

**IMPACT OF CLIMATIC VARIABILITY ON CROP PRODUCTION IN DASS
LOCAL GOVERNMENT AREA OF BAUCHI STATE, NIGERIA**

BY

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SPS/14/MGE/00062**

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**BEING A MASTER OF SCIENCE (M.SC.) DEGREE DISSERTATION IN NATURAL
RESOURCES MANAGEMENT AND CLIMATE CHANGE, SUBMITTED TO THE
DEPARTMENT OF GEOGRAPHY, BAYERO UNIVERSITY, KANO, NIGERIA**

OCTOBER, 2019.

DECLARATION

I hereby declare that this dissertation is purely the product of my own effort, conducted under the supervision of Dr. L.F. Buba and has never been presented anywhere for the award of any degree certificate elsewhere. All sources were duly scrutinized and acknowledged.

HABILA C.SUNDAY

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CERTIFICATION

This is to certify that this dissertation has been undertaken by Habila C. Sunday: (SPS /14/MGE/00062) in the department of Geography under my supervision.

Dr. L.F. Buba.

Supervisor

Date

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TABLE OF CONTENTS

CONTENTS

TITLE PAGE.....	ii
Declaration.....	ii
Certification.....	iv
Approval.....	v
Acknowledgements.....	vi
Dedication.....	viii
TABLE OF CONTENTS.....	ix
LIST OF TABLE.....	xii
LIST OF FIGURE.....	xiii
LIST OF PLATE.....	xiv
Abstract.....	xv

CHAPTER ONE

INTRODUCTION.....	1
1.1. BACKGROUND TO THE STUDY.....	1
1.2. STATEMENT OF RESEARCH PROBLEM.....	3
1.3 AIM AND OBJECTIVES.....	4
1.4. RESEARCH JUSTIFICATION.....	5
1.5. SCOPE AND LIMITATION.....	6
1.6. DESCRIPTION OF THE STUDY AREA.....	7
1.6.1. Location and Relief Features.....	7
1.6.2. Climate of Dass L.G.A.....	9
1.6.3 Geology and hydrology.....	10
1.6.4 Soil and Vegetation.....	11
1.6.5 Population and Land Use.....	12

CHAPTER TWO

LITERATURE REVIEW AND CONCEPTUAL FRAME WORK.....	14
2.1.REGIONAL TEMPERATURE VARIATION CHARACTERISTICS OF NORTHERN NIGERIA.....	14
2.2. COINTEGRATION MODEL.....	15
2.3. IMPACT OF CLIMATIC VARIABILITY ON CROP PRODUCTION.....	17

2.4 PERCEPTION OF SMALLHOLDER FARMERS ON THE IMPACT OF CLIMATIC VARIABILITY ON CROP PRODUCTION IN SUDANO SAHELIAN AND SUB HUMID ECOLOGICAL REGIONS OF NIGERIA.....	19
2.4.1 Perception on False Onset.....	19
2.4.2. Perception on Flood.....	20
2.4.3 Perception on Pest and Diseases	20
2.4.4 Perception on Dry Spells and Drought	20
2.4.5 Perception on High Temperature	20
2.4.6 Perception on Shortened Crop growing Days.....	21
2.5 AGRICULTURAL PRODUCTION IN DASS L.G.A.	21
2.5.1 Irrigation Farming in Dass.....	23
2.6 CLIMATIC VARIABILITY AND EFFECTS ON GLOBAL CROP PRODUCTION ...	25
2.7 CAUSES OF CLIMATIC VARIABILITY AND DROUGHT IN NORTHERN NIGERIA	27
2.8 CAUSES OF CLIMATIC VARIABILITY IN TROPICAL ATLANTIC REGION	30

CHAPTER THREE

MATERIALS AND METHODS.....	32
3.1INTRODUCTION.....	32
3.2 SOURCES OF DATA.....	32
3.4 SAMPLING TECHNIQUE AND SAMPLE SIZE.....	33
3.5 SAMPLE FRAME CHART FOR QUESTIONNAIRE ADMINISTRATION.....	34
3.6.METHOD OF DATA COLLECTION.....	35
3.7 DATA COLLECTION THROUGH QUESTIONNAIRE	36
3.8.ADMINISTRATION OF QUESTIONNAIRE.....	37
3.9 METHOD OF DATA ANALYSIS.....	38

CHAPTER FOUR

RESULTS AND DISCUSSION.....	40
4.1. INTRODUCTION.....	40
4.1. DATA ANALYSIS AND PRESENTATION	40
4.1.1. Bio Data Analysis.....	40
4.8.2. Drought Experience by farmers.....	42
4.1.3. Drought Effects.....	47

4.1.4. Farmer’s View on Rain Onset and Cessation Challenges.....	48
4.1.5. Types of Crops and Challenges	61
4.2 RELATIONSHIP BETWEEN CROP PRODUCTION AND CLIMATE.....	63
4.2.1 Introduction.....	63
4.2.2 Relationship between Rainfall and Temperature Vs Rice production	66
4.2.3 Relationship between Rainfall & Temperature Vs Maize production	66
4.3. RAINFALL VARIABILITY IN DASS	67
4.3.1. Mean Monthly and Annual Rainfall for the Study Area	68
4.4. TEMPERATURE VARIABILITY IN THE STUDY AREA	71
4.4.1. Mean Monthly Annual Temperature for the Study Area	72
4.5 RICE PRODUCTION TREND IN THE STUDY AREA.....	73
4.6 MAIZE PRODUCTION TREND IN THE STUDY AREA	74
4.7 DISAGREEMENT BETWEEN FARMER’S PERCEPTION ON CLIMATE VARIABILITY AND THE RESEARCH OUTCOME.....	76
4.8 AGREEMENT BETWEEN FARMER’S PERCEPTION ON CLIMATIC VARIABILITY AND RESEARCH OUTCOME	77
CHAPTER FIVE	
SUMMARY, CONCLUSION AND RECOMMENDATIONS	80
5.1 SUMMARY	80
5.2 CONCLUSION.....	82
5.3 RECOMMENDATIONS.....	84
REFERENCES	85
APPENDIX I	88
APPENDIX II.....	92
APPENDIX III	93

LIST OF TABLE

Table 1: Demographic Characteristics of the Respondent.....	42
Table 2: Drought Experienced by farmers.....	43
Table 3: Dry Spell experienced by farmers.....	44
Table 4: Dry Spell Frequency.....	45
Table 5: Dry Spell Getting severe or less.....	46
Table 6: Onset Rain in the Study area.....	49
Table 7: Irregular Starting Rain fall.....	50
Table 8: Changing Rainfall Onset Affecting Crop production.....	51
Table 9: Possible Spatial Variation in Rain Onset.....	52
Table 10: The Most Preferred Rain Onset Time.....	53
Table 11: Rainfall Cessation time?.....	54
Table 12: Changing Rainfall Cessation Time.....	55
Table 13: Changing Rain Cessation Time Affecting Crop Yield.....	56
Table 14: Possible Spatial Variation in Rainfall Cessation.....	57
Table 15: Slight Spatial Variation in Cessation affecting Crop Production.....	58
Table 16: Normal Rainy Season Experience with High Crop Yield.....	59
Table 18: Flood Disaster Forcing Farmers cultivate less.....	61
Table 19: Major crops produced (Rank).....	61
Table 20: Least produced Crops (Rank).....	63
Table 21: Relationship between Rainfall and Rice production.....	64
Table 22: Relationship between Rainfall and Maize production.....	64
Table 23: Relationship between Temperature and Rice production.....	65
Table 24: Relationship Between Rainfall and temperature vs Maize.....	66
Table 25: Mean Monthly Annual Rainfall Summary for the Study Area.....	70
Table 26: Mean Monthly Temperature Summary for the Study Area.....	73
Table 27: Climate and Crop Data Described.....	76

LIST OF FIGURE

Figure 1: Map of Bauchi state showing Location of the study area (Dass L.G.A).	8
Figure 2: Map of Bauchi state showing location of the study area, and Isohyet lines revealing the amount of rainfall received across the various locations.....	10
Figure 3: The Breakdown of the Sampling Frame.....	34
Figure 4: Major Crops Produced	62
Figure 5: Least crop Produced.....	63
Figure 6: Time Series Graph Showing Rainfall Trend for the study Area	68
Figure 7: Temperature Time Series plot for Thirty years	72
Figure: 8: Time Series Plot for Rice Production in the Study Area	74
Figure; 9: Time Series Plot for Maize Production.....	75
Figure: 10: Rainfall Overrall Monthly Time Series Plot for Thirty Years.....	79

