in the study area shared some experiences of climatic conditions, ecosystem function and process. While most of the farmers were not aware about changes in their local climate, they reported a better awareness of global climate change. Locally they understand mostly rainfall and temperature condition.

They were totally unaware about local climate change and its impacts. This complex may be largely due to the fact that much information on global climate change is made available to the farmers by international and national media than that of their immediate environment.

The implication of the above is that local efforts to adapt to climate change through adapt local or cultural practices such as: zero tillage, restricted tillage, controlled grazing and bush burning etc. may be hampered since the local dissemination of information on local changes is weak. Farmers in the area may not easily adopt to cultural practices that can mitigate climate change.

5.3 Local Farmer's General Climate Change Perception in the Study Area

Based on scientific and empirical analysis, climate change is a reality that is already affecting many sectors of our national development. Unless adaptation strategies are implemented, climate change poses a serious threat to sustainable development and may become a substantive shock to Nigeria's effort to achieve the objective of the vision 20:2020 and also the attainment of the Millennium Development Goals (MDGs). The importance of additional scientific research for improved understanding of the intricacies in the complex environmental interactions that are producing climate change effects, as well as the imperative for appropriate policy initiatives to address the phenomenon are needed now than any time in the study area for an all encompassing effort to mitigate its negative impacts.

Local farmers in the area are to some extent aware of changes in climatic conditions and the impacts of these changes on their environment (especially from the results of the FGD and interviews). This finding in the Kano area is similar to earlier works of Murphy and Timbal, 2008; de Jonge, 2010.

Farmers perception on the impacts of climate change are related with their awareness of climatic conditions in the area. For example, if a farmer is aware of the impacts of climate

change due to global warming, it is also possible that this farmer is aware of the impacts climate change may have. Such perception is influenced as well by the age, length of stay in the community, etc. of the farmer. Older farmers were found to have more experience with the natural variability and consider the changes in climatic conditions as part of natural variability. Hence, it is important to take away farmers doubt about the occurrence of climate change, for example, by providing them with more reliable information about climate change and the associated impacts.

In terms of farming, the monsoon rain is the most important seasonal phenomenon for rainfed agriculture in the study area especially for upland farmlands. Major food crops such as maize, millet, groundnut etc. grown in the summer (rainy season) depend largely on annual precipitation. One of the most significant observation in the rains by the farmers is a recent trends towards delayed onset of the rains, noticed in the last 3 to 6 years. The Local Farmers also noticed increasing number of dry spell days during the monsoon period (7-12 days), damaging crops and increasing cost of farming in the area. Linked with this, is the perception that the dry season is getting longer and hotter and more severe compared to the past. For example, compared to 2007 to 2010 season, the monsoon rains in 2011 started a little bit late with much dry spells.

Perception regarding hailstorms in Bichi and Shanono LGAs, is that strong winds appeared to be more frequent in the rainy seasons. Windstorms were seem as the greatest weather-related hazards by farmers in the area. The storms are particularly destructive to crops (maize and millet particularly mentioned), in the area (this finding agree with Macchi *et al* 2010). Farmers in Bichi and Shanono believed storms are increasing compared to the past, causing increasing damaged to property and crops. The storms generally starts in July/August and are extremely unpredictable, intense and frequent.

"At this period almost every village in the area experienced this as the greatest threat to farmers", said one of the farmers at the FGD in Bichi, 2011."

Perception regarding temperature changes in the studied villages were mixed; although most of the respondents have noticed a warmer summer (rainy season) and winter (harmattan season) in recent time, an increased variability in temperature is perceived especially by farmers in Bichi, Shanono, Albasu and Sumaila. There was also a general feeling that temperature is moving from regular pattern, but the changes is hard to pinpoint compared to changes in rainfall pattern. According to one respondents in the FGD in Albasu, "food will spoil in lesser days (2-3 days) now compared to the past" in the heat period. "Mosquito incidence appeared to be more now than previously and even during the cold months", claimed another respondents in Bichi LGA. The issue of mosquito problem may be due in part to human activity that encourages stagnant waters, and other dirt in the environment and not completely climate change.

Apart from climate change problems related to water and precipitation, farmers were also concerned about the increase in field pests and diseases. With most of the crops already negatively affected by recent changing weather, the increased incidence of pests and diseases have exacerbated the food insecurity situations of the state. Not only had there been a significant increase in known diseases and pest, but newer infestations are been observed. Cases of "blight", "grub", "black beetle" etc. are common infesting host crops and other crops. Although, there is strong believe linking climate change in the area to pest and disease problems of field crops, some of the farmers also linked the unprecedented incidence of crop pest with monoculture crops and increasing use of chemical fertilizers.

The findings of this study are based on perceptions of local farmers in kano and their experiences in recent times as compared to what it used to be in some generations ago.

5.4 Awareness and Perception of Local Farmers on Climate Change and their on-farm practices

Climate variation worry peasant farmers in the study area on daily basis. They respond differently to its impacts based on their income, level of awareness and perception or conceptualization (this agrees with Diggs, 1991, West *et al*, 2007).

5.4.1 Farmers Traditional On-farm Adaptation Strategies to Mitigate Climate Change Impacts in the Study Area

As stated earlier, in response to the impacts associated with climate change and variability, farmers in the study area employed different adaptation measures on the farm. Some of these observed measures are discussed below.

5.4.1.1 Soil Management and Tillage Practices as a Result of Climate Change

As a result of climate change extremes in the study area, especially in the selected LGAs in the drier northern part of the study area, farmers are said to ensure proper timing of different farming activities to minimize crop failure that may occur from prolong dry spell or sudden ceasation of the rains. Land preparation are delayed in recent time till the first rains, to avoid competition for labour during the peak period which normally occurs after the onset of the rains. Some of the farmers bury crop residues in the field so as to replenish the fertility of the soil and sequesters carbon. While others burn the residues to enhance quick release of nutrients. This finding agrees with Sakala, (1998); Majule, (1999); and Majule, (2009). Furthermore, farmers in the area burn residues to ease cultivation and also as a way of controlling new crop pest and diseases in the area as a result of the changing climate.

Farmers in the area classify soils locally by using colour, texture, natural fertility, depth moisture conditions of the soil on the farm through day to day experience. Based on their on farm categorization (may not be 100% correct), farmers select crops and determine planting dates to match different soils of the area. For example, it was reported by field officers of KNARDA that farmers plant millet and groundnut, on contours ridge, while maize is planted on flat area. The contour ridges are used as a strategy to minimize soil erosion and to encourage better root penetration and enhance soil moisture conservations. In this case, such tillage practice tends to improve infiltration rates of water and thereby reducing surface run off associated with short but heavy rains which are usually common in recent times in the area. This finding is linked with the findings of Mahoo *et al* (2007).

5.4.1.2 Staggered Seed Crop Planting:

In all the LGAs, it was observed that some of the farmers in attempting to overcome rainfall variability impacts use more than one plot for cultivation of a particular crop type. To avoid loss of crop risk, due to prolonged dry spells and drought. Staggered planting of seed crop is common to most of the farmers, whereby crops are planted before the onset on uncultivated plots. Others were planted immediately after the rain, while still a few plots are planted a few days after the first rains. Tilling of the land commences in fields which were planted prior to cultivation on the 2nd or 3rd week after the onset of the rain. By this, early germinating weeds are destroyed and weeding activity is also destroyed. This activity were done purely to distribute risk by ensuring that rain was utilized to the maximum. This agrees with Liwengai, 2003.

5.4.1.3 Crop Diversification

Mixed cropping or multiple cropping involves growing two or more crops proximity in the same field. Although majority of the farmers attested to this practice in the study area,

where cereals (maize, sorghum, millet), legumes (beans) and nuts (groundnuts) are intercropped. From discussion with KNARDA field officers and farmers in the area, it was noted that local farmers in the study area have wide field knowledge from experience on merits of such mixed cropping with varying attributes in terms of maturity period (maize and beans), drought tolerance (maize and sorghum), and even end use of the products. The study shows that farmers do such diversification of crop types as a means of spreading climate change risk on the farm. This is similar to the findings of Orinidi and Erikson, (2005); Adjer *et al*, (2003); Mary and Majule, (2009). Crop diversification do serve as insurance against rainfall variability.

5.4.1.4 Irrigation/Fadama Farming

In response to prolonged dry spells and drought farmers in the area resort to irrigation/fadama farming where available). Many of the respondents (67%) indicated that dry season or irrigation farming is less risky than the rainfed agriculture. Challenges of this period is mainly access to pumping machines, higher cost of fertilizer and transportation since market is not readily available for their products (i.e. agricultural products).

5.4.1.5 On-Farmer Seed Selection

Farmers in the area in an attempt to avoid risk of total failure do seed selection on farm at the point of harvest. Seed selection for the coming season is done on the farm before harvest. Well developed heads of millet and sorghum are selected on the farm and preserved for the next season. The most critical factor considered by the farmers is the health of the crop and the crop tolerance to extreme climate events as prolonged drought.

5.4.1.6 Delayed Land Preparation

Farmers in the area attested to the fact that preparation of land is now with much adjustment depending on observed wind of the time. Land clearance used to be carried out in April before the rain. But in recent times this is shifted to late May and with much care because of the rainfall variability. The rains now are said to be more stormy and torrential, that often causes soil erosion if the land is completely cleared bared. To avoid this, farmers wait until first weeding stage (i.e. third on forth week after the onset). This is because the old stalks, grasses and shrubs will help to reduce wind erosion during delayed onsets and sheet erosion during heavy down pours of the early rains.

A total of about 14 (fourteen) traditional on farm adaptation strategies to cope with the changing climate where observed from the interviews that farmers in the area carry out to directly or indirectly ward off the impact of climate change in the area. These include:

i. Soil management
ii. Soil tillage practice
iii. Staggered seed crop planting
iv. Mixed cropping or crop diversification
v. Varied farmland clearance /preparation
vi. Adjusting planting date before the rain
vii. Cross ridging
viii. Intecropping
ix. Wider crop spacing
x. Dry season irrigation /fadama farming
xi. Thinning of crops
xii. Planting cover crops like melon and legumes to conserve soil moisture
xiii. Zero tillage so as not to expose the soil to loss of nutrients.

xiv. Early planting with the first rains onset

These traditional adaptation strategies can be grouped into six (6) broad groups: 4 groups according to Ariyo *et al* (1996) and extra 2 (two) groups (i.e. v & vii) by this present work, as follows:

(i) Techniques for conserving water

(ii) Techniques for preventing soil erosion

(iii) Techniques for labour saving

(iv) Techniques for risk minimizing

(v) Techniques for culshioning short term impacts of climate change

(vi) Techniques for strengthening neighborlineess or brotherhood tight and religious tied

5.5 Local Farmers Coping with Identified Climate Change Challenges in the Study Area

That the climate of Kano area is changing in most recent time is attested to both by the farmers and results of the meteorological data analyzed. The farmers identified various climate change challenges in their environment.

Climate related challenges are already having severe impacts on the people's daily livelihood, particularly those at the northern part and those without access to irrigation water for dry season farming (i.e. those highly depend on rainfed agriculture). Apart from identified climate change challenges identified in table 5.4, water scarcity or excess floods (during the rainy season), drastic reduction in agricultural yields increasing crop pest and diseases, etc. are some of the climate change challenges that farmers are facing in the area.

The farmers responsed in various ways to these challenges. For example, farmers' response to erratic rainfall pattern by adjusting planting or sowing date, and resowing if there is crop failure due to long dry spell or flood episodes (i.e. coping strategy). Adaptation

strategy to erratic rainfall include, use of improved seed that promised early maturity or increase yield (by those that can afford it), changing to crop that can withstand stress e.g. millet used to replaced rice after flood episode. In case of rising temperature, no much coping and adaptation strategy is employed. In few cases mulching of the ridges with grasses and maize or millet stalks are employed. Application of traditional methods such as scattering of ash, setting fires in the field to kill insect pest are some of the coping strategies used in times of pest and disease infestation. Other strategies include, crop rotation and planting of different crops in between season to limit pest infestation.

5.6 Climate Change Impacts and Vulnerable Groups in the Study Area

Closely linked to the identified climate change challenges, are the hazards posed to the local farmers by the climate events of erratic rainfall pattern, rising temperature, increasing incidence of pest and diseases, flood, drought etc. as a result of their low income status. Farmers in the area have very low income (see fig 4.8). The poor farmers excessive dependence on agriculture as source of livelihood predetermines their vulnerability. Literacy and their educational background are also vital in seeking other profession or income opportunities in an effort to adapt to changing climate condition. The income status of the farmers is grouped into 3: the rich, the medium rich and the poor (see table 4.10). Among the three (3) groups in the area, wage labour was seen as the only livelihood option apart from agriculture for the non-literate. The relationship between poverty and literacy is a vicious cycle in the area. The poor farmers do not have good access to higher education since they cannot afford the cost. In addition the poor farmers have the least access to financial institutions as well as to new skills, knowledge and other strategies for improving well being.

The lack of capital makes it difficult for the poor farmers to properly diversify their livelihoods. They do not have collateral for bank loan. Their main asset base was

landholdings. The lack of access of the rural poor farmers in the area to financial institution is a major constrain in tackling the impacts of climate change.

Wind storms and floods are a big hazards in most of the villages studied. They destroy maize, millet and sorghum in the field. The communities in the northern part of the state do not have access to river water (most streams dry up in the dry season) and were dependent more on rainfall. Most fields in the north are not irrigated, which limit production when rainfall did not arrive in the expected amounts at the expected time. New emerging weeds in fields are another hazards. Most farmers now, clear their field weeds 2-3 times before harvest. This is additional labour.

Although the government of Kano state provide free basic education, the rural poor farmers cannot always afford text books or school uniforms or the cost of loosing children labour. The low income of farmers in the area, limit their resilience and adaptive capacity, therefore making them more vulnerable to climate change.

5.7 Synergy of Meteorological Data and Farmers Perception of Seasonal Changes in Rainfall and Temperature in the Study Area.

The spatial and temporal variability of rainfall and temperature over Kano state may be partly due to its unique inland location or the dynamics of the ITCZ over the state within the year. The mean annual rainfall in the state indicates a significant spatial variation in recent time ranging from 124mm and 248mm in 1911 to 138mm and 246mm in 2010. Rainfall is the major climate parameter with the highest degree of spatial and temporal variability (see appendix 2). Kano has one major seasonal peak receiving the highest rain in June-August, when the entire country is experiencing maximum distance into the northern part of the ITCZ. The spatial distribution of rainfall, shows an increase in yearly total in recent years (10-15 years).

Trends in the distribution of rainfall variability from 1911 to 2010 in the state indicate a significant variation in the mean annual rainfall with an overall increase in recent annual total (see appendix 2) and appreciable change in annual temperature through the years. The results of records of rainfall and temperature shows a great agreement with the general perception of the weather condition over the state in recent years. While the data were not insitu (that is from the LGAs), the general records covering the State can be taken to be in line with the perception of the farmers in the LGAs (which is a strong indication of the reality on ground in the state).

5.8 Kano State Government Intervention in Tackling the Problem of Climate Change in the State

According to the result of the FGDs in almost all the LGA's with exception of Kura (where about 49.3% appreciate the state government efforts of tackling climate change events) it was noted that the issue of climate change has never been given the practical seriousness in the state. This was however refuted by about 67% of the KNARDA Field Officers who claimed much have been on going through their extension services to the farmers. About 76% of the respondents from all the local government FGD centres claimed that not much is being done by the government in managing climate change events in the state. Specifically they claimed such intervention is non-existent, slow and limited to very little economic compensations, which are not spread to affected communities and individuals. In Shanono LGA, it was highlighted by about 67% of the respondents that there were no new programmes or activities by the government apart from the normal ones of fertilizer distribution during planting season, seedling for farming, water supply for irrigation farming. Besides these, all other governmental programmes on climate change were said to be limited or non existing in the study area.

CHAPTER SIX: STUDY IMPLICATIONS

6.1 Introduction

This chapter presents the practical implication and contribution of this study to the body of knowledge. A model of perception and adaptation to climate change in a traditional farming community was developed.

6.2 Practical Implications of the Study

Based on the above findings in the study, a generalized model of perception and adaptation in a traditional farming community in dryland area of Kano state was constructed.

Fig.6.1 shows the linkages between changing climate in the community, farmers perceived causes and perceived impacts, mal-adaptation and planned adaptation for building resilience against impending impacts.