LIST OF PLATE

Plate 1: A Photograph Showing the Topography of the Study Area	11
Plate 2; A photograph showing an example of irrigation farmland in the study area.	25

Abstract

This study was premised on examining the relationship between climate and crop production of the study area, for a period of 30 years. Climate data (rainfall & temperature), and crop production data per m²/tone both for the study area, which spanned for 30 years period, were sourced from Nimet office Bauchi, and Bauchi State Agricultural development Program respectively. Questionnaire data was acquired by means of field interview in the study area. Descriptive statistics, time series, linear regression, and multiple regressions were employed to analyze these data. The results for linear and multiple regressions conducted between climate and crop production data proved that climate was not mainly responsible for low crop production in the study area. This is also evident in the production trend of both crops plotted on time series graph and rainfall variability trend. Rainfall was on the rise for almost three decades but none of the crops responded correspondingly, except in few years each. Regression coefficient value for rainfall vs rice accounted for 18.6% of rice production, and temperature accounted for only 1% against rice. It was maize production that rainfall accounted for highest impact of 35%, and temperature accounted for 15.4% of its production. The joint relationship between climate data and crop production (rice & maize) predicted 19.6%, and 17% production over 30 years respectively. The results for the various analysis conducted in this study prompted recommendations for an urgent intervention by the government, community, Ngo's, private organizations and individuals to work relentlessly toward identifying the problems of crop production in the study area and evolve quickest solutions to boost crop production in the study area, which could have the multiplier effects of curtailing food insecurity and crime rate in the study area. Frequent workshop and provision of credit facilities were also recommended, to educate farmers on contemporary farming strategies.

CHAPTER ONE

INTRODUCTION

1.1. BACKGROUND TO THE STUDY

Climatic variability is said to occur when climate varies over seasons and years instead of day-to-day like weather, some summers are colder than others some years have more overall precipitation which affects agriculture and global ecosystems in many geographical locations. Even though, people are fairly perceptive of climate variability as the way climate fluctuate yearly above or below a long term average value, Heinlin, (1974). These parties complement each other; Understanding the range gives context to the average and vice versa. One way to understand the difference between weather, climate variability and climate change is to think about how they operate on different time scales.

Changes in climate are hard to detect without very long term records. Weather describes current atmospheric conditions, such as rainfall, temperature, wind speed, and relative humidity, at a particular place and time, it changes from day to day. Climate is the average (or normal) pattern of weather for a particular place over several decades. Changes in climate are not easily noticed but changes in weather are easily noticed, climate is what you expect, weather is what you get Heinlin, (1974).

Climatic variability therefore, is one of the global phenomenon's that have plagued agricultural production in no small measure; the impact of climatic variability on agricultural production is growing in an alarming rate leading to global food crisis most especially in the dry land regions of the third world. There is no doubt about the fact that our climate is changing. The world's climate has been changing for several thousand years, seven thousand years ago, for example, the Sahara was a landscape of lakes and forests, worth noting is also the fact that climatic variability preceded these changes (Brown and Crawford 2009). The recent "warming of the climate system is unequivocal" as it is now evident from observations

of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level (IPCC, 2007 p.5). The impacts of climatic variability and change, such as rising global average temperature and changes in precipitation patterns of local and regional climate of the world are undeniably clear impacts already affecting ecosystems, biodiversity and human systems throughout the world. Future impacts are expected to worsen as the temperature continues to rise and as precipitation becomes more unpredictable. Among the many adverse risks of climatic variability, the risks to agricultural production and food security is considered most significant Cline, (2007) and Dinar et al. (2008). Agriculture is very sensitive to weather and climate variables including temperature, precipitation, light, weather extremes, such as droughts, floods and severe storms. Molua, (2002).

Climatic variability therefore, which is the focal area for this research can't be separated from climate change scenarios, it's believed that climate change scenarios are exacerbating climatic variability all over the globe, mention must also be made of the fact that global climate change and variability existed naturally in climatological history, their causes are mainly attributed to natural drivers such as, volcanic eruption (aerosols), sunspot, orbital variation of the earth, mountain building ,continental drift, variation in solar radiation due to time scale and location as well as natural shift in climate, (Wikipedia 2018) .

Global warming and natural climate change issues are not the real challenges to crop production, but the rate at which the global climate is changing so fast, causing more variability in climate of many regions incomparable to the natural changes that use to take thousand years before slight changes were noticed, IPCC (2007). The faster rate of changes in global climate and its variability have been proven by scientist to be accelerated by anthropogenic activities IPCC, (2004). The abusive use of the global environment through industrial activities and primitive agricultural practices has induced anacceleratedchanges in

global climate systems WFO, (2000). The earth ecosystem is being rubbed of her vegetation at a faster rate as, enormous amount of GHGs are constantly being emitted into the earth atmosphere in the course of these practices.

Recent research has shown that developing countries will be more vulnerable to climate change and variability than the developed countries, and there is medium confidence that climate change and variability would exacerbate income inequalities between and within countries Smith et al, (2001). Research also had it that a small temperature increase would have net negative impacts on market sectors in many developing countries and net positive impacts on market sectors in many developed countries, Smith et al, (2001). Sub-Saharan Africa, (SSAs') is considered most vulnerable to the impact of climate changes because of its overdependence on agriculture and natural resources, warmer baseline climates, low precipitation and limited ability to adapt Kulukurasuriya, (2007).

1.2. STATEMENT OF RESEARCH PROBLEM

Climatic variability has become an area of attention to so many researchers over the past 4-7 decades, after realizing its potentiality to assume disaster proportions on the entire world ecosystem, as well as agricultural production on which the survival of human kind solely depends. The consequences of climatic variability is much more felt by dwellers of dryland regions of the world, but much severe impacts are felt or are more practical in arid, semiarid, Sudano-Sahelian and, Gunea Savanna regions across the globe (Hestenrath et al, 1990). In these regions of the world, rainfall has exhibited undesired behaviors in which considerable reduction in rainfall has been recorded, moreover, it has become more erratic yet, unpredictable thereby, posing a severe peril to agricultural activities (Hernandez, 1988). Adejiwon, (2001), stated that rain water variability impacts analysis is a way of looking at the range of consequences of a given rainfall event or change. Odekunle et al, (2002), asserted that, scientific evidence of rainfall variability and its effects on crops yield is now stronger

than ever. They attributed the causes of famine in Gunea Savannah part of Nigeria to crops failure resulting from insufficient or untimely rainfall. However, Adebayo, (2003), argued that although climate is not tangible, some resources emanating from it such as rainfall are tangible. He further stated that though climate may be regarded as plentiful being naturally available, its variability over space is unpredictable, provides the scarcity and value that makes the economics of climate worth considering. Odujo, (2004), in his paper on the analysis of rainfall patterns and its implication in Nigeria concluded that, rainfall decreases from 1350mm (1941-1970), to 1276mm (1970-2002). These decreases according to him has created ecological destabilization and altered the vegetation belts especially northern Nigeria but, more severe impacts are felt by inhabitants of the Northern fringes.

Rainfall variability seemed to have intensified in Dass L.G.A. community over the recent past, resulting in a decline, and considerable variability in agricultural production. This situation has threatened the income, livelihood and the welfare of farmers.(Bauchi state Agricultural Development Program Report and statistics on crop production and rainfall of Dass L.G.A. (2000). Dwindling rice production in Dass L.G.A must be having its bearing from rainfall variability, Ali Garba, (2006).

1.3 AIM AND OBJECTIVES

The aim of conducting this research is to investigate the relationship between rainfall, temperature, and crop production over the past three decades in the study area.

- i. To examine rainfall and temperature variability for a period of thirty years.
- ii. To examine the relationship between rainfall, temperature and crop production over thirty years period.
- iii. To examine the perception of farmers on the effects of rainfall variability on crop production over the past thirty years.

1.4. RESEARCH JUSTIFICATION

This research was conducted purposely to use the information of the research findings to educate farmers on the enormity of climatic impacts on agricultural activities, although many farmers appeared to have known that climate have become more variable than ever before and at the peril of agricultural production, yet many of them may not have known to what extent it has been affecting their economy as well as the future impact it can have on them. This research therefore, proposed to impart the knowledge of the far reaching consequences of climatic variability on their wellbeing, since majority of the inhabitants have farming as their lone occupation. Because of this, the research also see the need to broaden the knowledge of farmers on how their potential source of income could be jeopardized by climatic variability, which could in turn result to serious economic crisis, if new approaches in contemporary agriculture are not abided by, to circumvent some climate related impacts on agriculture.

Many a times in some agrarian societies, so many people have often resorted to involvement in criminal activities immediate aftermaths of crop failure seasons, in order to provide their family needs, and simply because they have been bereaved of their only fortunes with no alternatives Molua, (1999). If agrarian societies of our nation whose population have the highest percentage of the poor, as well as illiterates, are left to grapple with extreme climatic impacts on agriculture on their own without an intervention by our government, such a situation could spell future food insecurity doom days, thus, resulting to alarming increase in crime rate.

Livestock farming is not spared from the impacts of climatic variability, water and fodder scarcity resulting from extreme drought condition or other weather events are potential threat to the wellbeing of animal that could inturn result to disease and death, loss of weight,poor quality beef, incapacity to reproduce, hence impoverishing the herdsman. Consequently our

society suffers fall in the supply of meat. In situation where water and fodder scarcity become severe, crisis between farmers and herders are often inevitable, many herdsmen have often embarked on criminal activities amid such conditions in order to meet their needs for survival. Poor harvest or crop failure resulting from climatic variability is a potential cause for extreme malnutrition and poverty in most agrarian societies thereby, predisposing it's victims to deadly diseases as insufficient diet can weaken immune systems of every victim.

Looking at their range of challenges and their contribution to the food basket of the nation, as well as the economy, this research felt the need for agrarian societies to have constant agricultural education, most especially pertaining to new farming strategies, timely information on crop weather focus by the government. Provision of aids to ameliorate some extreme weather and climate events affecting farmers was also suggested after the finding of this research, this research also made a clarion call to the government, NGOs, international organizations, communities, and well meaning individuals to make rural agriculture one of their top priorities, so that economic and social consequences emanating from the impacts of climatic extremes would be kept at the barest minimum. These suggested measures if taken into consideration and practiced by could give a huge push to our dwindling agricultural production as wells as our economy.

1.5. SCOPE AND LIMITATION

This study focused on investigating current and previous influence of climate on crop production in the study area for a defined period of 30 years. Emphasis was laid on direct impact of rainfall and temperature on crop production which from time immemorial has been the only means of sustaining livelihood for a common man, as well as the major source of income generation Hanandez, (1998). The study however, confined its findings on examining the degree to which rainfall and temperature as an inherent property of climate has impeded crop production by means of fluctuating below and above average over three decades. The

study worked toward gaining an insight to the possible extreme cases of rainfall and temperature which may have led to crop yield variability or reduction. Crop yield data of rice and maize for thirty years was taken as samples and subjected to statistical analysis, hence an assessment of the possible yield reduction/ variability over time, see chapter four. The research was confined within four wards of Dass L. G. A. which is stated in chapter three in the sampling frame. Rice and maize production data over a period of 30 years were taken and analyzed by means of linear regression with climate data (rainfall and temperature), maize vs rainfall, rice vs rainfall, and rice vs temperature, maize vs temperature, as well as multiple regression of the four data under examination, these were conducted to enable this research see how significant or insignificant rainfall and temperature variability has affected crop production in the past three decades, see chapter four for details.

1.6. DESCRIPTION OF THE STUDY AREA

1.6.1. Location and Relief Features

Dass local government area of Bauchi state is located in the northern guinea savannah zone of Nigeria, between latitude $10^{\circ}45'$ and $10^{\circ}15'$ North and, longitude $9^{\circ}15'$ and $10^{\circ}45'$ east, (Bauchi State Ministry of lands and survey 1985). The L.G.A covers a total land area of 535 km². It has a population of about 89,940, (2006 census), recent projection puts the figure at 1900 000. The study area is located on the northern central highland of Nigeria with an average of 2500-3000m above Sea level with undulating surfaces seen everywhere in the area, there are ridges with big boulders all over the area, Wikipedia, (2019). Some of the ridges extend up to the neighboring local governments, particularly Toro L.G.A. All the rocks particularly hills, are of plutonic origin from tectonic activity solidified underneath and later exposed by denudation where hard rocks stand out as mountains. There are plains that surround these standout-rocks in the area which is the area where most of the settlements are; moreover, they are products of deposition from ridges and mountains. Dass L.G.A. is located

on hilly environment, where some seasonal falls are found as a result of the nature of their hilly environment, Bauchi State Ministry of Lands and Survey (1985).

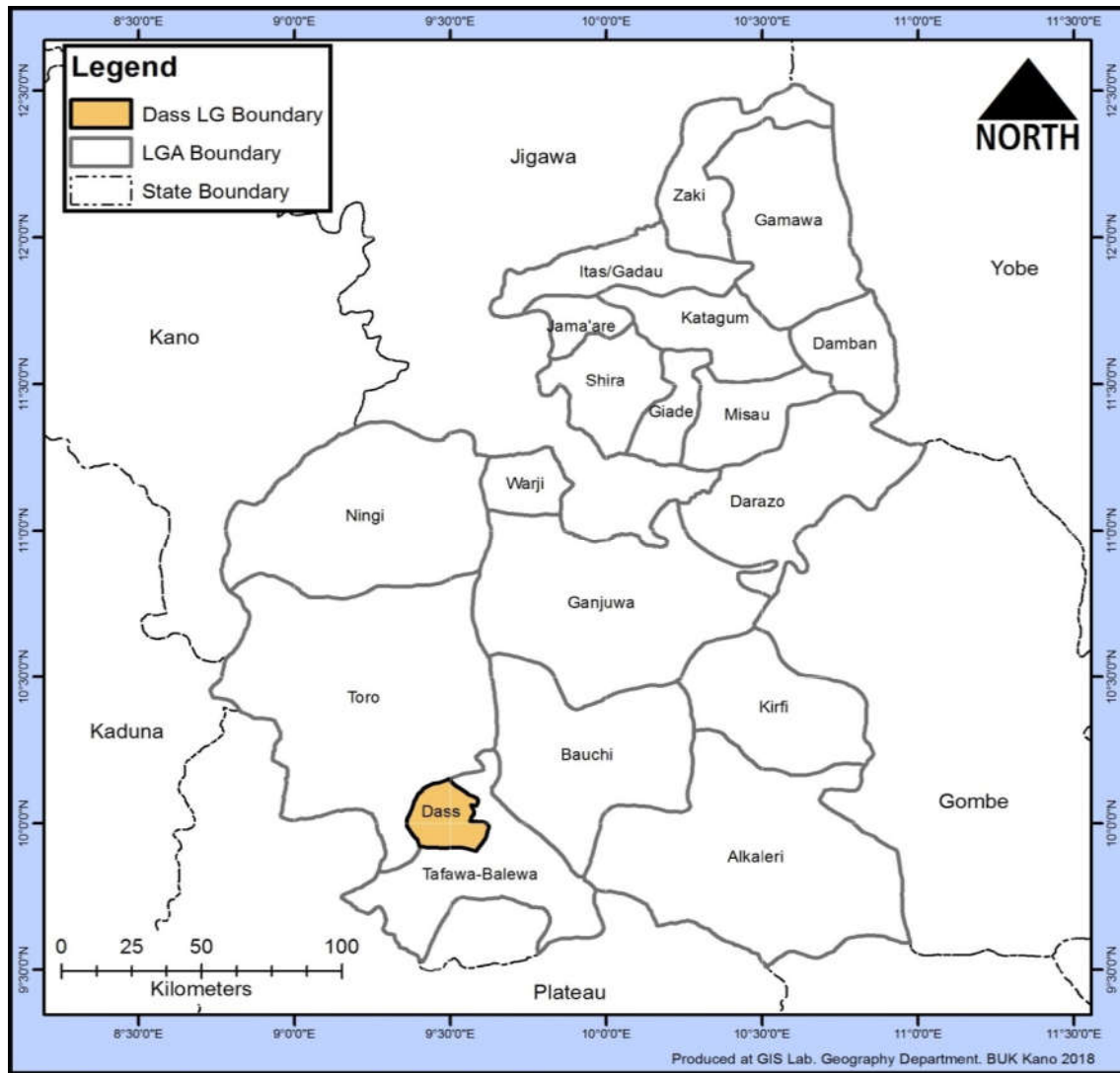


Figure 1: Map of Bauchi state showing Location of the study area (Dass L.G.A).