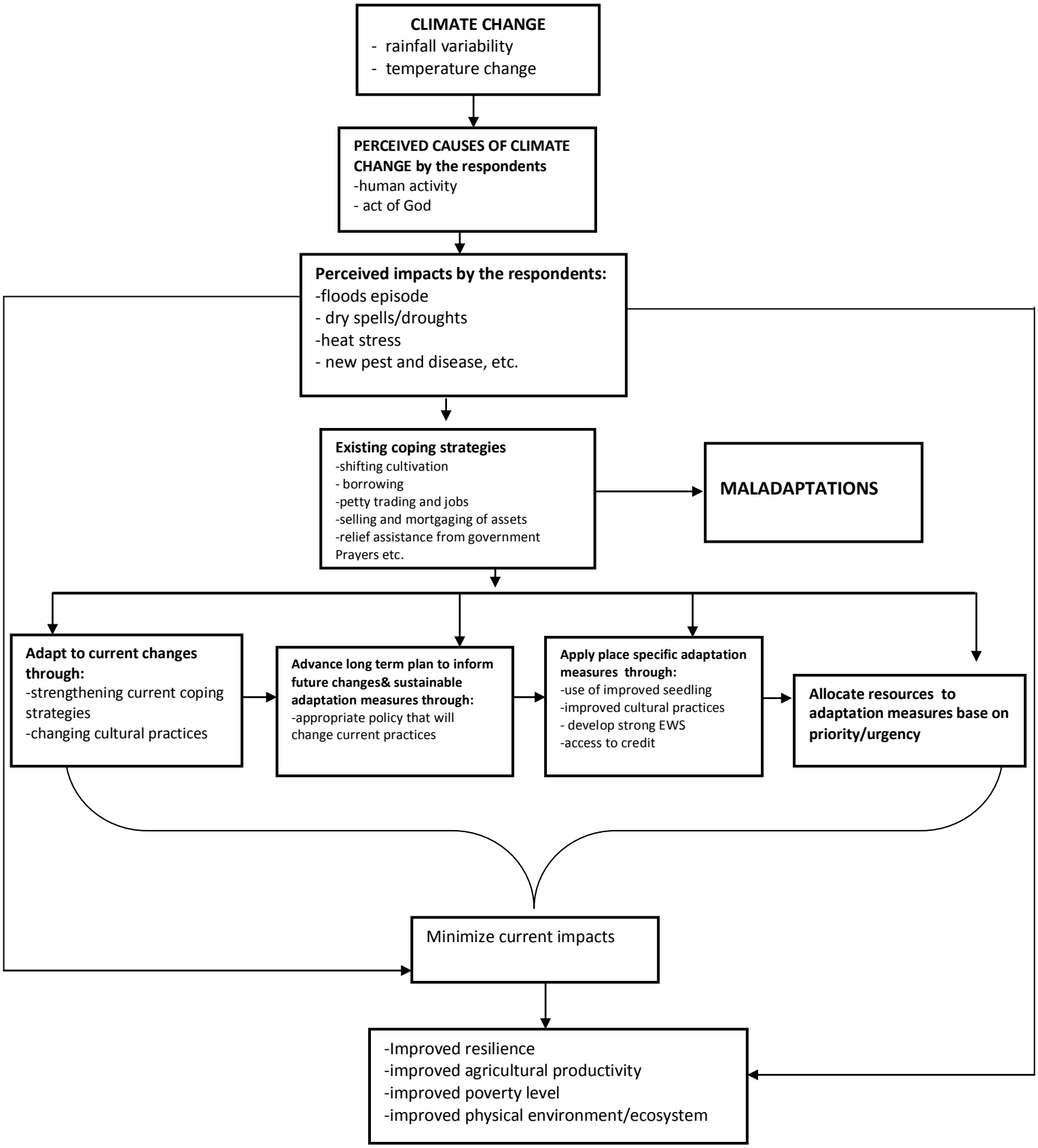


Fig. 6.1: A Model of Perception and Adaptation to Climate Change in a Traditional Farming Community

The model is build from emphasis on stakeholders participation and strengthening adaptive capacity. In this regard, the direct analysis of adaptation process start from the system of interest (i.e. what causes climate change in area), then assess its sensitivity (i.e. impacts in the area) and its adaptability to changes in the area (applying location specific adaptation measures) to build resilience and improved productivity of the farmers.

Perhaps the most important aspect of this model is its applicability to small varieties of scales: at regional level, to small community or state level.

It is such multi-facts levels of application that set this model apart from the conventional ones that are based on large scale climate change scenarios often used by Americans and European researchers.

This model is developed from the experience of individual local farmers using a bottom-top approach in a traditional African farming community. Thus when compared to this generalized model, conventional adaptation models are inadequate the following aspects: Firstly, they are built out of assumptions of large scale climate change scenario, which hid within it vital indices of smaller area. Secondly, the smaller the region/ community becomes the less reliable are such model. Thirdly, most often, they adopt the top-bottom approach methodology and do not involve participation of the farmers and other stakeholders at the bottom or/local level.

Step 1: Where climate change is identified, the first step is to identify possible short-term coping strategies to the impending climate change i.e. retrospective measures. For example, in the study area such coping strategies may include: borrowing from relatives, petty trading, use of chemical fertilizer to tackle crop performance and pesticides and herbicides to handle emerging pest and weeds, government intervention in terms of relief assistance and supply of basic home needs to alleviate needs, alteration of agric calendar, repeat sowing of failed crop or replacement after failure, building side drains to divert water during strong storms or

floods etc. in terms of erratic rainfall, floods, etc. application of traditional pest management strategies such as scattering of ash, cow dung, setting minor fire on the farm to kill insects (especially at night), increased use of chemical pesticides etc.

Step 2: Following the above short term coping strategies (retrospective measure) must be a well planned information dissemination system and planned strategies that are more prospective and implemented with external assistance (government policy, financial institutions, NGOs etc) this will include strong political will to create enabling polices, financial, human and technological resources, including reliable information and knowledge. Presently the few planned intervention in the area are single sporadic activities, inaccessible to individual farmers and too small to reach critical mass of the peoples. A good early warning system should be put in place to help in preparation for climate change.

Step 3: Linked to A2 (step 2 above) should be a well researched location specific adaptation measures that harmonize modern and existing adaptation techniques in the area. For example, in terms of erratic rainfall, planned adaptation may include: change to crop varieties that can cope with water and temperature stress, build canals and ponds to harvest the rain water during the rainy season and irrigate during the dry season, introduction and use of improved seeds that can mature early, promised high yield even under water stress (dry condition), cultivating vegetables off-season etc. In terms of pest and disease infestation, planned adaptation may include: practicing of crop rotation and planting of different crops every season to limit rate of infestation, promotion of organic pest control practices etc. In terms of increasing temperature planned adaptation measures may include: introduction of crop species that can withstand temperature and water stress, cultivating more than one crop per year. In terms of wind storm, planned adaptation in the area should include: mixed cropping (e.g. beans with maize) to protect the maize plant from wind, use of plant variety with lower stalks, etc.

Step 4: Strategy for adaptation mechanism will require micro level intervention on a case to case basis. This could be a tedious process but is possible through targeted policies that allocate adequate resources and generate appropriate capacity. Scientific enquiry should take place in collaboration with communities using participatory approaches like action research that builds on traditional practices. Such an approach is not only cost effective but also found to be most effective. Involvement of local farmers in the state for seeking solutions to improving their traditional practices and livelihood system must be a prerequisite for every intervention that support adaptation.

In terms of policy implications, it appears that improved farmer education would do most to hasten adaptation in the study area. Similarly, the provision of free extension services to a larger number of the farmers, may also play a role in promoting adaptation. Also adaptation policy aim at integrating the farmers traditional or existing practices to modern techniques will be most effective in the area.

6.3 Adaptation and Coping Strategies to Climate Change in the Dry Land Kano

In the Kano area, many of the observed responses to climate change were more of short term coping strategies rather than long-term adaptation measures. For example, in almost all the sampled villages in the LGAs in the state, most mitigating activity include shifts in the agricultural calendar in response to varying rainfall regime, (onset and cessation), resowing after an early season failure due to long dry spell regime, use of field crops as hay or fodder for livestock, borrowing money and selling assets, migrating to the urban center for causal works such as Okada business, and other menial labour work etc.

Many of these coping strategies may deplete the farmers assets base in the long run and may render them more vulnerable if the shocks (climate shocks) persist or reoccurs. Adaptation strategies are long-term and sustainable. In the study area, few of these exist among few number of the farmers. These include: use of hybrid crops, maintaining multiple cropping

systems, growing more than one crop per year especially in Kura where irrigation activity is higher and farmers with Fadama opportunities, construction of water harvesting system (very few in Bichi, Shanono and Albasu; new technology being promoted by KNARDA), livelihood diversification such as off season trading, livestock farming etc.). In order to increase the resilience of dryland farmers in the Kano area, appropriate long-term strategies that is location specific need to be researched into. Such long-term strategies must build on the farmers traditional knowledge, rather than focusing on short-term responses which may reinforce vulnerability in the long-term.

6.3.1 Local Farmers' Mal-Adaptation Responses to Climate Change in the Study Area.

Climate-related changes are already having severe impacts on the people of the study area, particularly, those that are highly dependent on rainfed agriculture (with some exception with irrigation options in Kura).

Water scarcity –especially in zone 3 of the state food security zone or over abundance during flood, drastic reductions in agricultural yields, increase in crop pests and disease, health issues –malaria, meningitis, etc. are some of the challenges that rural farmers in kano are facing, this is similar to earlier findings by Agrawal and Pernin, 2009; Adger *et al*, 2003; Brook and Adger, 2005).

Although more adaptive on-farmer strategies are listed in the area, rural farmers in the Kano area used coping strategies much more frequently than adaptive strategies. Strategies such altering planting date, using of stalks of failed crops as fodders, off season migration to urban town in search of menial labour, are mostly restropective strategies, employed on a year-in-year out basis depending on the actual weather events. Strategies such as re-sowing after an early planting failure, borrowing of money or selling of assets base may render the

farmer more vulnerable as they depletes their asset base. Such practices which is common in the area are MAL-ADAPTATION.

Planned responses to climate change strategies that are mostly prospective and implemented with external assistance, mostly from local or international institutions, and requiring resources (financial, human and technological, including information and knowledge) are not common in the study area. Rather, planned interventions in the study area were, mostly single sporadic activities (e.g. relief from the government during floods or severe droughts) which are often not accessible to the farmers and too small to reach the critical mass (poor farmers).

The sustainability of the identified response strategies and their potential to increase farmers resilience in the study area are presently unknown, as they will depend on the extent and direction of the change that will occur.

Good practices from the different LGAs, effective in limiting damage(s) caused by changing weather pattern year-in-year out, need to be researched in order to provide farmers with as many response options as possible.

In the study area, there are some local coping and adaptation strategies adopted in response to observed risk and hazards related to climate. Most of the coping and adaptation activities were found to be event specific based on local knowledge and weak, innovations, because most of the farmers were not aware about actual impacts of climate change on their immediate environment e.g. majority of the farmers in Kura, Shanono and Albasu are practicing vegetable farming instead of cereal and grain crops as crop diversification and some other off farm activities to earn more income. Changes of local natural seeds to improved or hybrid seeds has resulted to loss of local races. This may become vulnerable in the long-run for crop failure in the context of climate change, since the hybrid seed require more fertilizer input which are not within the economic power of the farmers.

The present trend of changing varieties of crops and not protecting local races of crops, and seek short-term solutions borrowing money, selling assets, migrating to the city for menial job seeking etc is bad and a "Mal-adaptation". On the basis of this, it can be said that there is not any structured strategy in the study area solely focusing to adaptation to climate change. This may be due to lack of working organization(s) to explain all the causes and consequences of climate change to the local farmers.

6.3.2 Adapting to Erratic Rainfall Pattern in the Kano Area

In response to erratic rainfall patterns, farmers in the study area, were observed to adjust their agricultural activity often, by delaying or advancing the sowing or planting date of crops in the areas, especially with crops that depends much on the monsoon. For example, when there was an early planting failure due to long dry spells or inadequate rainfall farmers that could afford a second batch of seeds either re-sowed or planted the crop or replace it. For example, rice was often replaced with soyabean in Kura- especially among farmers within the plain, maize with soyabean or vegetables e.g. pepper, tomatoes etc. among most farmers across the state.

Maize and other crops that do not do well are used as fodders. Farmers plant late millet with the hope of having some yields and use the stalk if there is none. Mulching is a traditional way of spreading organic fertilizer compound of dung, leaves and grass over fields to increase soil much and nutrition to the soil.

In order to address the problem of reduced soil moisture, farmers do ploughed the fertilizer into the soil immediately after dispersing. They sometime covered millet seedlings with mulch to prevent them from drying up or dampened maize seed before sowing.

6.3.3 Adapting to Rising Temperature Condition in Kano Area

Changing temperature conditions is one of the identified climate change challenge by the farmers in the Kano area. Rising temperature is a concern to farmers in the area as touching heat waves or scorch that normally accompany rising temperature. As a result of rising temperature some fruits and groundnuts are found to mature faster in the area. This makes some of the crops to be harvested before their normal time. The present shortened growing season now do not allow for more crop cycles per year compare to five (5) to ten (10) years back.

6.3.4 Adapting to Pests and Disease due to Climate Change in the Study Area

Emerging pests and disease is one of the identified climate change challenge in the study area. The farmers observed that in recent time more crops play host to single insect pest species compare to the past. Traditionally, ash, cow urine and salt spray do serve as effective pesticides. But now, their effectiveness appear to be decreasing as evidenced by increase in field pest" Shehu Mai Alubosa, Kura LGA FGD 2011, "in those days, traditional methods of pest control like spraying of salt or ash were effective in controlling the pest, but now, it is no longer so, because of increase in pest infestation, such method has become less effective" FGD, 2011. Use of chemical pesticide, is costly and its effectiveness in the long-run is less, according to some of the farmers.

6.3.5 Coping with Food Insecurity Resulting from Climate Change in Kano Area

Climate variability and change affected livelihoods of the local farmers mostly through impacts on food production. It is for this that the state is divided into three (3) food security zones to take measures based on a zones peculiarity and impacts. (though very little is being done by the state government). Majority of the individual farmers interacted with

throughout the zones cannot sustain their household throughout the year from their harvest. They supplement their income with Wage labour or by selling off of their livestock. Some of the farmers agreed that their harvest had decreased drastically in recent years due to lack of or untimely rainfall. Although farmers in Kura LGA (especially those with access to irrigation opportunity) claimed that their harvest have increased over the years (thanks to chemical fertilizer and irrigation services in the area), most of the farmers are experiencing low or poor harvest in the state.

When the supplement efforts mentioned above is not sufficient, the farmers took to loans from money lenders in the community, grain merchants who buy their farm products, selling off of assets ranging from livestock to property. Unfortunately this activity of the farmers reinforces the cycle of poverty in the area, as it reduces future livelihood opportunity.

6.3.6 Religious Coping and Adaptation Mechanism Against Climate Change in the Study Area.

Praying for divine intervention was one of the most common coping strategy reported by some of the farmers interacted with in the area against climate abnormality. Most farmers in the area felt completely helpless when there is delay in the onsets of the rain or sudden unusual dry spell or unusual infestation of pest in the field. The farmers consult their malam for prayers and even the entire community may gather at a selected spot for prayers led by the elders of the village/community. Majority of the farmers especially the older ones claimed to have God intervention in bringing the rains or stopping pest infection after such prayers. Similar findings have been reported elsewhere (Donner, 2007; Salick, 2009; Leduc, 2007).

Believing in higher spiritual being plays an important role in determining whether people believe that human action can influence the climate or weather.

The implication of beliefs in higher power being responsible for weather extremes (and any possible changes therein) is that, people or governments are not perceived as having any control , influence or responsibility for that which is in God's hands. Particularly if climatic change is interpreted as God teaching a lesson or punishing sinners, public acceptance of climate policy may be undermined.

Regardless of people's awareness and understanding of climate change, farmers in the Kano area recognize to some extent that their climate is changing and that those changes such as; erratic and insufficient rainfall (especially at the northern part of the state), failed or poor harvest, etc. are profoundly affecting their lives. Some of the farmers explained that God alone has the power to change the weather. This "GOD FRAME" leaves little if any room for human activity as a cause, and therefore for a role of them (the farmer) or any other humans in mitigating climate changes in the area.

The pervasiveness of such version of the "GOD FRAME" across the state has important implications for public engagement and policy development.

(i) the impacts of a changing climate can be viewed as punishment for people's sin or purely nature (act of God) and

(ii) there is nothing one can do but cope.

6.4 Climate Fluctuation and Management of Selected Crops in the Study Area

The management of selected crops in the study area by farmers in the face of climate fluctuations within the year is presented in table 6.1

Table 6.1: Management of Selected Crops in the Study Area in Face Of Climate Change

Farming operations	Maize	Bull rush millet and sorghum	Finger millet	Groundnut
Planting time	Shifting from March to early May	Shift from March to early May	Now, more after establishing the onset of the rains	Shifted from March to late May
Planting methods	Shift from broadcasting to staggererd planting and wide spacing	Same as maize in most cases	Same as maize in most cases	No much change in planting method
Changing crop and crop variety	Use less of local and more of improved variety	Use of more of long and snow growing variety for sorghum. Use of the improved and local variety	Use of more of the local variety	Use of more of the improved variety seed
Pest and diseases incidence	Increasing cases of field pest hence use of more pesticides	Increased pest and diseases e.g. birds	Same as sorghum and millet	Increasing cases of rodents
Harvest time	Shifting from August/Sept to late Oct/Nov	Shifting from Sept to late Oct/Nov.	No much change	Insent the right time
Storage methods	Local storage facility to treated bags	Local storage facility to treated bags	Local storage facility to treated bags	Local storage facility to treated bags
Storage problems	Increased insect pest attack	Pest attack more on sorghum than millet	Not much compare to sorghum	Rats
Estimated harvest amount	A general decrease in recent time e.g. from about 15 or 12 bags to about 10 to 6 bags per hectare	Almost the same as maize i.e. relatively decreased	Relatively decreased	Relatively decreased

Source: Field Survey, 2011

According table 6.1, farmers have changed most of their cropping practices due to changes in rainfall pattern and amount over the last four decades. Planting methods for some crops such as maize, and sorghum have also changed from broad casting on flat land to row planting on ridges with recommended wider spacing. This is basically aimed to encouraging moisture conservation and reduce competition arising due to many plants per area. Another common practice is planting early and late maturing crop varieties (depending on the crop types) on the same area or plot. Implication of this is that, reduction in the length of the

growth period is likely to result in substitution of some crops species, e.g. maize maybe substitute by sorghum and millet since they are more suitable to drier conditions/ environment. This implies that climate change and variability might result into changes in plants and crops in certain agro-ecological zone to suit prevailing conditions. This finding is similar to that of Thorton *et al* (2007).

CHAPTER SEVEN: SUMMARY, CONCLUSION AND RECOMMENDATION

7.1 Introduction

This chapter presents the summary of findings from the study; conclusions and recommendation were drawn and made from the findings.

7.2 Summary of Findings

The following are the summary of major findings in the area by the present study:

i. Climate change is present in the area and farmers are experiencing its severe impacts

ii. The perception of climate change by the farmers are in line with results of meteorological data records. Statistical analysis of rainfall records for one hundred years shows great inter annual fluctuation in its amount and intensity, while temperature trend show an increase of between 1^{0c} and 2^{0c} .

iii. As a result of increasing temperature and rainfall variability, farmers seems to oscillate between new explanation (science) and traditional knowledge of predicting rainfall onsets and ceasation in planning agricultural calendar.

iv. Farmers awareness of climate change in their immediate environment seems to be limited compared to their awareness of global climate change. This is so because of their source of information on climate change (mostly from the international media-radio; e.g. BBC and national media). Awareness creation programme on climate change in the State does are not specifically targeted at the farmers and did not involve the farmers.

v. There are few existing coping and traditional adaptation measures in the area. Most of the adaptation measures in the area, strictly speaking, are short-term coping strategies. They are not planned, but are mostly response to climate change.

vi. Major source of climate change information in the study area are media and extension services provided by KNARDA officials.

vii. Some critical climate change challenges in the area include;

- Floods episodes especially in recent years
- Increase incidence of new pest and weeds. Most farmers now weed between 2-3 times
- Extreme heat stress due to increasing temperature
- Crop failure due to prolonged dry spells or drought condition.

viii. The elderly, disabled, women and children were perceived as most vulnerable groups in the study area.

ix. Farmers identified access to credit, labour (agro-labour), petty trading, livestock trading and austerity measures as coping mechanism for short-term changes.

x. In terms of local knowledge and climate perception, the following were observed:

- Local farmers in the area may not understand the science of climate change, but they rightly observe and feel its effects in their environment.
- Some of the local farmers, although admit to changes around them, attributed the changes (climate changes) to other factors rather than climate change e.g. the act of God.
- Though some of the respondents strongly agree that man has contributed to the current change and can help in solving the problem, others felt it was the act of God and nothing can be done to solve it, except prayers for God's mercy.

xi. Information dissemination on climate change in the state is poor and weak. There is need for a kind of community radio programme to enlighten the local farmers, and improve on the present inadequate climate information and information services.

xii. There is poor preparedness of the people for climate change, hence the high impacts of climate change on the farmers.

xiii. Some of the able bodied young men are migrating from the rural area

xiv. Although, some adaptive strategies are listed by the farmers in the area, the farmers used coping strategies much more frequent than adaptive strategies. For example, strategies such as shifting of the agricultural calendar or using stalks of failed crops as fodder are mostly retrospective strategies employed on a year-by-year basis depending on the actual climate or weather episode. Such strategies most often are only effective in the short-term, they can buffer the extreme loss of harvest but still result in decline in agricultural yield and lack the ability to prevent changes caused by persistent variability in the rainfall regime. Similarly, strategies such as resowing of crops after an early season failure (either due to dry spells etc.), borrowing of money or selling of assets may even render the farmers more vulnerable as it may deplete their assets base.

7.3 Conclusion

The major impact of climate change is felt among local rural farmers, especially those inhabiting the fragile ecosystems of the dryland. Such impacts manifest with severe implications of increased food insecurity, increased poverty levels, high disease level etc. It is therefore critical to understand and research the challenges facing these farmers.

This study examined farmers perception and adaptation to climate change using structured questionnaire survey data and meteorological data in the grain producing area of Kano state. Although the number of participated farmers is high, the result obtained by the study cannot be generalized beyond the sampled population (i.e. Kano state). The results however, provide insights on how farmers perceive adopting to climate change. In addition, the results justify that adaptation to climate change depends on the farmers perception of the impacts of climate change episodes. Poor farmers in the Kano area are not only faced with rapidly changing socio-economic conditions, they have also been coping to the best of their ability and resources with rainfall variability and temperature stresses resulting from climate variability and change. These stresses are expected to continue and increase, and the constant coping strategy will have consequences, eventually depleting the assets base of the farmers, if new planned adaptation measures are not taken. Young able bodied people in the area are disillusioned and most are trying to migrate to the urban if they can. Statistical analysis of temperature for forty (40) years over the state shows a trend of increasing temperature between 1^{0c} and 2^{0c}, especially in the transitional or heat period between the ceasation of the rains and the onset of the haramttan. The 100 (hundred) years rainfall data analyzed showed that rainfall in the area is characterized by inter annual variability with a substantial increase in monthly total and high erratic patterns, particularly in the last 5 – 10 years. The farmers perception of climatic variability in the area are in line with climatic data records analyzed. Indeed, farmers in the area were able to recognize that temperature is increasing and there has been a fluctuation in the volume of rainfall. Farmers with access to extension services provided by KNARDA are observed to perceive better changes in the climate because extension services provide information about climate and weather. Climate change impact were identified to contribute to decline in productivity and yield, emergence of new pest and weeds in the field, human diseases, etc. Having access to water for irrigation was observed to

increase resilience of farmers to climate variability, hence farmers in Kura seem to pay less attention to changes in rainfall pattern because of irrigation opportunities in the area.

Although, farmers in the area show some awareness of climate change, only few seem to take step to adjust their farming practices. There are few adaptation and coping strategies in the area, these include: change in cropping pattern, choice of crops, mixed cropping, altering agricultural calendar etc. There was limited awareness, knowledge and capacity at the farmers level to understand properly climate change scenarios, address issues, and conduct long-term planning.

As a way forward government of Kano state need to urgently put in place policies that will ensure farmers have access to affordable credit to enhance their ability and flexibility to change their production strategies in response to climate change in the area. Since access to water for irrigation increases farmers resilience to climate variability, irrigation investment programme of the state should be pursued vigorously to allow farmers across the state increase water control to counteract adverse impacts from rainfall variability and change. To promote efficient water use, emphasis should be on on-farm water harvesting.

7.4 Recommendation

Despite the challenges, there are possibility for addressing the problems that will arise as a result of climate change and assist the farmers in the area to adopt and mitigate the impacts of climate change in the area. On the above summarized findings and the entire work, the following are the proffered recommendation as a way forward.

(i). Raising of Farmers Awareness. According to Agrawal and Perin 2009, response to climate change can be retrospective or prospective. Most strategies currently in use in the study area were retrospective rather than prospective. This may be due to the fact that many of the farmers were not aware or unclear about the reason why weather patterns in

their area are changing. They therefore cannot anticipate climate-related risks. Many of them believe the changes were distance far and or simply an act of God. Since adaptive capacity is partly determined by knowledge (including local knowledge) and the awareness of climate change risks, it will be crucial to raise local farmers in the study area awareness of potential climate related risks, as well as appropriate mechanism to address such risk. It will also be necessary to raise similar awareness within the state and local government.

(ii). Create conducive policy that will enhance adaptive capacity of the farmers: given the high degree of uncertainty about how climate change may affect farmers, and rural people in dry land area, government policy intervention in the state should focus primarily on addressing the underlying causes of vulnerability of the people and the limited adaptive capacity of the farmers, including their high dependence on natural resources, persistent poverty, inadequate education and employment alternatives/opportunities. Such policy must be adapted to local content and integrated into broader long-term development plan at different scales. Strengthening local public and private institutions and raising awareness among them about climate related risk will be key, since local institutions play a major role in supporting or hindering communities in their process of adapting to change.

(iii). Improve on existing support service delivery mechanism. With exception of few communities (those that are easily accessible by KNARDA), communities in the Kano area generally lack adequate access to support service across the state (extension services, access to subsidized food, education, micro-credit institutions, off-farm income opportunities etc.). Even when these services did exist, they were often not responsive to the increasingly erratic weather patterns affecting farmers in the area. Therefore, there is a need to increase coverage and improve quality of and access to those services that are

responsive to climate change related risk. A special focus is also needed on disadvantage groups –poor farmers of very remote areas, aged men and women, children etc.

(iv). Seizing new climate change opportunities: climate change can and do have positive impacts that can be utilized for new opportunities of livelihood. For example in the Kano area, with rising temperature, the growing season will be lengthening, and certain crops will be maturing early, providing an additional cropping season that can help improve food security and provide high income (as observed in Kura irrigation farms where the farmers now have additional season in their farm business), planting cereal crops and vegetables at least twice a year. Similarly, the excessive rainfall provides much rain water during the short periods of the rain. This rain water can be harvested by the farmers on the farmer and used to irrigate their crops in the dry season. The change in climate should not be seen or associated with negative impacts alone, rather ways should be sought for capitalizing on emerging opportunities offered by the change in the area.

(v). Diversifying livelihood activity: Weather patterns in the Kano area is becoming more variable (especially in recent times) and difficult to differentiate between normal short-time fluctuations and long-term trends. Nevertheless, there is a clear indication from meteorological records that the variability in itself is increasing, and that changes are taking place in rainfall and temperature patterns, and that it is becoming more difficult to predict weather events that affects agriculture in the area. Hence, diversifying livelihoods and moving away from current over reliance on natural resources dependent activity will be unavoidable, and must be pursuit by the government.

(vi). Community assistance involvement; when there is a climate change episode, the community can be mobilize to help through;

a. **Self-help groups:** through the help of the government, such organised group can be form to start a kind of micro-credit activity, to help operate small scale activities such as poultry raising, vegetable gardens, etc.

b. **Religious bodies assistance**. This is already existing in the area. They can be strengthen to extend helps to the needy when their crop fails.

(vii). Kano State does not have the necessary institutional infrastructure in place to mitigate disasters. It lacks coordination mechanism and adequate capacity to strongly implement and manage disaster. There is need for the reorganization and strengthening of government agencies in the state to monitor the onset of such disaster as droughts, floods, temperature scourge etc.

(viii). Kano State is water scarce and concerted effort is needed to preserve the little that is currently available by:

a. A scheme to harvest flood water and transfer it to areas with water deficiency should be developed and implemented. This will greatly improve the livelihoods of farmers in the area through provision of water for both domestic and livestock use during dry season.

b. Rain water harvesting strategies need to be developed and encouraged. This will provide water not only for domestic and livestock purposes, but also for productive use in irrigation agriculture, thus contributing to poverty alleviation effort of the state.

(ix). Recurrent droughts, dry spells, heat stress and change in soil moisture condition are identified critical climate change challenge in the state. Recommended adaptation and mitigation strategies during such hazards include:

a. Better land management/conservation farming using improved methods of land husbandry to better conserve soil water and the integrity of natural and managed ecosystem is needed.

b. Use of high yielding, drought tolerant or escaping crop varieties: drought resistant, modern seed varieties are very important to farmers in the area. While high-yielding varieties do presently exist for most crops cultivated in the area (maize, sorghum, millet, beans, cowpeas etc.) they are not widely adapted. The high cost of fertilizer required for the high-yielding varieties erode their profitability. To realize the potential of the zone, modern stress resistant varieties that respond well to small amount of external inputs are needed. Crops with short growing season will also be important as season variability is becoming more common. These varieties should be ensure to meet the local taste so that they be appeal to the farmers. The State Government should develop a long-term adaptation plan in this regards.

(x). Small credit; scheme can be created by the government through its MDG, NEED, poverty alleviation scheme, etc. to allow for farmers to borrow money for seeds and fertilizers in times of needs. This micro-loan programmes have taken off in recent years but are mainly focused on women groups and small businesses. A focus on agriculture is needed for crop production

(xi). Establishment of reliable data base generation system to provide real time monitoring of rainfall and temperature at local level is recommended. The data should be regularly updated to enable prompt recognition of anomalies well in advance taking into consideration drought cycles and the spatial and temporal variability of rainfall.

(xii). Kano state lacks a holistic climate change policy and strategy to prepare and manage climate change related issues and associated impacts. The existing efforts by government

agencies to manage impacts of natural disasters including recurrent floods and droughts such as giving relief assistance, are very short-term and concentrate on adhoc crisis response. It is therefore recommended that a strategy detailing the steps and actions to be undertaken to prepare both the Government and farmers in the state to withstand the impacts to climate change be developed. Such long-term strategy should articulate the role, responsibility, coordinations and networking and participation of all stakeholders

7.5 Future Research Areas

- To conduct a more extensive research of this nature covering the country on people's perception and to support it with strong empirical data.
- To strengthen people's awareness and assist in their capacity building for better alternative means in tackling change impacts.
- To assess and recognize ecological problems as it links with climate change issues.