1.6.2. Climate of Dass L.G.A

The study area is characterized by two distinct climatic seasons, dry & wet season. It is located within the guinea savannah type of climate 5-7 month of rainfall usually starting from April and has 5-6 dry season from November to March or April every year. Dass L.G.A.S use to records more than 1000 mm annually during early 80's (BSADP Bauchi, 1983), the rainfall of the area originates from the Atlantic maritime air masses, occurring on the leeward side of north central highland of Jos Plateau. The two air masses that cover Nigeria and comes into contact at inter tropical discontinuity ITD which resulted into occurrence of the rainfall in the area. The cold dry wind of continental origin forms part of the dusty harmattan wind that is experienced from December to February and in some instance up to march as it does in most part of northern Nigeria. The surface temperature of the area is relatively high with mean annual temperature of 30⁰c.

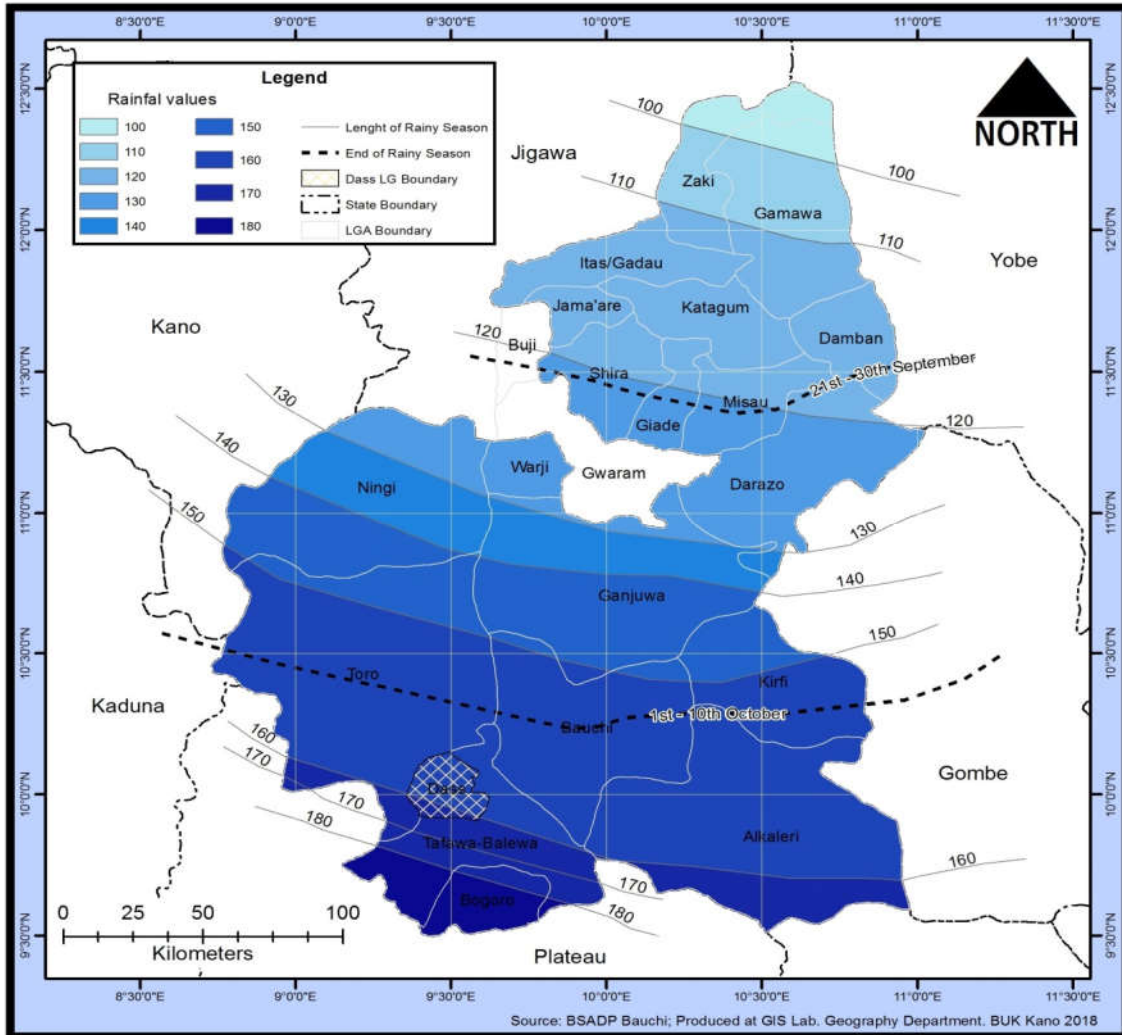


Figure 2: Map of Bauchi state showing location of the study area, and Isohyet lines revealing the amount of rainfall received across the various locations.

1.6.3 Geology and Topography

Dass L.G.A. is located on the basement complex rocks of north central highland. It is characterized by plutonic rocks that solidified at some depth within the earth crust, solidification of the rocks was slowly made thereby forming large crystals of rocks or coarse grains. The granite, gabbros, magmatites, gneises, and diorite that are seen on the surface in the study area are now exposed to the surface by denudation or erosion. The plutonic rocks in the area mostly contain acid rocks with the presence of silicate and aluminium which most

times makes it lighter in color. It contained quartz and some fraction of mica. The geology of the area shows that the area is a basement complex with shallow water table at average depth of 7.41m Nyanganji, (2011). The basement complex of the underlying rocks is highly permeable due to penetrating cracks, fault and fissures which allow water to percolate easily and fast into the rock mass.

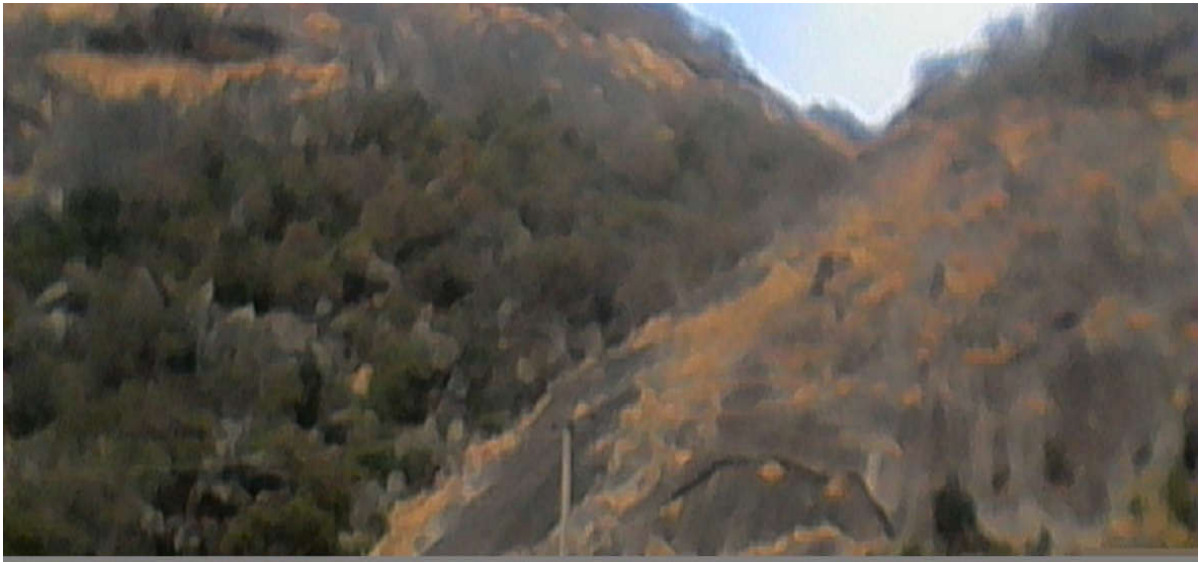


Plate 1: Badel village in Bununu Ward, showing a very rough topography of the study area.

1.6.4 Soil and Vegetation

There are different types of soil and soil profile in Dass because of the fact that the area is occupied by ridges and hills. Therefore soils, around and on the hills are azonal soils that are immature having several layers with different structures that are said to have emanated from recent deposition of sediments, examples are alluvial soil and pearts, Bauchi State Agricultural Development Program, (BSADP 1981). Although soils like laterite are typical example of zonal soil found in the area. The vegetation of the area of study is guinea savanna type.

1.6.5 Population and Land Use

The study area which is ranked the least in terms of population and land mass among the entire 774 L.G.A. of Nigeria is said to have a population figure of 89,943 according to 2006 National census. While the 1991 census put the population figure at 50,281 with a total land mass of 535/km² and a population density of 236.6/km², (National Bureau of Statistics 2016). The population structure seemed to comprise of large number of labor force of 42,481 of 0-14 age group, and 45,001 of 15-64 age group which is almost the total percentage of the entire population.

The land uses in the study area are, mainly housing, agriculture, religion, public or educational land uses, which could be an institution, health center, transportation network land uses as demanded by the government are mandatory. As the population increases demand for further building and settlement increased over time, agricultural land use and housing have weighed more pressure on the land use than any other land use demand.

Religious land uses are also apparent as the inhabitants are religious practitioners, this result to demand for land where mosque and churches for worship and cemeteries for each religions are build. Land use system have been changing based on changes in population, religion ethics, government policies which are inevitable

1.6.6 Farming System

The farming systems in the study area are mostly those that are practiced in most part of the sub humid and Sub-Saharan Africa. Farmers in the majority are sedentary and operate subsistence farming where direct labor is mostly required for the farming activity, however, over the recent years there has been improvement in the area of labor. Hiring of tractors from the government or private individuals has helped some farmers who have the financial capacity to afford. Another common alternative to use instead of direct labor which has

relieved farmers a great deal, is the use of animal for ploughing, most especially cattle. Cattles are mostly used for plow by most farmers in the study area, and most of the farming system commonly practiced there are, mix cropping, inter cropping, annual cropping, multi cropping and mono cropping system. Some farmers have been able to cultivate three times a year in areas where irrigation potentials are available with sufficient water sources, Eniola (2015).

CHAPTER TWO

LITERATURE REVIEW AND CONCEPTUAL FRAME WORK

2.1. REGIONAL TEMPERATURE VARIATION CHARACTERISTICS OF NORTHERN NIGERIA

As this research intend to study relationship between climate and crop production, it appears essential to review literatures on temperature and rainfall issues in Nigeria, most especially its northern part in which geographical region the study area is located, and must have come under focus in the course of conducting related researches in the region.

A study conducted on the temperature variability characteristics in Northern Nigeria seeking to compare the result with (IPCC, 2007) findings on global temperature rise generally regarded as global warming was reviewed. In the course of this study, the result for this finding was compared with the assertion of the (IPCC, 2007) on global warming, this was done so the research would be able to see the degree to which global warming felt in Northern Nigeria would correspond with IPCC assertion. However, several stations were studied simultaneously but, in comparisons with one another in the same region, in order to see the variability trend between these stations of same geographical location. This literature also focused on comparative analysis of the regional variability resulting from regional and local geographical factors.

The study revealed that temperature distribution over Northern Nigeria closely follows the seasonal migratory pattern of the overhead sun. The key issue is that seasonal temperature values range between 21⁰C and 33⁰C, the annual temperature range is small. However, a weak spatial variability could be observed. Seasonal average temperature in the Sudano-Sahelian zone do not differ markedly; 22⁰C to 25⁰C for December, January and February; 23⁰C to 30⁰C for March, April and May; 26⁰C to 30⁰C for June, July and August; and 25⁰C to

27⁰C for September, October, (Buba 2017). Similar arrangements were observed in the Northern and Southern Guinea ecological zones. That is to say temperature variations increased with latitude. In the Northern Guinea ecological zones temperatures are generally characterized by low variability. Sudano sahelian zone are said to have more temperature variability than the former, where in the Northern zones variability is higher in the month of December, January and February compared to other months.

In the Guinea Savanna mean monthly temperature varies between 29⁰C and 40⁰C. While the mean monthly maximum temperature is lowest at about 29⁰C and highest in April at around 36⁰C. However, the mean maximum temperatures are higher in the Sudano – Sahelian zone than what they are in the Guinea Savannah varying between 30⁰C and 40⁰C. The highest maximum temperatures for this zone are recorded in May, while the lowest maximum temperatures are expected in December and January, (Buba, 2017). Minimum temperatures are on the average about 10⁰C lower than the maximum temperatures in the Southern Guinea ecological zone, varying between 19⁰C in January and 24⁰C in April. Differences between minimum and maximum temperatures are approximately 14⁰C in the Northern Guinea ecological zone.

The study area which is sometimes described to savannah and sudano- Sahelian ecological zones seemed to poses similar characteristics of temperatures of these zones.

2.2. COINTEGRATION MODEL

Co-integration model was employed by (Ayinde, Muchi, Olatunji, 2005) to analyze the possible impacts of climate variables (rainfall and temperature) on crop production. These study ensemble two different stations across Nigeria with different climatic characteristics to assess the possible variable impacts of climate on agricultural production within the two different locations. This was done for a period of three years so as to enable the researcher see the probable influence of rainfall and temperature reflecting in crop production within the

three years period. Should the annual crop production dwindle in a season of lower rainfall, the reason could be pointed to the rainfall reduction in that particular station after an analysis of the rainfall and crop relationship in the study area is done and evidence is obtained regarding the extent of climatic effects on the crops in view. However, the same model insist that the two different station could record similar annual crop production despite a significant difference in the amount of rainfall received between the two geographical locations which could be attributed to poor farm management and other unknown factors that would require an in depth research before the problems are discovered.

The same researchers extended the model on analyzing climate data (rainfall and temperature) for two different agricultural areas in Nigeria with similar climate behavior, to be compared in terms of the relationship between crop production and climate.

A climate data of rainfall and temperature of fifty years was analyzed using descriptive statistics, regression, correlation, and error correction model to compare with annual crop production in the two locations so that the relationship existing between the two could be revealed on the time series plot for both values.

The co-integration theory states that if two variables Y and X are co-integrated, then the relationship between the two can be expressed as error correction model (E.C.M). The equation for co-integration model equation is given as:

$$LY_1 = \beta_0 + \beta_1 LX_n + \beta_2 LX_n + U_1 \dots \dots \dots (1)$$

Where;

Y_t = Agricultural productivity index

X_1 = Annual temperature ($^{\circ}C$)

X_2 = Annual rainfall (mm)

The model however seemed so complex but it was a suitable tool used in examining the true influence of climate on agricultural production. The degree of variability of both the rainfall and crop production was examined so as to arrive at the point where the influence was significant or insignificant.

The statistical tool used apart from descriptive statistics had the potency to correct the statistical errors. This model advocated for conducting a thorough analysis of climate data and crop productivity data of the same period, thereafter ran a correlation for a significant test.

2.3. IMPACT OF CLIMATIC VARIABILITY ON CROP PRODUCTION

Several researches on global climate system have revealed that climatic variability as a major threat to global agriculture and ecosystem has intensified in recent years more than ever before. The increased frequency, intensity, spatial extent, duration, and timing of extreme weather and climate events are clear evidence of an increase in climatic variability (IPCC, 2012). Changes in climate variability in relation to changes in temperature and rainfall patterns and amounts will combine to bring about shifts in the onset and length of growing seasons in the future. Projected changes in lengths of the growing period for Africa to the 2090's were estimated Thornton et al., (2011). Climate variability and extreme events can also be important for yield quality and protein contents, temperature and rainfall variability affect quality and quantity to changes in probability distribution shown on regional and global maps in several literatures.

The scientific research conducted by IPCC, (2001) have attributed its causes to anthropogenic activities, while some researchers such as Walsh and Johnson, (1979) argued that such variability are traceable to natural causes which depends on long term circles.