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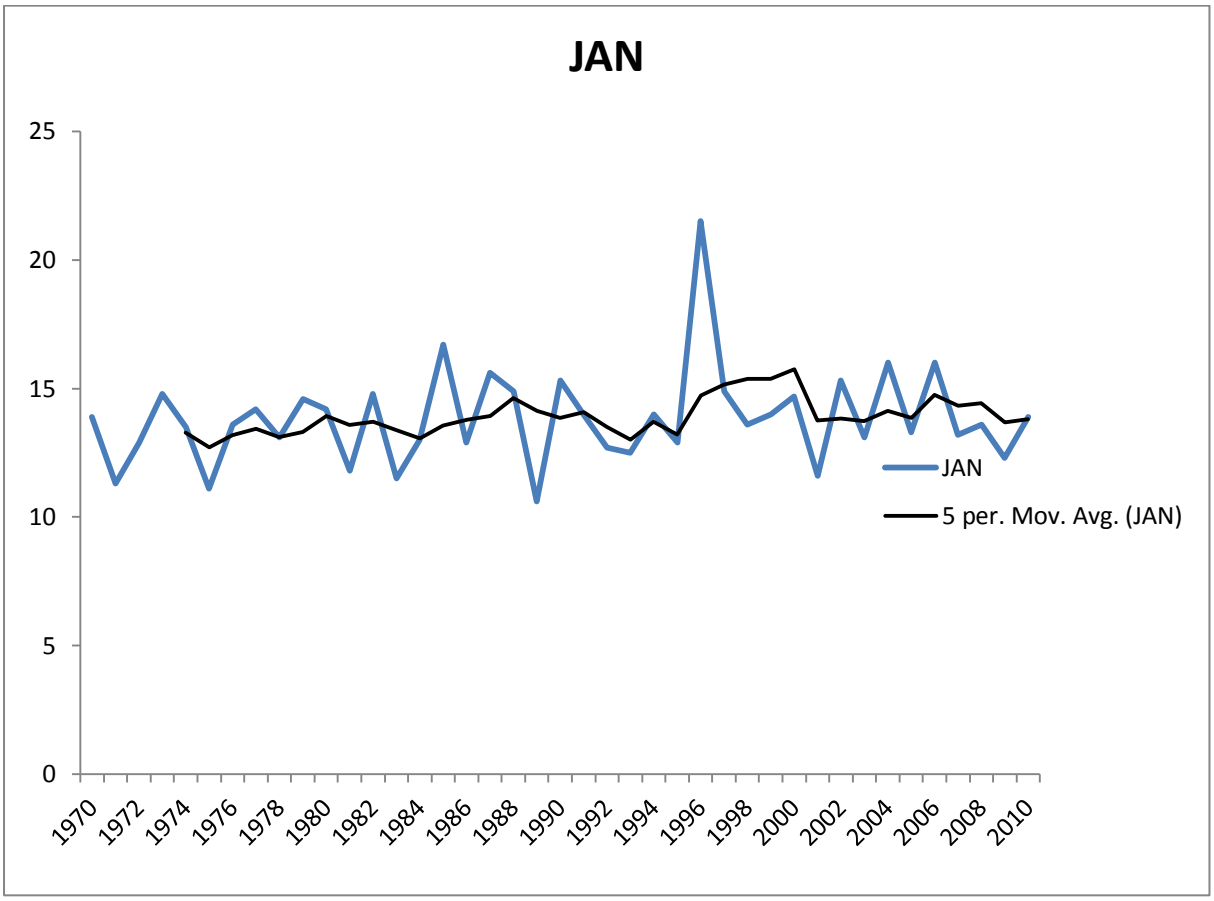
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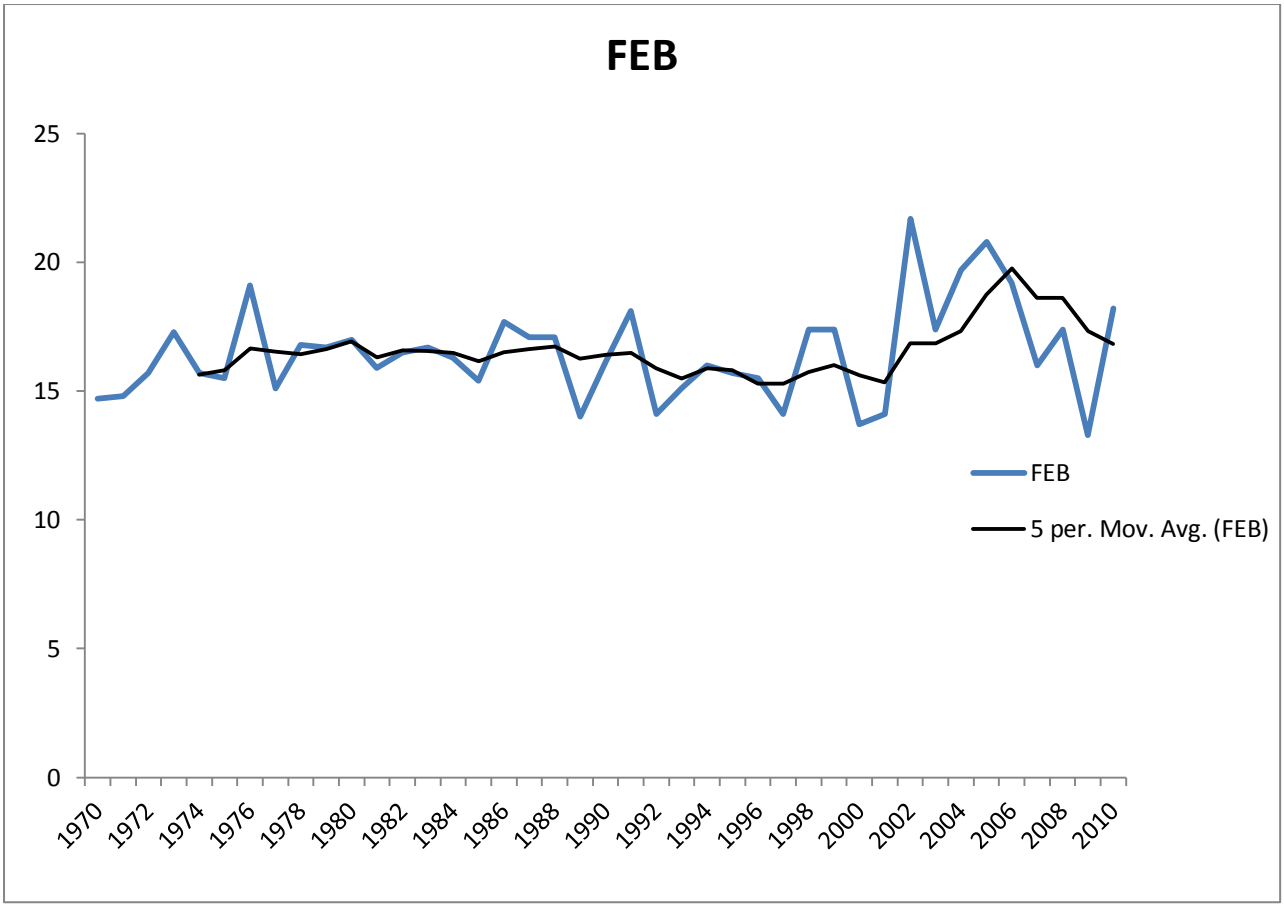
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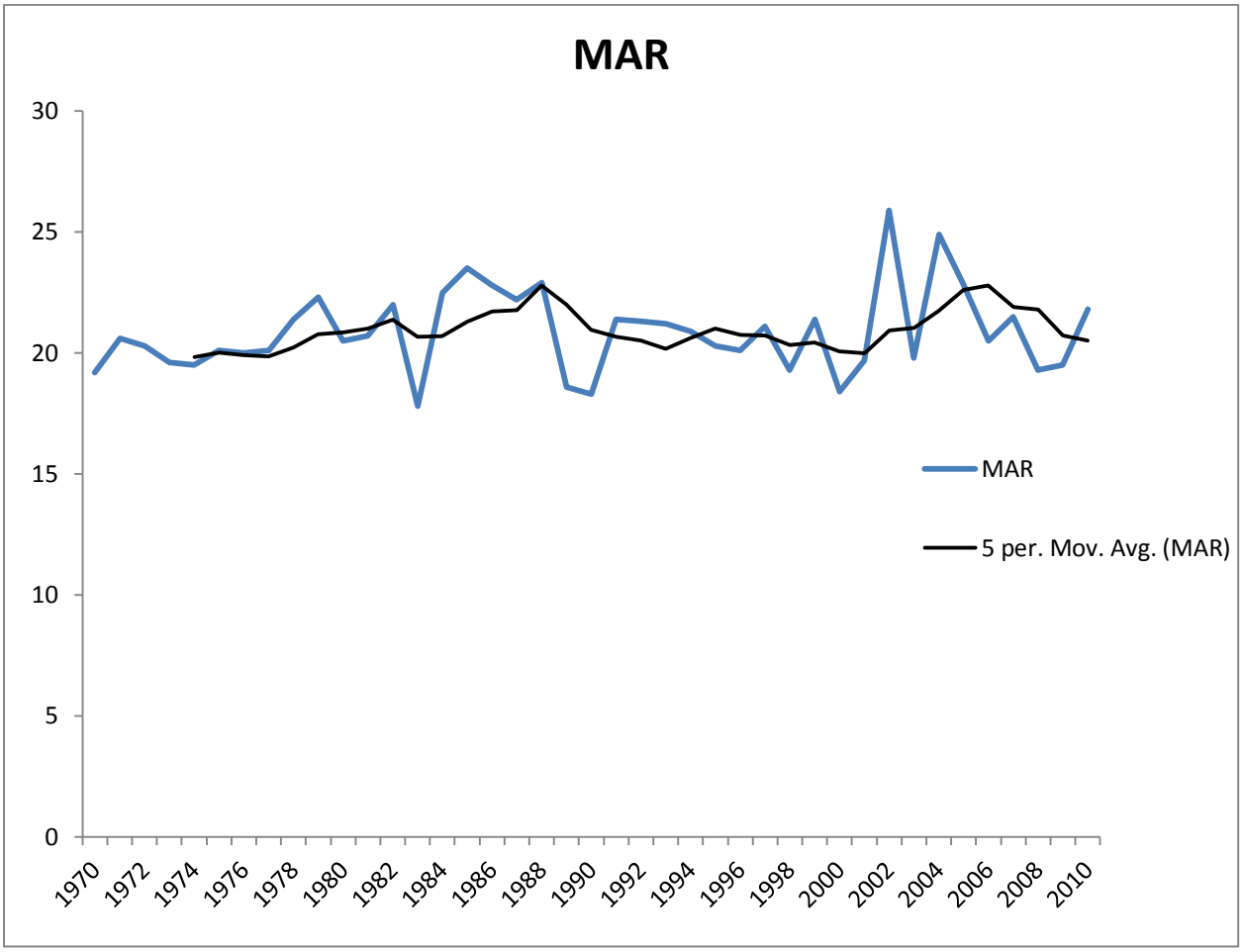
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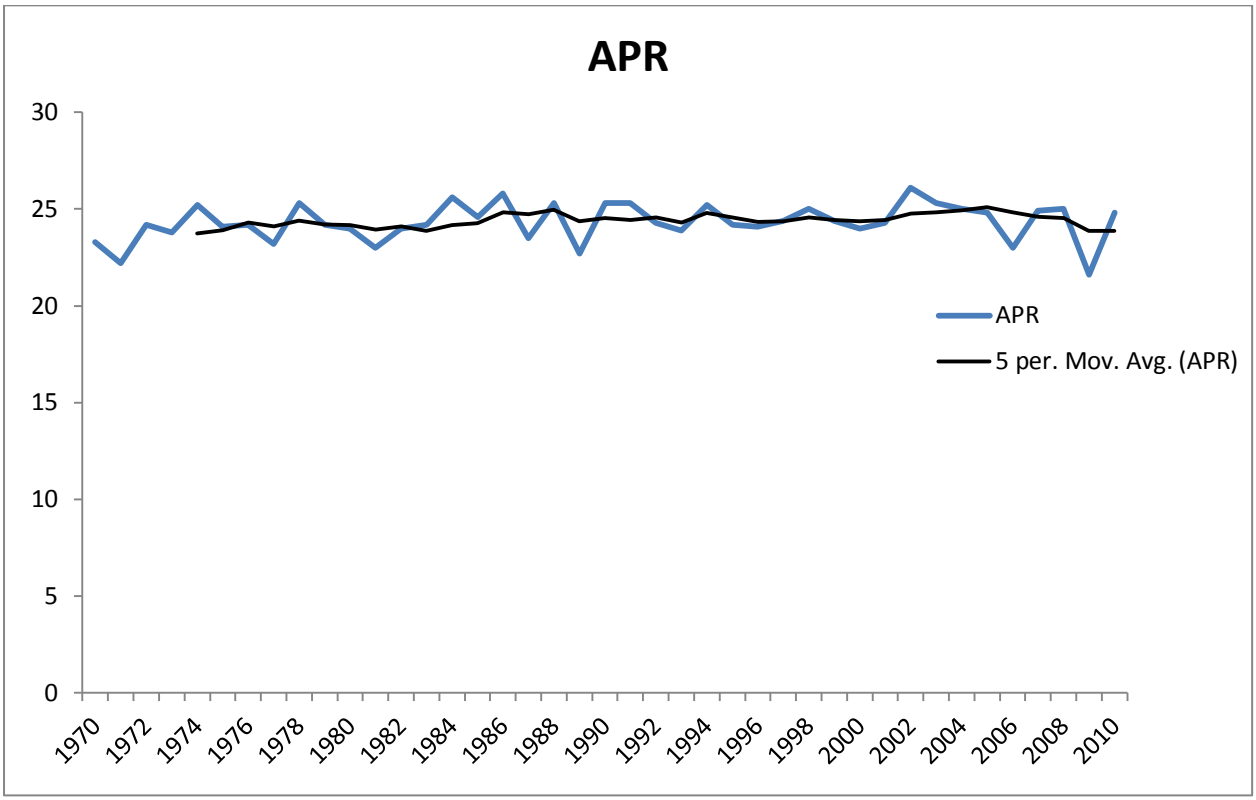
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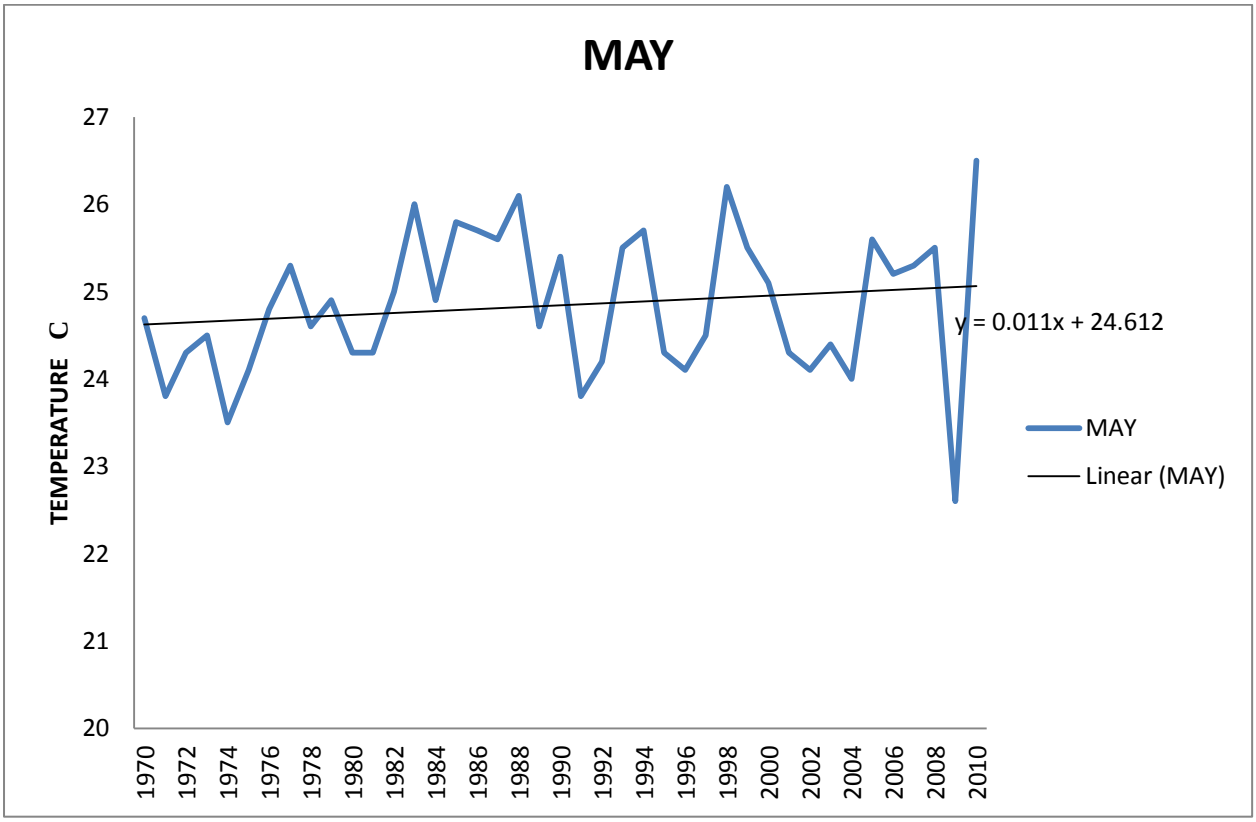
APPENDIX 1: Graph of Temperature trends over the study areas (Jan –Dec).