Climate variability already has substantial impacts on biological systems and on the small holders, communities and countries which depend on them. The importance of rainfall variability at the national level, for example variability in seasonal crop yield as a result of rainfall variability is manifesting in the gross domestic product and agricultural gross domestic products for three countries in Sub-Saharan Africa Hastenrath et al, (1988) changes, in rainfall variability extremes have been observed since 1950, and there is evidence that some of these changes are a result of anthropogenic influence, although attribution of single extreme event to these influences remains challenging IPCC, (2012). In situations where changes in climate and climate variability may be larger, more, fundamental changes may occur, particularly if critical thresholds in temperature and for rainfall are reached Gornall, et al, (2010). Changes in the nature and timing of the growing season may include small holders to grow shorter duration and/or more heat – and drought-tolerant varieties of crops.

Mixed crop-livestock systems are prevalent in much of the developing world and climate variability in the future may affect the relationship between crops and livestock in the landscape in many places, Herrero et al., (2010). And many places will increasingly become marginal for crop production, livestock may provide an alternative cropping. Such transition could occur in up to 3% of the total area of Africa, largely as a result of increase in probability of season failure in the drier mixed crop livestock systems of the continent; these are approximately projected to increase from the current rate of one year in five to four or three, Herrero et al, (2010).

2.4 PERCEPTION OF SMALLHOLDER FARMERS ON THE IMPACT OF CLIMATIC VARIABILITY ON CROP PRODUCTION IN SUDANO SAHELIAN AND SUB HUMID ECOLOGICAL REGIONS OF NIGERIA

An investigation carried on the perception of smallholder farmers in the Sudano Sahelian and Sub humid ecological zones of Nigeria by Akinubu et, al (2015-2016), revealed that climate variability has already affected crop production in these geographical regions. Some farmers in the study areas asserted that climate have for several years now exhibited an unusual behavior which have affected crop production, some farmers in the study areas complained of some extreme weather and climate events affecting crop production in the study area. Some of the challenges encountered were given by sample respondents in the study areas as follows:

2.4.1 Perception on False Onset

Majority of respondents in the study area with (69.79%) reported frequently experiencing good rainfall at the beginning of raining season which are mostly trailed by dry spells. Smallholder farmers also reported they are always tempted to plant seeds with early rains which result in scotching the seeds during dry spells, This often require farmers to undergo several rounds of sowing which are scarced and limited Babatolu & Akinubi, (2016). According to the smallholder farmers in these regions, those who plant after the first or second rain usually run into huge loss. Few of respondents volunteered to say that in the period before 1980s farmers could predict the rains almost accurately and they knew precisely when to plant their crops. But because of climate variability farmers could no longer determine when to plant and when to harvest, thus they are losing control of and initiative to climate change or variability.

2.4.2. Perception on Flood

Some smallholder farmers in the study area who constituted (79.6) of the sampled respondents reported that rainfall is sometimes unusually heavier and falls within a short time, thus leading to incessant floods in the study area. According to smallholder farmers in the study areas the floods affects crop production through washing away or destruction of crops, hence reduction in yield or crop failure. Washing away of crops has become so rampant along streams, rivers, and slopping plains affecting rice, sugarcane and similar crops in the study area.

2.4.3 Perception on Pest and Diseases

Smallholder farmers (45.49%) acknowledged significant increase in to crop damage by pest diseases and weeds in a Sub humid area of Nigeria (upper River Niger). Increase in temperature and rainfall was related to proliferation of pest and diseases as observed by the respondents in the study area, Babatolu (2016).

2.4.4 Perception on Dry Spells and Drought

Closely related to this is dry spells and drought which frequently occurs within the growing season. Respondents in the study area (upper River Niger) locations in the Northern Nigeria with (76.6%) claimed to experience the dry spell during the rainy season which sometimes leads to dry scotching of crops and ultimately retards crop growth and reduced yield. Few respondents recall that whenever dry spell occur at a critical periods of crops it led to low yield or crop failure.

2.4.5 Perception on High Temperature

Significant number of smallholder farmers of (89.9%) as part of sampled respondents in the Lower Niger River Basin area during a research, (2016), perceived that high temperatures particularly at the beginning of the rains and during long spells usually burn germinating

seeds. Smallholder farmers also reported a great loss of early yam seed through scotching of sprouting temperature, were always experienced in February and March when high temperature and low rainfall were always experienced. Smallholder farmers also reported rotting and scotching of germinating of maize seed in March and April.

2.4.6 Perception on Shortened Crop growing Days

A significant (69.2%) Smallholder farmers sampled respondents during a research in Sub humid part of Nigeria reported an unpredicted and unreliable onset and retreat of rains and shrinking of the rain growing season. According to them, more often than not crops grown there find it difficult to survive while fruiting or maturing with good yields. Respondents cited the experience of smallholder farmers in the wetter southern part of the study area (Location in the Lower River Niger) where climate support The production of early maize (April-July) and late maize (July-October) before 1980s, but which can hardly support in most of the years now. Guinea corn and rice suffer the same fate, particularly during the flowering period. This implies increased risk of crop failure due to reduction in crop growing season.

2.5 AGRICULTURAL PRODUCTION IN DASS L.G.A.

The study area is an agrarian society, almost all of the populations in the area are farmers, except for few business men and civil servants who are not even completely dependent on their business profits and monthly salary earnings to sustain their livelihood, Ali Garba, (2004). Thus, majority of the inhabitants in the study area are depending much more on agricultural activities for sustaining their livelihood than any other source of income.

The study area is a major producer of crops such as, rice, onion, tomato, sorghum, millet, maize, cowpea, groundnut, sugarcane soya beans, and a wide variety of vegetables. However, the major crop produced in larger quantities among many others mentioned is rice, followed

tomato and onion as their cash crop while maize and sorghum are their major cereal crops. The total land area estimated for rice cultivation in the study area is about 3000-6000 hectares (15 -20%) of the total land area BSADP, (2016).

The study area whose climate is often described to either guinea savannah, derived savannah or Sudan savannah, is obviously having advantage of rainfall duration over its neighboring areas in northern states, such as Kano, Yobe, Gombe, Maiduguri, Adamawa, Taraba. However, over the past, the area is said to have witnessed similar climatic challenges experienced in some of the neighbouring areas in northeastern states of the country, Ali Garba, (2006).

There has been stiff challenge for farmers in in the study area, approximately for the last 20-30 years. Among the challenges encountered in the course of time, unstable rainfall has been the greatest threat to agriculture, most especially to crops like maize, rice, and other vegetables whose drought resisting capacities are low, Hamidu (2001). And, the obvious challenges encountered in recent times are the uncertainty in the starting and cessation period of the rainfall in the study area. Rice, maize ,onion, tomato cultivation takes dominance over other crops being cultivated in the study area, these crops are known to require much of water or moisture in the soil on which they are cultivated before the expected yield are produced.

It is a common believe that all water on the earth comes from the air and are stored as surface water such as rivers, ponds, oasis, or underground water as spring and water table. NiMeT revealed that Nigeria's climate is characterized by strong latitudinal zone which becomes progressively, drier as one moves northward from the Atlantic coast in the south, and south western part of the country. Rainfall is the key climatic variable and there is a marked difference between the wet and dry season in most areas of the country. The study area use to experience starting rainfall by March to April, but the present starting period now is remains uncertain as the rainfall is continually becoming more erratic Bauchi State Agricultural

Development Program (BSADP) report on rainfall and crop production relationship (1997). For over two decades now when people in Dass L.G.A. have never boasted of having their rainfall by March or April, the earliest period they get their earliest rainfall now is either Mid May or early June, most rainfalls recorded in march, April, even early may are said to be false onset as asserted by Hernandez, (1988). Even if rainfall starts early April or May, it will hardly remain steady, so that, no farmer could bestow confidence on the nature of rainfall to start planting his crops immediate aftermath of the starting rain. Having experienced disappointment several times in the past, farmers avoid planting immediate aftermath of rainfall starting in early April, sometimes even in early May, they have always preferred seeing a steady rainfall at the starting period before cultivating their crops which are sensitive to water (rainfall) but such expectations have for most years proved elusive. The study area seems to have shallow water table almost all over the area because of the rocky nature of the area, and the kind of basement complex they have yet, they are not spared from the negative impacts of climatic fluctuation on water resources. The fact that my study area are major producers of rice, maize, and vegetables in Bauchi State, informs the degree to which rainfall variability can constitute a severe catastrophe to agricultural production in the area. The crop yield in this area has therefore dwindled on account of rainfall variability either leading to flood disaster or drought which have the potentials to render the crops useless as asserted by some farmers during a reconnaissance survey conducted in the study area,(2016) .