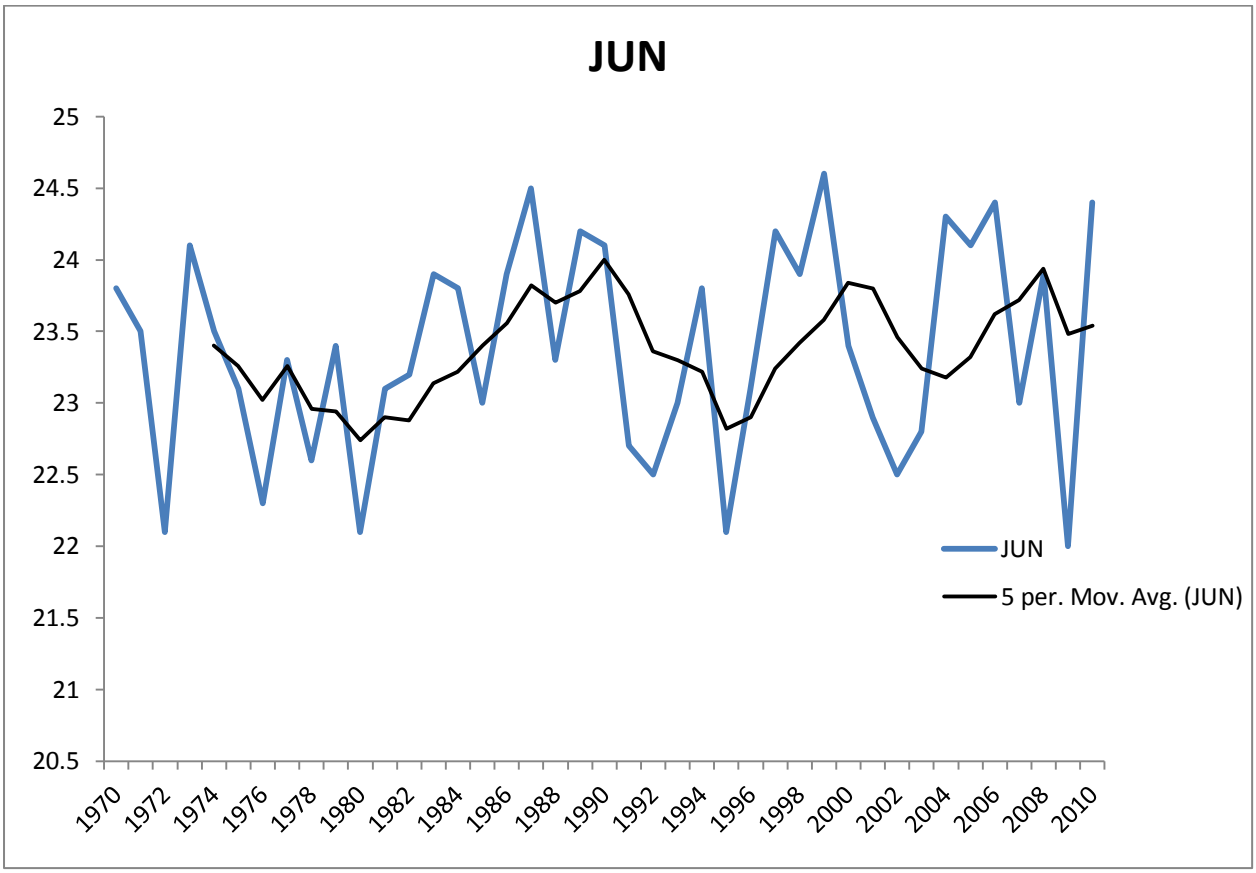


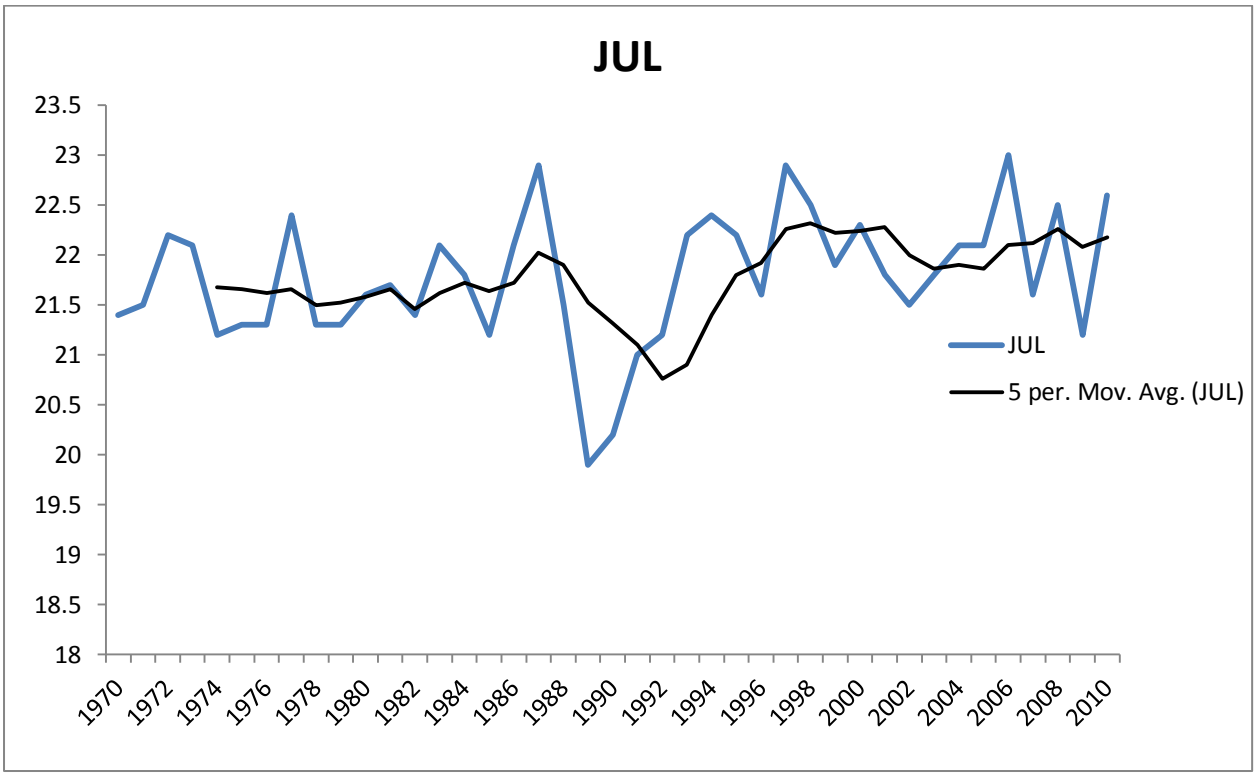

FEB
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2000
2002
2004
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2008
2010
FEB
5 per. Mov. Avg. (FEB)

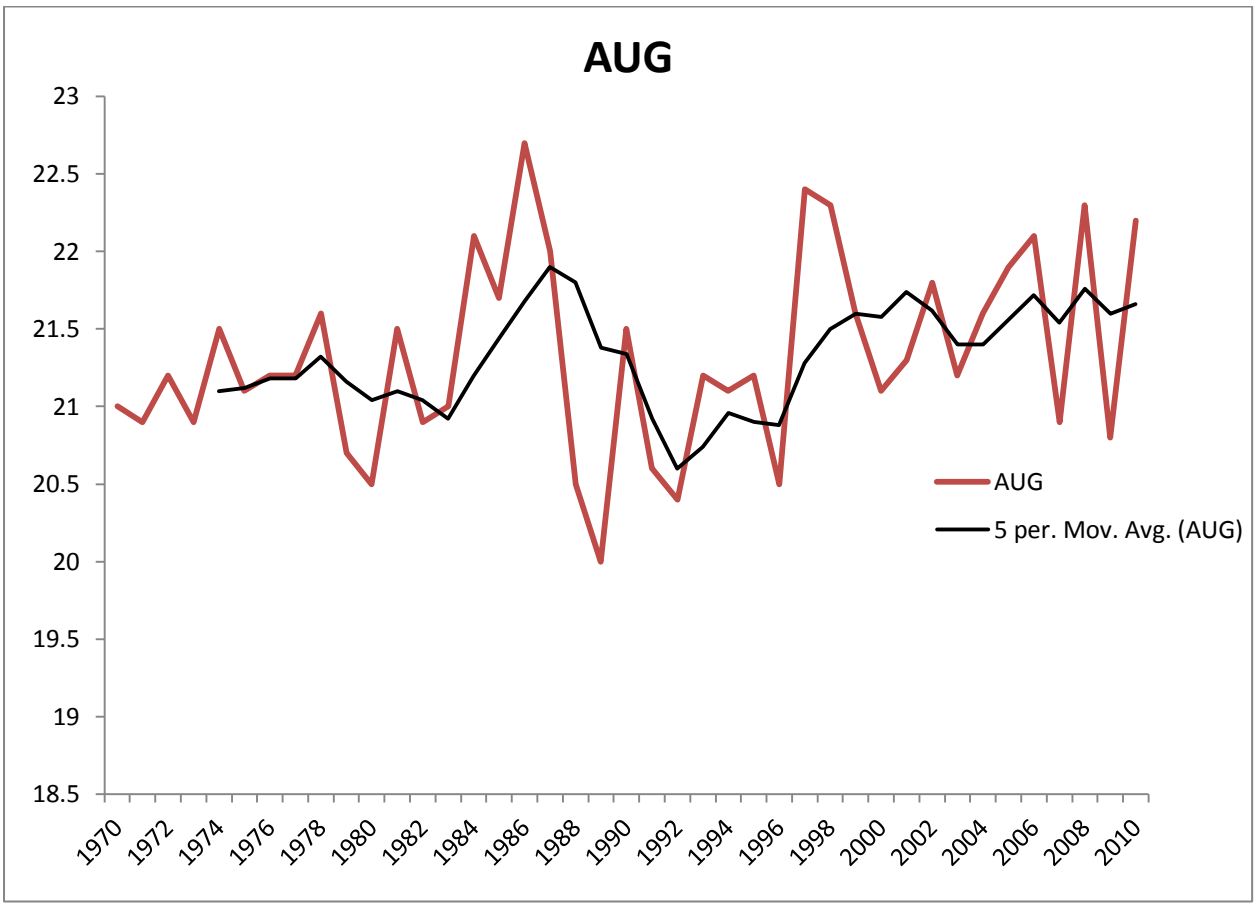

MAR
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2006
2008
2010
MAR
5 per. Mov. Avg. (MAR)

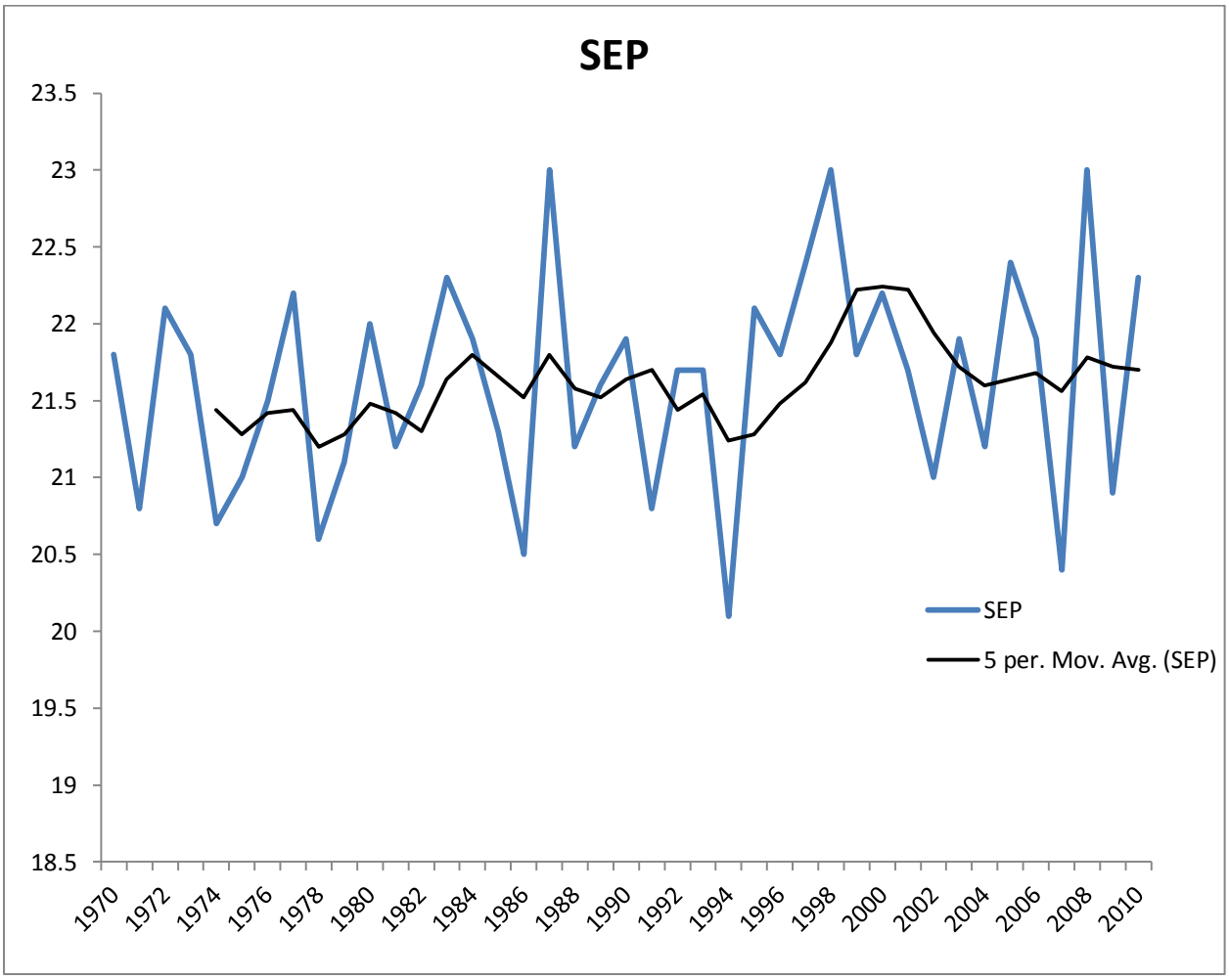

APR
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APR
5 per. Mov. Avg. (APR)

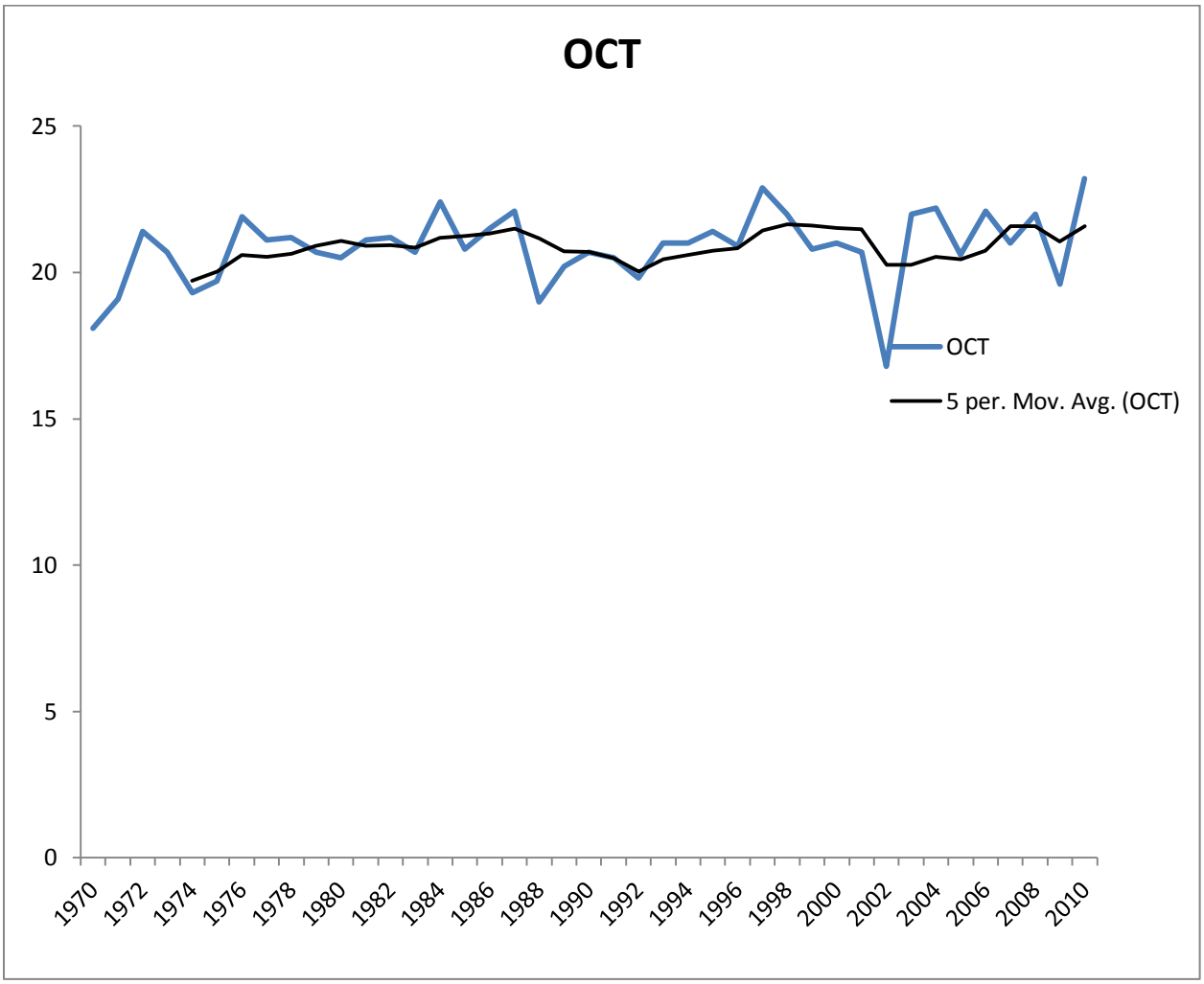

MAY
TEMPERATURE C
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2006
2008
2010
y = 0.011x + 24.612
MAY
Linear (MAY)

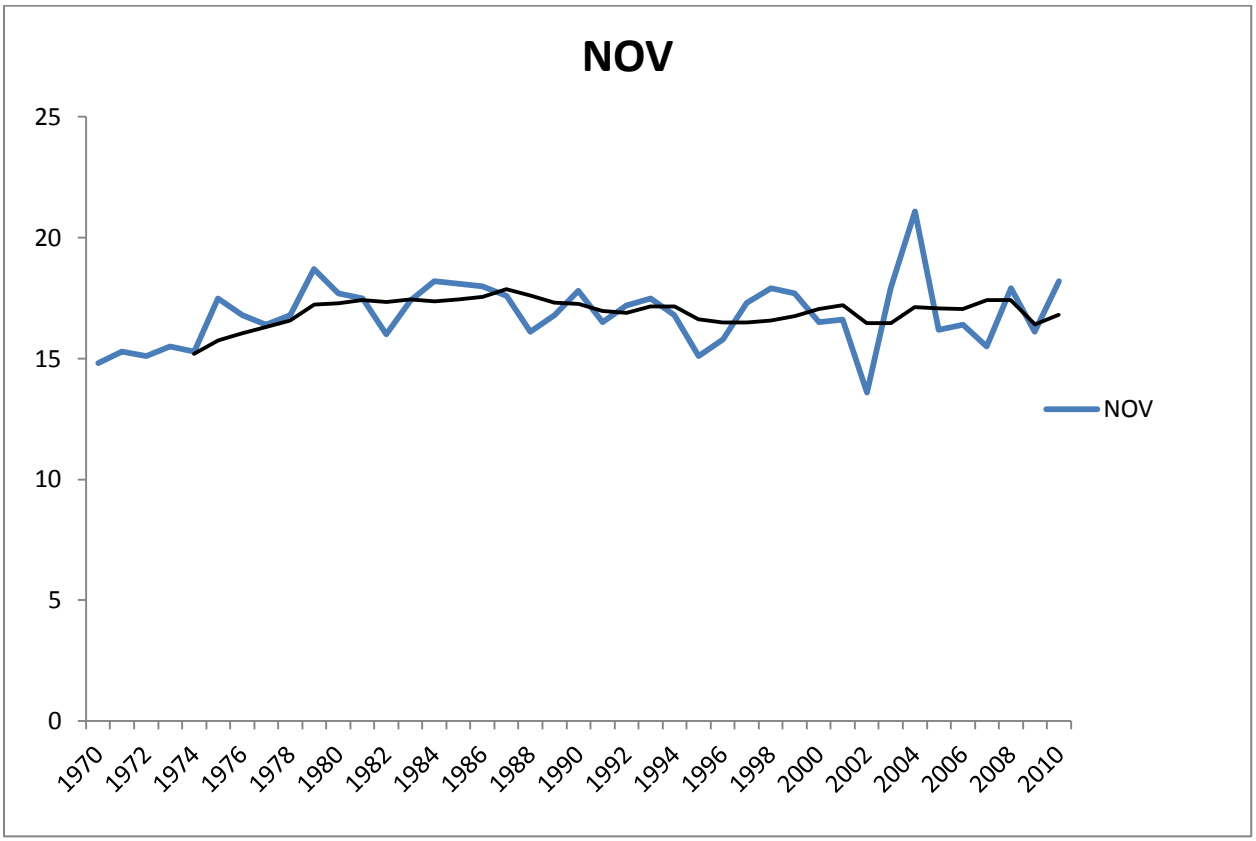

JUN
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24.5
24
23.5
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22.5
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21.5
21
20.5
1970
1972
1974
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1978
1980
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1984
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2000
2002
2004
2006
2008
2010
JUN
5 per. Mov. Avg. (JUN)

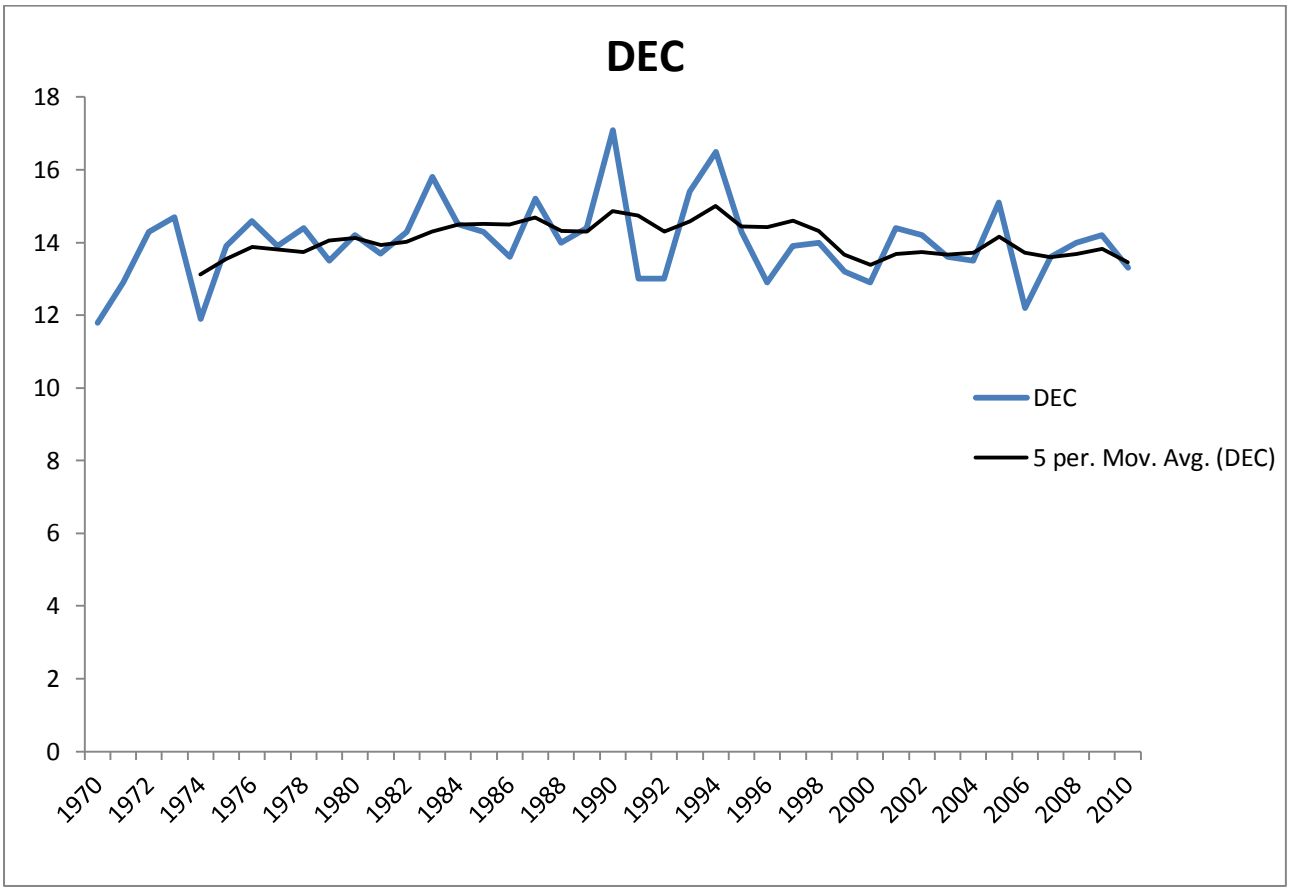

JUL
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23
22.5
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2002
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2006
2008
2010
JUL
5 per. Mov. Avg. (JUL)


AUG
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22.5
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21.5
21
20.5
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2010
AUG
5 per. Mov. Avg. (AUG)

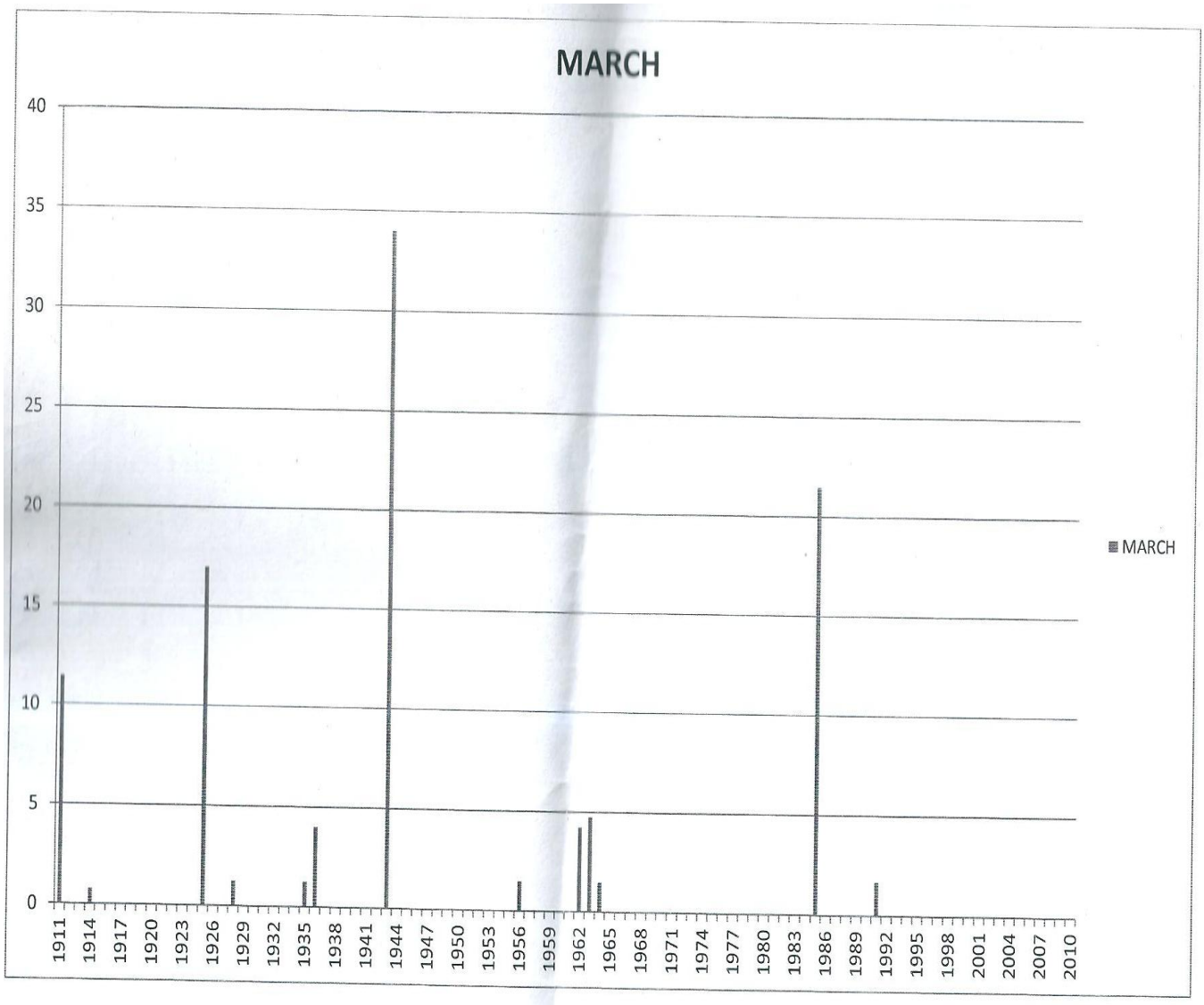

SEP
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22.5
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21
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19.5
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2008
2010
SEP
5 per. Mov. Avg. (SEP)

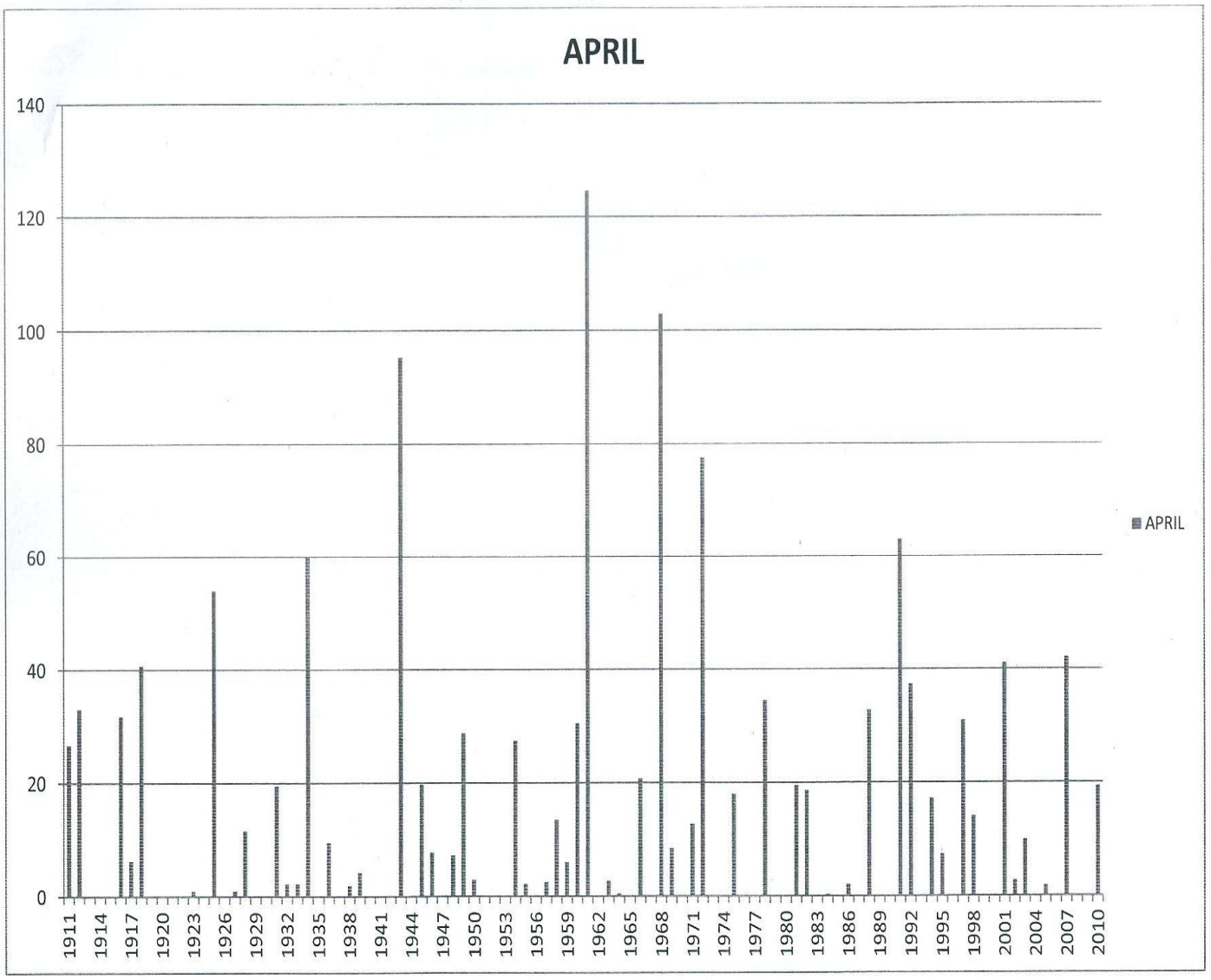

OCT
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2008
2010
OCT
5 per. Mov. Avg. (OCT)