2.5.1 Irrigation Farming in Dass

Dass area has a kind of geology that enhances shallow water table as mentioned previously; If not for rainfall fluctuation that have often affected their water sources including table water/aquifer, the area look to have the potentials for dry season irrigation of crops such as maize, tomatoes, onion, and some vegetables Nyanganji, (2011), and Hamidu, (2005). There

are many farmers who are engaged in practice of agricultural irrigation in the area, most especially in the peak of dry season, which is believed to be more source of income than most crops they cultivate in rainy season, Hamidu, (2011).

It must also be pointed out that most of the farmlands used for irrigation activities are no longer supporting same capacity of agricultural irrigation as much as it did years back, even though, more agricultural technologies have been employed to enhance easy farming, encourage farmers to operate at larger scales than ever before yet, we have got a great cause to admit to this challenges. This raised the question of climate variability or change to have been the possible causes of such significant depletion of underground water that is known to have supported more irrigation in the past Hamidu, (2001). The water table in the study area used to be accessible at an average depth of 7.41mtres Nyanganji, (2011).

Artesian wells, local wells, rivers and streams located along the route of water tables have provided the opportunities for dry season irrigation in Dass L.G.A (BSWBD geological survey report 1988. It has also been observed that, the climate change and variability is causing more floods in the southern ecological zones of Nigeria than in the northern Nigeria, while the northern Nigeria are much more affected with drought and unstable rainfall than the southern ecological zones, this trends are also observable in my study area, and they remain the greatest challenges to agriculture. It has been observed that other non-climatic factors affect agricultural production but most of them cannot be as fatal as insufficient and erratic rainfall can be.



Plate 2; River Lutt in Baraza Ward, showing an irrigated area as part of the study area.

2.6 CLIMATIC VARIABILITY AND EFFECTS ON GLOBAL CROP PRODUCTION

(Hansen et al., 2011, Maxwell, and Fitz Patrick, 2012 and Lizumi et al., 2014.), Confirmed that numerous studies have suggested that climatic variability and climate change can have adverse impacts on global crop production and food security. Climate variability driven by Major inter annual-scale climate modes, such as the El-Nino Southern Oscillation, have been playing a key role by often leading to drought and decrease in crop yields that could further result in famine in some food insecure regions. Droughts in the United States of America, 2012, heat wave and associated wheat embargo in 2010/2011 and draught in Australia in 2006/2007 and 2007/2008 resulted in scarcity of cereal stock and steep increase in food prices likely worsening an access to affordable food for many consumers, including the poor in import-dependent countries according to findings by (Food and Agricultural Organization (FAO) 2007), (FAO) 2010 and (FAO) 2012. Ongoing climate changes and, associated changes in the intensity, frequency and duration of weather/climate extremes, in conjunction with growing population, dietary shifts are additional concerns for Global Food Security, for

example, Lobel et al., (2011) estimated that climate change and variability from 1980 to 2008 has already reduced global production of maize by 3.8% and wheat by 5.5% relative to counterfactual without climate change. Climate variability not climate change is the most significant problem people have in most agrarian societies of African dry land which, included the study area. The variability of rainfall defined as the average derivation from the mean, is enormous, sometimes up to 40-80% and increases up to 40-80% and decreases in annual rainfall totals especially in marginal areas such as the Sahara desert the Sahel and the sub- humid, Sudan zone, rainfall unpredictability poses enormous threats to agricultural production causing food deficits, localized and general food crisis. The impact of climate have for most part of the recent past triggered migration of farmers and herders in most part of dry land Africa of which Dass L. G. A. is not an exception.

The increasing rainfall variability in most part of Dass L.G.A has caused a very low recharge of aquifers, low river regimes, leading to scarcity of domestic water supply which has affected farming and pastoralism, hence general agricultural production, BSWB Geological survey team in collaboration with BSADP, (1988).

Climatic variability have always manifested itself in many forms in all parts of the study area, posing a severe peril to crop production which has in turn affected the local economies of the study area today. However, the impact of climatic anomalies naturally varies from one geographical location to another, just as locations and time are never the same, climate also varies in its display of characteristics, within space and time scale, this same climatic behavior are said to have been intensified in the study area. Complains and records have been documented regarding slight spatial variability in the study area despite its small size which should have spared it from this challenges, although spatial variability across the study area are not severe but variability have widely been accepted, most especially intra-annual variability. Some of these variations have not been shared proportionately among farming

areas in the study area. The direct impact of climatic variability to agriculture is practically seen in the inconsistencies, uncertainties, delay in rainfall starting period, early cessation as well as erratic raining Ekpoh, (2007). These are climatic situation that has often led to massive crop failure in many agrarian societies, which does not spare the study area. Sometimes, some seasons could offer excess rainfall that could result in catastrophic floods destroying crops, yet erratic.

A rainfall decrease of 29-49% has been observed in the 1968 -1997 period compared to the 1931-1960 baseline period within the Sahel region, (IPCC 2001). Also, a study conducted in Senegal showed a significant trend towards earlier cessation of the summer rains over a 43 years period from 1950 to 1992 with abrupt shift occurring around 1970 Camberbalin, and Diop, (2003). Other studies conducted in this same region have also noticed a trend towards delayed onset and early cessation, resulting in a shorter rainy season, hence insufficient moisture for crops as well as reduction in water resources in the affected areas (Houndenon, and Hernandez, 1998). Climate has many elements, affecting biological and human systems in different ways. The considerable spatial heterogeneity of climate change impacts has been widely studied, global average temperature increases mark considerable differences in temperature rise between land and sea and b/w high latitudes and low latitudes precipitation increases are very likely in high latitudes, while decreases are likely in most of the tropics and sub- tropical land regions (IPCC, 2007). It is widely projected that as the planet warms, climate and weather variability will increase.

2.7 CAUSES OF CLIMATIC VARIABILITY AND DROUGHT IN NORTHERN NIGERIA

Climatic variation in northern Nigeria is not altogether new because this part of Nigeria contains a significant portion of the Sudan-Sahel ecological zone of West Africa. However, since the early 1970s, climatic anomalies in the form of recurrent droughts, frightening dust storms and rampaging floods have overprinted their rhythms, creating short-duration climatic

oscillations as against the normal cycles of larger amplitudes. Thus the last 40 years have witnessed four severe droughts, numerous dust storms and three killer floods. Indeed, the climate of the region has become highly unpredictable, making many people to wonder what has happened to the climate, Adefalalu, & Kamara, (1986).

The persistence of drought in parts of northern Nigeria during the 1970s, 1980s and 1990s has been attributed to the prevalence of a stagnated anti-cyclonic circulation of the tropical atmosphere over areas that normally should be exposed to the rising arm of the tropical Hadley Cell circulation by mid-summer (Adefolalu, 1986; Kamara, 1986). These conditions are themselves related to the tropical component of the global general circulation system. Tropical circulation patterns are particularly influenced by heat inputs from such sources as warm ocean surfaces acting through latent heat released in deep cumulus convection, Lockwood, (1988). Related heat sources which also have important bearing on tropical circulations are high plateaus and equatorial rainforests (Nicholson and Tucker, 1998). These heat sources display visible latitudinal and longitudinal variations, and also a marked tendency to vary on both annual and, in case of oceans, non-annual scales. One of the consequences of these circulation patterns is that rainfall patterns in West Africa, including northern Nigeria, show both annual and greater than annual variations and also marked Teleconnections with distant locations (Nicholson, 1985; 1993).

Most of the droughts that occur in these regions have been found to be associated with a late start of the rainy season and early cessation of the rains, resulting in drastic reductions of the length of the rainy season. For instance, a number of studies within the Sahel region have shown a significant trend towards false onset (false onset is a situation where the rainy season starts normally and then ceases abruptly, creating a dry period between the false onset and the true onset. Late or delayed onset (late or delayed onset is a situation where the expected start of the rainy season is delayed, and early cessation (early cessation is a situation where the

rainy season stops far ahead of the expected time, of the summer rains over a 30-year period from 1969 to 1998 (Hernandez, 1998). In addition, long-term rainfall analysis for the area has observed frequent appearances of false onsets, as well as, a trend towards a pronounced decrease in annual rainfall amounts (Ekpoh, 1999, Floyd and Ekpoh, 2007).