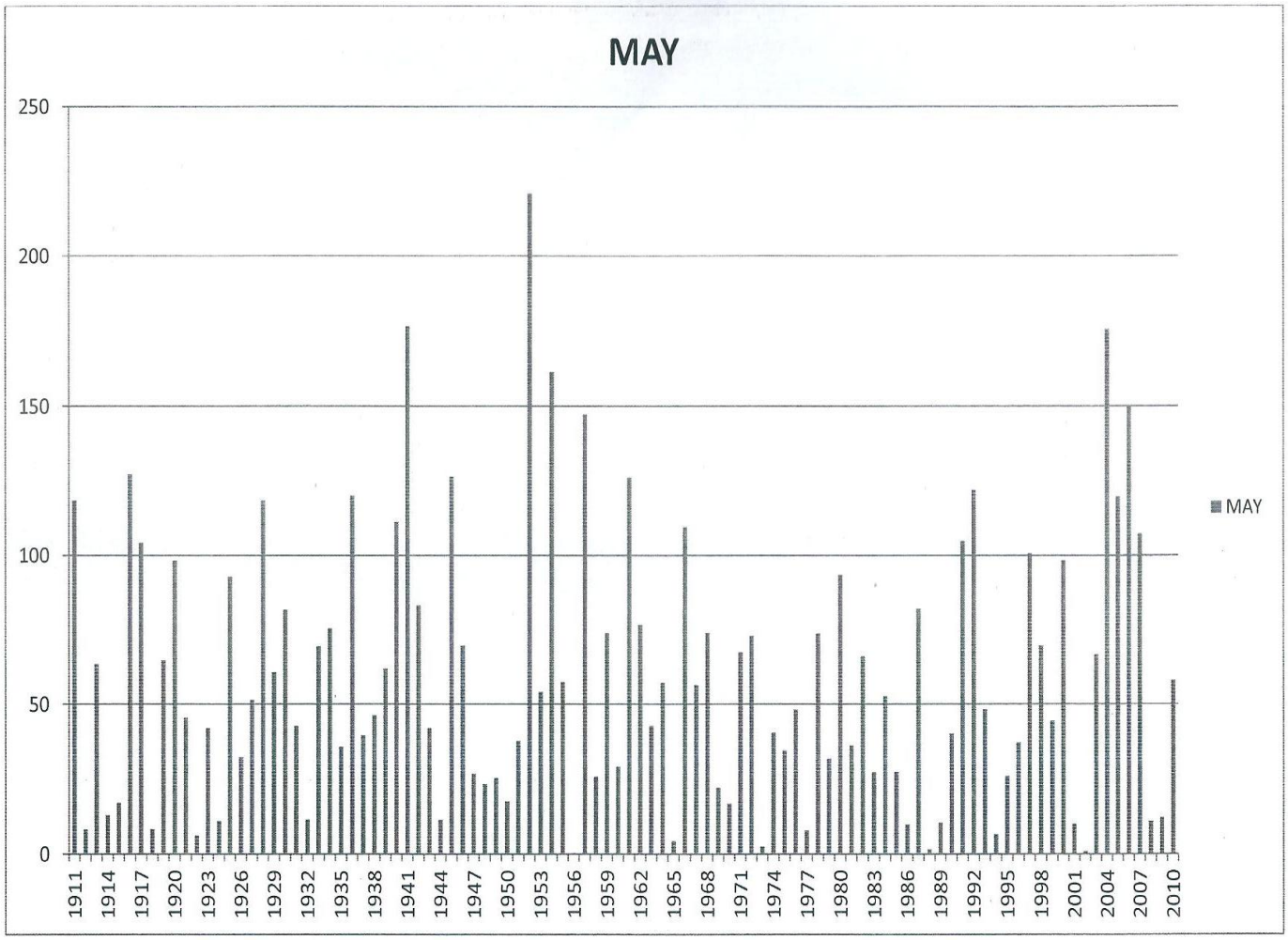

NOV
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NOV

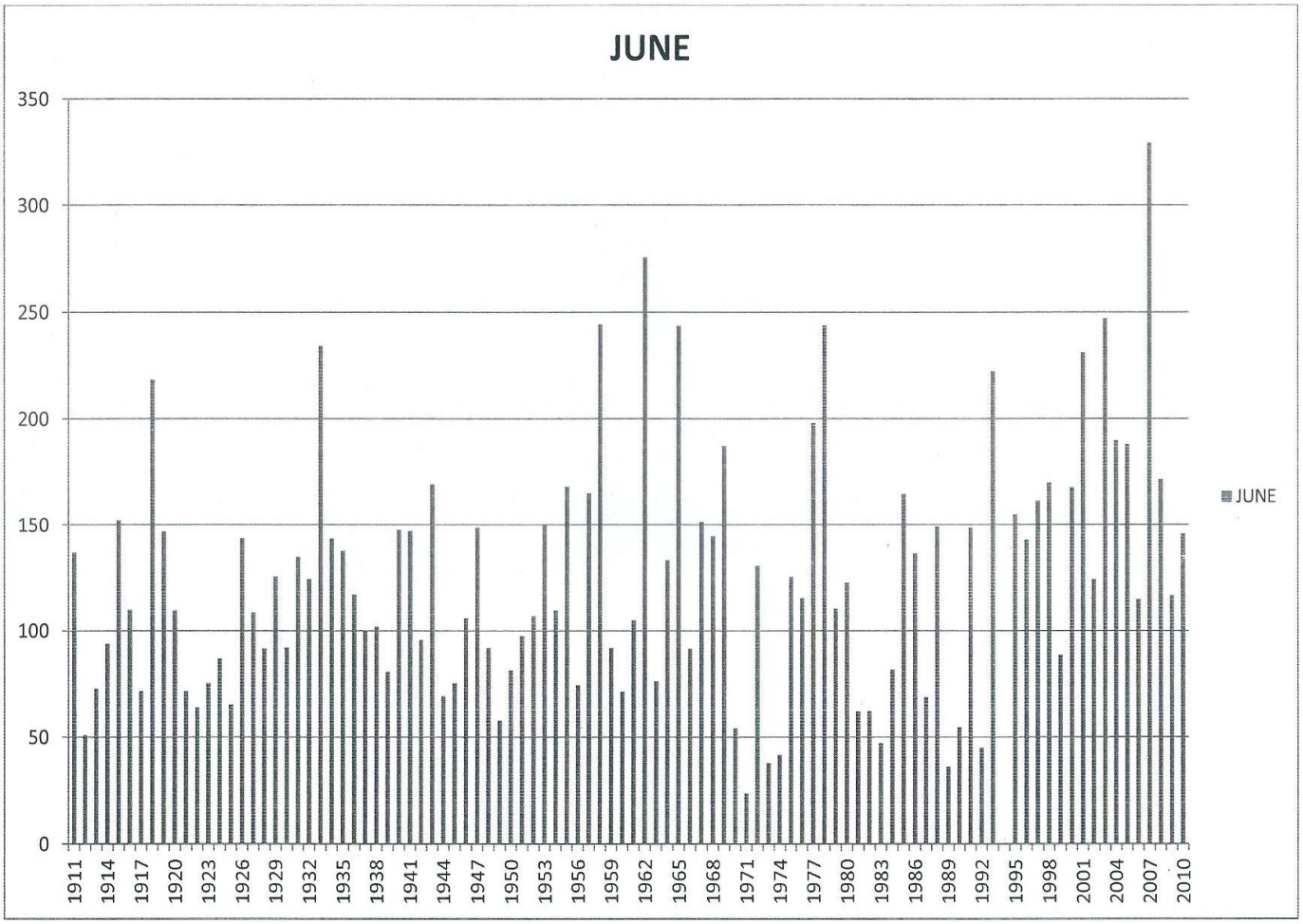

DEC
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2006
2008
2010
DEC
5 per. Mov. Avg. (DEC)

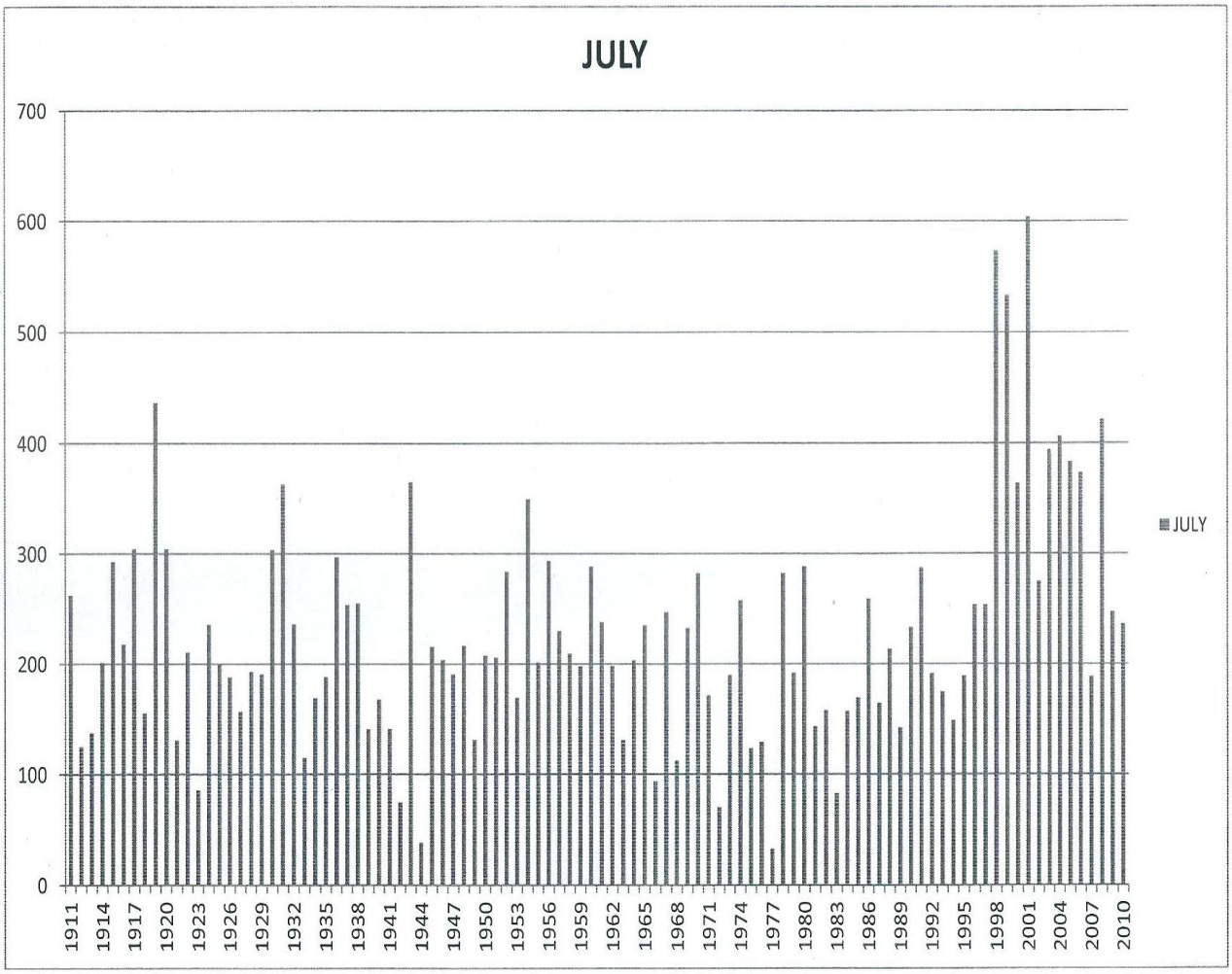
Appendix: 2: Total rainfall pattern over study area for 10 decades

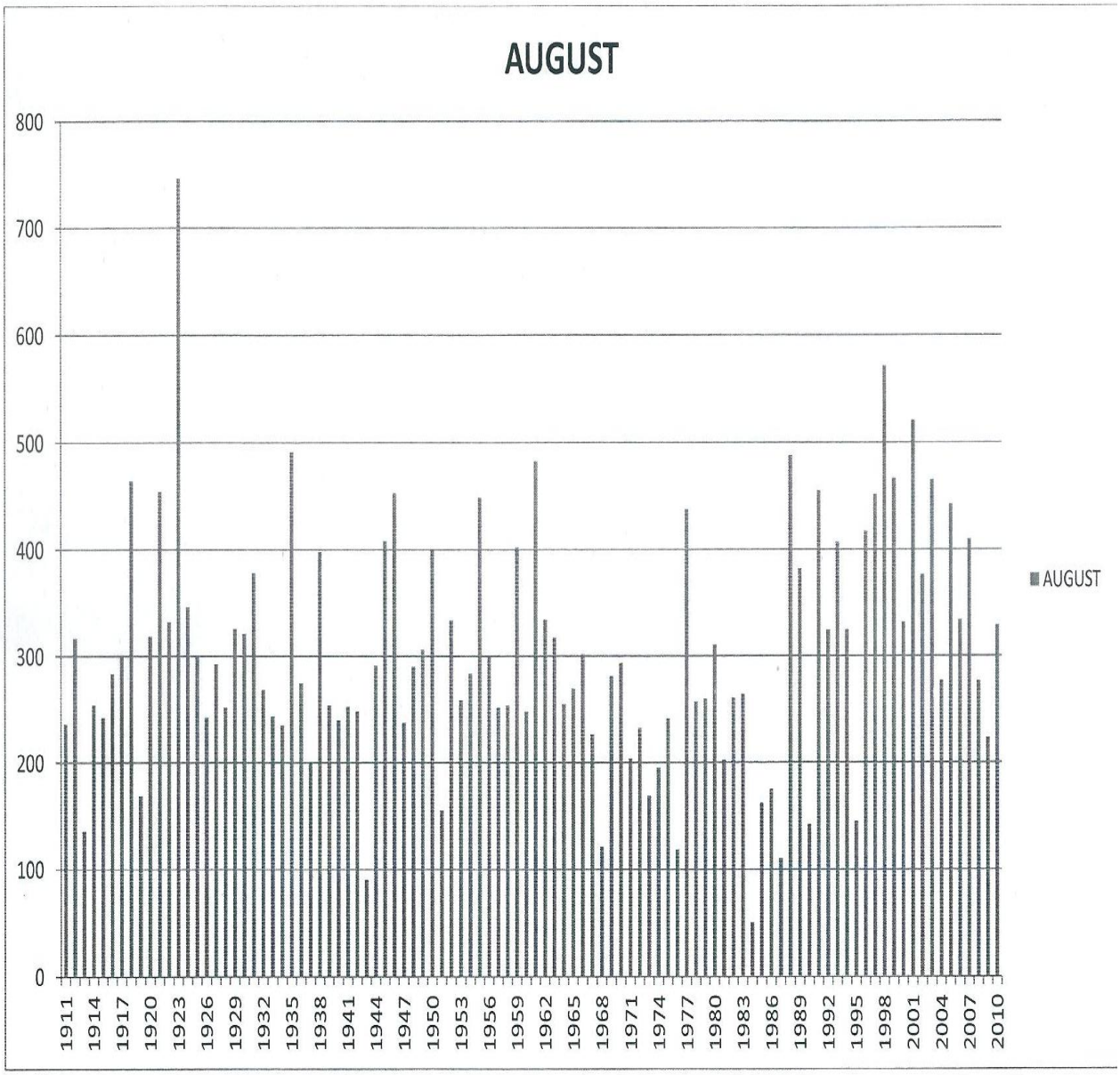


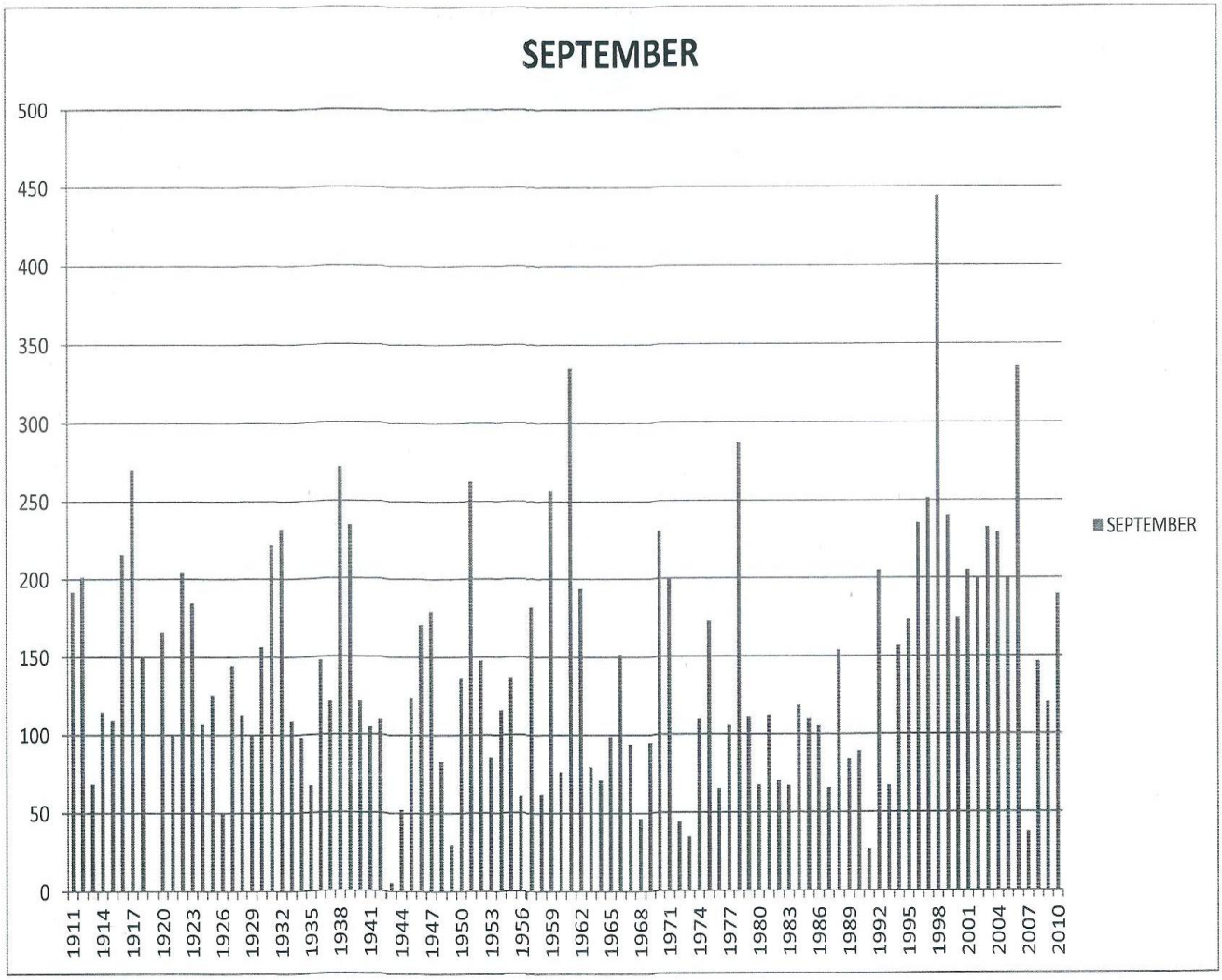

APRIL
140
120
100
80
60
40
20
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1911
1914
1917
1920
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APRIL

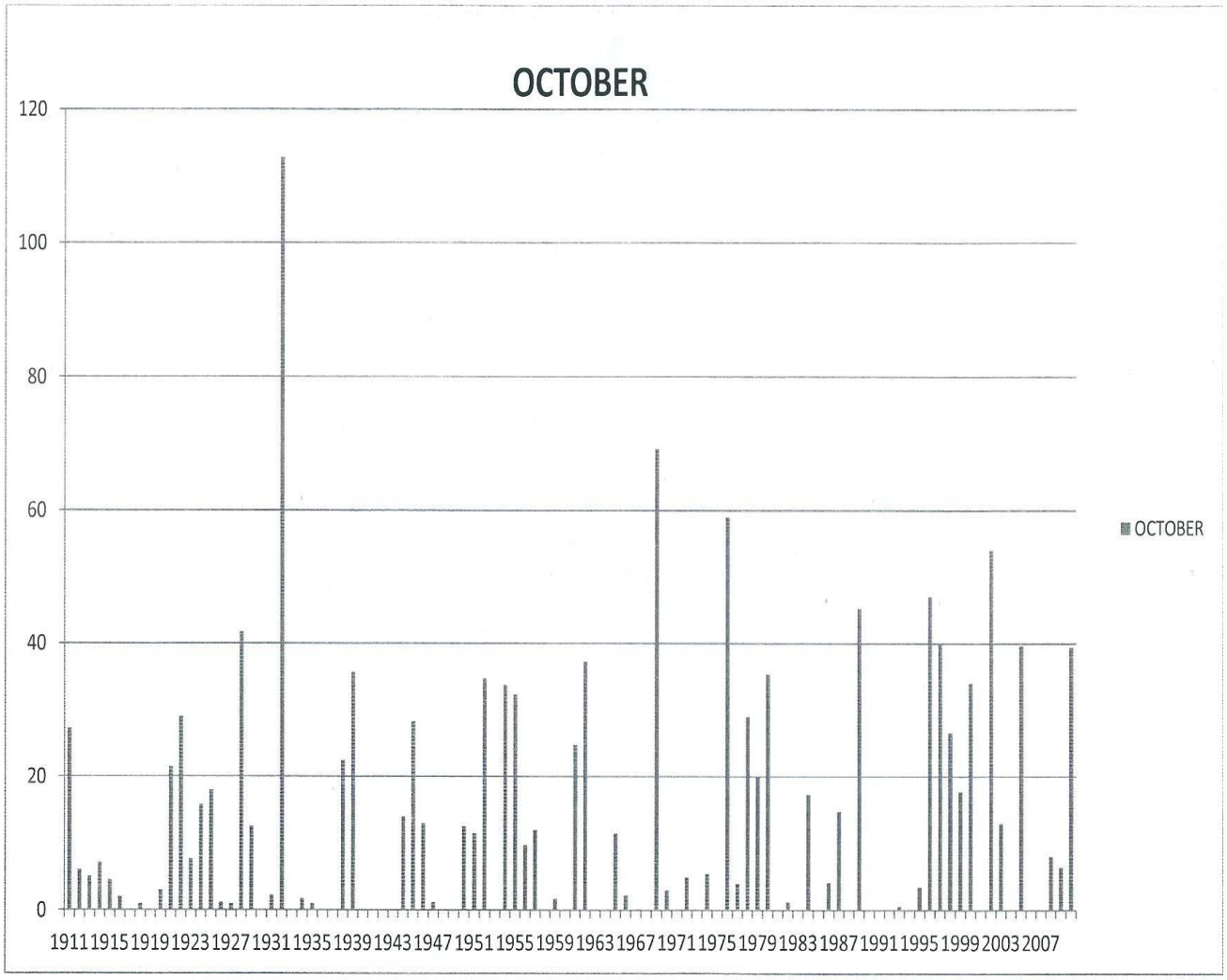

MAY
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1998
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2004
2007
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MAY


JUNE
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2007
2010
JUNE


JULY
700
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500
400
300
200
100
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2004
2007
2010
JULY


AUGUST
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AUGUST


SEPTEMBER
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2007
2010
SEPTEMBER


OCTOBER
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1911 1915 1919 1923 1927 1931 1935 1939 1943 1947 1951 1955 1959 1963 1967 1971 1975 1979 1983 1987 1991 1995 1999 2003 2007
OCTOBER

Appendix 3: Calculated ten (10) decades onset and cessation and length of growing season over Kano.

Years	Calculated onset and cessation	Result
1911	Onset 31x (———)= 3rd May 124 LGS Cessation 30x (———) = 4th September 248	= 124
1912	Onset 30x (———)= 6th June 158 LGS Cessation 30x (———) = 7th September 251	=93
1913	Onset 31x (——)= 25th May 146 LGS Cessation 30x (——) = 20th September 264	=118
1914	Onset 30x (———)= 11th June 163 LGS Cessation 30x (———) = 12th September 256	=93
1915	Onset 31x (———)= 7th June 159 LGS Cessation 30x (———) = 13th September 257	=98
1916	Onset 31x (———)= 5th May 126 LGS Cessation 30x (———) = 7th September 251	=125

1917	Onset 31x (———)= 13th May 134 LGS Cessation 30x (———) = 6th September 250	=116
1918	Onset 30x (———)= 6th June 158 LGS Cessation 30x (——) = 10th September 254	=96
1919	Onset 31x (——)= 24th May 145 LGS Cessation 31x (———) = 9th August 222	=77
1920	Onset 31x (——)= 16th May 137 LGS Cessation 30x (——) = 9th September 253	=116
1921	Onset 30x (———)= 2nd June 154 LGS Cessation 30x (———) = 9th September 253	=99
1922	Onset 30x (———)= 21st June 173 LGS Cessation 30x (———) = 3rd September 247	=74
1923	Onset 30x (———)= 3rd June 155 LGS Cessation 30x (———) = 7th September 251	=96

1924	Onset 30x (——)= 14th June 166 LGS Cessation 30x (———) = 10th September 254	=88
1925	Onset 30x (——)= 19th April 110 LGS Cessation 30x (——) = 8th September 252	=142
1926	Onset 30x (———)= 4th June 156 LGS Cessation 31x (———) = 1st August 214	=58
1927	Onset 31x (——)= 30th May 151 LGS Cessation 30x (——) = 10th September 254	=103
1928	Onset 31x (———)= 10th May 131 LGS Cessation 30x (———) = 2nd September 246	115
1929	Onset 31x (——)= 26th May 147 LGS Cessation 30x (———) = 12th September 256	=109
1930	Onset 31x (——)= 19th May 140 LGS Cessation 30x (——) = 10th September 254	114

1931	Onset 30x (———)= 2nd June 154 LGS Cessation 30x (———) = 7th September 251	97
1932	Onset 30x (———)= 8th June 160 LGS Cessation 31x (——) = 14th October 288	=128
1933	Onset 31x (———)= 22nd May 143 LGS Cessation 30x (——) = 14th September 258	=115
1934	Onset 30x (——)= 26th April 117 LGS Cessation 30x (———) = 15th September 259	=142
1935	Onset 30x (——)= 3rd June 155 LGS Cessation 30x (——) = 22nd September 266	=111
1936	Onset 31x (———)= 10th May 131 LGS Cessation 30x (——) = 10th September 254	=123
1937	Onset 30x (———)= 3rd June 155 LGS Cessation 30x (——) = 13th September 257	=102

\ 1938	Onset 30x (———)= 1st June 153 LGS Cessation 30x (———) = 3rd September 247	=94
1939	Onset 31x (———)= 20th May 141 LGS Cessation 30x (———) = 2nd September 246	=105
1940	Onset 31x (——)= 14th May 135 LGS Cessation 30x (——) = 13th September 257	=122
1941	Onset 31x (——)= 9th May 130 LGS Cessation 30x (——) = 15th September 255	=125
1942	Onset 31x (——)= 19th May 140 LGS Cessation 30x (——) = 14th September 256	=116
1943	Onset 30x (——)= 5th April 96 LGS Cessation 31x (——) = 16th August 229	=133
1944	Onset 30x (———)= 17th June 169 LGS Cessation 30x (——) = 21st September 265	=96

1945	Onset 31x (———)= 8th May 129 LGS Cessation 30x (———) = 6th September 250	=121
1946	Onset 31x (———)= 8th May 140 LGS Cessation 30x (——) = 7th September 251	=111
1947	Onset 30x (———)= 5th June 157 LGS Cessation 30x (———) = 8th September 252	=95
1948	Onset 30x (———)= 7th May 159 LGS Cessation 30x (——) = 18th September 262	=103
1949	Onset 30x (———)= 13th June 165 LGS Cessation 31x (——) = 2nd August 215	=50
1950	Onset 31x (———)= 11th June 163 LGS Cessation 30x (———) = 8th September 252	=89
1951	Onset 30x (———)= 4th June 156 LGS Cessation 30x (———) = 5th September 249	=93

1952	Onset 31x (——)= 7th May 128 LGS Cessation 30x (———) = 3rd September 247	=119
1953	Onset 31x (——)= 29th May 150 LGS Cessation 30x (——) = 7th September 262	112
1954	Onset 31x (———)= 4th May 125 LGS Cessation 30x (———) = 4th September 248	=123
1955	Onset 31x (———)= 26th May 147 LGS Cessation 30x (———) = 4th September 248	101
1956	Onset 30x (———)= 20th June 172 LGS Cessation 30x (———) = 20th September 264	= 92
1957	Onset 31x (——)= 10th May 131 LGS Cessation 30x (——) = 16th September 250	=119
1958	Onset 30x (———)= 1st June 153 LGS Cessation 30x (——) = 25th September 269	=116

1959	Onset 31x (——)= 18th May 140 LGS Cessation 30x (———) = 6th September 250	=110
1960	Onset 30x (——)= 9th June 161 LGS Cessation 30x (——) = 20th September 264	=103
1961	Onset 30x (——)= 11th April 102 LGS Cessation 30x (———) = 2nd September 246	=144
1962	Onset 31x (———)= 19th May 140 LGS Cessation 30x (———) = 2nd September 246	=106
1963	Onset 30x (———)= 1st June 153 LGS Cessation 30x (——) = 19th September 263	=110
1964	Onset 31x (———)= 27th May 148 LGS Cessation 30x (——) = 21st September 265	=117
1965	Onset 30x (———)= 6th June 158 LGS Cessation 30x (———) = 12th September 256	=98

1966	Onset 31x (———)= 9th May 130 LGS Cessation 30x (———) = 10th September 254	=124
1967	Onset 31x (——)= 28th May 149 LGS Cessation 30x (——) = 16th September 260	= 111
1968	Onset 30x (——)= 15th April 106 LGS Cessation 31x (———) = 1st August 214	=108
1969	Onset 30x (———)= 3rd June 155 LGS Cessation 31x (——) = 23rd October 297	=142
1970	Onset 30x (———)= 19th June 171 LGS Cessation 30x (——) = 6th September 250	=79
1971	Onset 31x (———)= 18th May 139 LGS Cessation 30x (——) = 8th September 252	=113
1972	Onset 30x (——)= 11th April 109 LGS Cessation 31x (——) = 1st August 214	=105

1973	Onset 31x (———)= 2nd July 184 LGS Cessation 31x (———) = 3rd August 216	=32
1974	Onset 31x (———)= 1st July 183 LGS Cessation 30x (——) = 12th September 256	=73
1975	Onset 30x (———)= 4th June 156 LGS Cessation 30x (——) = 9th September 253	=97
1976	Onset 30x (———)= 1st June 153 LGS Cessation 31x (——) = 27th October 301	=148
1977	Onset 30x (——)= 7th June 159 LGS Cessation 30x (——) = 13th September 257	=98
1978	Onset 31x (———)= 7th May 128 LGS Cessation 30x (——) = 2nd September 246	=118
1979	Onset 30x (——)= 5th June 157 LGS Cessation 30x (———) = 8th September 252	=95

1980	Onset 31x (——)= 17th May 138 LGS Cessation 30x (———) = 7th September 251	=113
1981	Onset 30x (———)= 7th June 159 LGS Cessation 30x (——) = 14th September 258	=99
1982	Onset 31x (———)= 15th May 136 LGS Cessation 30x (———) = 21st September 265	=129
1983	Onset 31x (———)= 1st June 183 LGS Cessation 30x (——) = 23rd September 267	=84
1984	Onset 31x (——)= 30th May 151 LGS Cessation 30x (———) = 9th September 253	=102
1985	Onset 30x (———)= 1st June 153 LGS Cessation 30x (——) = 14th September 258	=105
1986	Onset 30x (———)= 9th June 161 LGS Cessation 30x (———) = 9th September 257	=96

1987	Onset 31x (——)= 19th May 140 LGS Cessation 30x (———) = 17th September 261	=121
1988	Onset 30x (———)= 2nd June 154 LGS Cessation 30x (——) = 10th September 254	=100
1989	Onset 31x (———)= 1st July 183 LGS Cessation 30x (———) = 2nd September 246	
1990	Onset 30x (———)= 6th June 158 LGS Cessation 30x (——) = 17th September 261	103
1991	Onset 30x (——)= 23rd April 114 LGS Cessation 31x (———) = 2nd September 215	= 101
1992	Onset 31x (———)= 3rd May 124 LGS Cessation 30x (——) = 7th September 251	=127
1993	Onset 30x (———)= 1st June 153 LGS Cessation 30x (——) = 22nd September 266	=113

1994	Onset 31x (———)= 6th July 188 LGS Cessation 30x (——) = 8th September 252	=64
1995	Onset 30x (———)= 4th June 156 LGS Cessation 30x (——) = 8th September 252	=96
1996	Onset 30x (———)= 3rd June 155 LGS Cessation 30x (——) = 1st September 245	=90
1997	Onset 31x (———)= 6th May 127 LGS Cessation 30x (——) = 1st September 245	=118
1998	Onset 31x (———)= 16th May 137 LGS Cessation 30x (———) = 2nd September 246	=109
1999	Onset 31x (———)= 3rd May 124 LGS Cessation 30x (———) = 4th September 248	=124
2000	Onset 31x (——)= 16th May 137 LGS Cessation 30x (——) = 3rd September 247	= 110

2001	Onset 30x (——)= 5th June 157 LGS Cessation 30x (——) = 7th September 251	94
2002	Onset 30x (——)= 11th June 157 LGS Cessation 31x (——) = 29th October 303	=146
2003	Onset 31x (——)= 19th May 140 LGS Cessation 30x (——) = 5th September 249	=109
2004	Onset 31x (——)= 9th May 130 LGS Cessation 30x (——) = 7th September 251	=121
2005	Onset 31x (——)= 13th May 134 LGS Cessation 30x (———) = 2nd September 246	=112
2006	Onset 30x (———)= 5th May 126 LGS Cessation 30x (——) = 5th September 249	=123
2007	Onset 31x (———)= 3rd May 124 LGS Cessation 31x (———) = 1st August 214	=90

2008	Onset 30x (——)= 7th June 189 LGS Cessation 30x (——) = 9th September 253	=94
2009	Onset 30x (———)= 10th June 162 LGS Cessation 30x (——) = 11th September 255	=93
2010	Onset 31x (———)= 17th May 138 LGS Cessation 30x (———) = 2nd September 246	=108