While rainfall variability is a major characteristic of the Sudano-Sahelian climate, the last 40 years since 1969 have witnessed dramatic reductions in mean annual rainfall throughout the region (Diop, 1996; Ekpoh, 1999; Hulme, 2001). According to the Intergovernmental Panel on Climate Change, a rainfall decrease of 29 – 49 percent has been observed in the 1968 – 1997 period compared to the 1931 – 1960 baseline period within the Sahel region (IPCC, 2001). Also, a study conducted in Senegal showed a significant trend towards earlier cessation dates of the summer rains over a 43 year period from 1950 to 1992, with abrupt shift occurring around 1970, (Camberlin and Diop, 2003). Other studies conducted in this region have also noticed a trend towards delayed onset and early cessation, resulting in a shorter rainy season (Hernandez, 1998; Traore *et al.*, 2000). With further significant variations in the climate of the Sahel being predicted by General Circulation Models (GCMs), it is important that scientific studies be undertaken at regional levels so as to provide society with accurate information on the real and potential impacts of extreme climatic variability, as well as, the mitigation and adaptation options available. At a time when the world is grappling with diverse environmental problems including global warming, ozone depletion, acid rain, killer hurricanes, destructive thunderstorms, recurrent droughts and major flood episodes, any effort at finding explanations to these and other problems should be quite significant, since the environmental, social and economic cost of extreme climatic variability is bound to be enormous from the standpoint of society and human activity.

Drought is a condition of extreme but short term climatic variation which results in insufficient rainfall to meet the socio-economic demands of a region in terms of water supply

for domestic and industrial uses, agriculture and ecosystem. One of the earliest and most influential explanations of the cause of drought in the Sahel was that of Charney *et al.* (1977), which suggested that reductions in rainfall were the result of human activity. In what has come to be known as Charney's model, decreases in vegetation cover caused by over-grazing and deforestation lead to an increase in the reflectivity or albedo of the land surface. The essence of Charney's hypothesis is that this increase in reflectivity results in a reduction in the heating of the ground, which in turn reduces the heating of the atmosphere by the ground, resulting in a reduction in the convection that is essential for the formation of rainfall-generating clouds. The notion that the people of the Sahel have systematically degraded their lands through forest clearing, overgrazing, and inappropriate land-use practices has been an article of faith to many observers and researchers since the 1920s, especially by visitors to the region who have very often misinterpreted variations in annual rainfall amounts and decreases in vegetation cover, as evidence of environmental change or the encroachment of the Sahara desert. Also, drought in the region used to be attributed to a simple southward displacement of the Inter-Tropical Convergence Zone (ITCZ). This rather simplistic explanation has been rejected because it failed to explain many important characteristics of rainfall such as late onset or early cessation (Nicholson, 1989, 1993). Other studies have even suggested that the build-up in atmospheric dust, exacerbated by anthropogenic factors such as fire-wood exploitation, bush burning and poor farming practices, as well as, frequent sand storms, which cause changes in surface albedo may be responsible for large-scale climatic alterations in the Sahel (Ekpoh, 2007).

2.8 CAUSES OF CLIMATIC VARIABILITY IN TROPICAL ATLANTIC REGION

Although sea surface temperature anomalies in tropical Atlantic are weaker than those associated with the Pacific El-Nino, they are thought to play a role in sometimes disastrous climate hazards over the Americas and Africa. In the tropical Atlantic, rainfall is governed

by the annual migration of the sub-tropical high pressure cells on both sides of the equator and the changes in their strengths, as well as the North-South swings of the ITCZ. Many of the continental regions bordering the tropical Atlantic experience a sharp seasonal contrast in rainfall in which half of the year is wet and the other half is dry. Some have abundant rainfall, while others are semi-arid. It is in these semi-arid regions that a delay in seasonal rainfall or a significant drop in its total amount can bring serious hardship; for example SSA (the Sahel, 15° W-15° E, 15°-20° N) with its boreal summer rainfall and the Northeast corner of Brazil (Nordeste, 35°-45° W, 2°-10° S), where it rains in the boreal winter. There has been much study of the dynamics of climate anomalies in these two regions, Hastenrath et al., (1977). Moura Shukla et al., (1981) Hastenrath et al., (1984) found that the tropical Atlantic SST distribution and associated anomalies in SLP and wind are leading factors in determining anomalies in seasonal Nordeste rainfall. These same climatic factors were also found to be strongly linked to rainfall anomalies over the Sahel and western tropical Africa (Lamb, 1978; Hastenrath et al; 1984; Folland et al., 1986).

More than two centuries ago, missionaries noticed that year to year fluctuation in winter time air temperatures on both sides of Iceland were often out of phase with one another, Van loon and Rogers (1978). When temperatures are below normal they are above normal in Scandinavia, and vice versa. Simultaneously, coherent fluctuations in temperatures, rainfall and sea level pressures were documented, reaching eastward to central Europe, southward to sub-tropical West Africa and Westward to North America. This mode of climatic variability is now known as the North Atlantic Oscillation (NAO), a name first cited by Walker, (1924) and Rogers,(1984). It is now firmly established that its fluctuations influence climate from North America to Siberia and from the Arctic Ocean, to the equator and perhaps beyond.

CHAPTER THREE

MATERIALS AND METHODS

3.1 INTRODUCTION

Methods employed for this study are presented and discussed under the following contexts: Types of data, sources of data, sampling technique and sample size, method of data collection as well as data analysis.

3.2 SOURCES OF DATA

The data required for this research were obtained from Nimet office Bauchi, and Bauchi state agricultural development program (BSADP). Nimet office Bauchi provided climate data of temperature and rainfall for a period of 30 years from (1986-2015), for the study area (Dass), while Bauchi state Agricultural Development Program provided crop production data for rice and maize earlier selected as samples for the study area, these crop data were studied in relation to climate data which spanned for 30 years period both.

QUESTIONNAIRE DATA; An open ended questionnaire was another instrument employed to aid collection of primary information from the study area.

3.3 TYPES OF DATA

3.3.1 Primary data;

climate data of rainfall and temperature spanning for a period of 30 years for the study area is one of the primary data acquired from Nimet, which were later analyzed for the purpose of achieving the real substance of this study.

3.3.2 Open ended questionnaire data

The data acquired through an open ended questionnaire provided primary data which were mainly primary information the relationship between climate of the study area and crop production in the study area over 30 years period.

3.3.3 Secondary data

Crop production data of sample crops for the study area (maize and rice) per sq²m of hectares which spanned for a period of 30 years was the major secondary data obtained for this study.

3.4 SAMPLING TECHNIQUE AND SAMPLE SIZE

Purposive sampling procedure was employed to select the sample areas in the study area, and later random sampling procedure was also employed, the former sampling method requires the existing knowledge of the study area by the researcher, which must have been acquired in the course of visiting the study area, the pre- knowledge of the large agricultural areas with enough farming experiences were selected as samplesto which an open ended questionnaire earlier designed to capture information on climate and crop production relationship was administered, four areas were earmarked out of these large agricultural areas. Among these four prominent agricultural areas selected were wards such as, Dott ward, Baraza Ward, Wandu Ward, Bununu Ward, as Habila found out, (2016). Names of villages under these large areas were written and 5 villages were selected from each ward but, at random and each village presented five households with one experienced respondents to represent each of the selected households. This resulted to a total population of eighty people drawn from the sample areas.

Eighty questionnaires were produced to suffice the sample size and promptly distributed to the sample areas as follows; Four villages were drawn from each of the four wards, and five household were drown from each of the five villages selected from the four wards, which required 20 questionnaires for each ward. Figure 2 is the chart showing the breakdown of sampling procedure, questionnaire distribution, as well as its administration was conducted.

NAMES OF MAJOR AGRICULTURAL AREAS (WARD) WHICH WERE TAKEN AS RESEARCH SAMPLES

BARAZA WARD

1. Baraza
2. Buzuri
3. Gibkir
4. Bagan

WANDI WARD

1. Dawaki
2. Jeem
3. Abuja
4. Zing

BADEL WARD

1. Badel
2. Bagas
3. Gital
4. Bunjang

DOTT WARD

1. Kuletu
2. Unguwan Galadima
3. Bondi
4. Lutt

3.5 SAMPLE FRAME CHART FOR QUESTIONNAIRE ADMINISTRATION

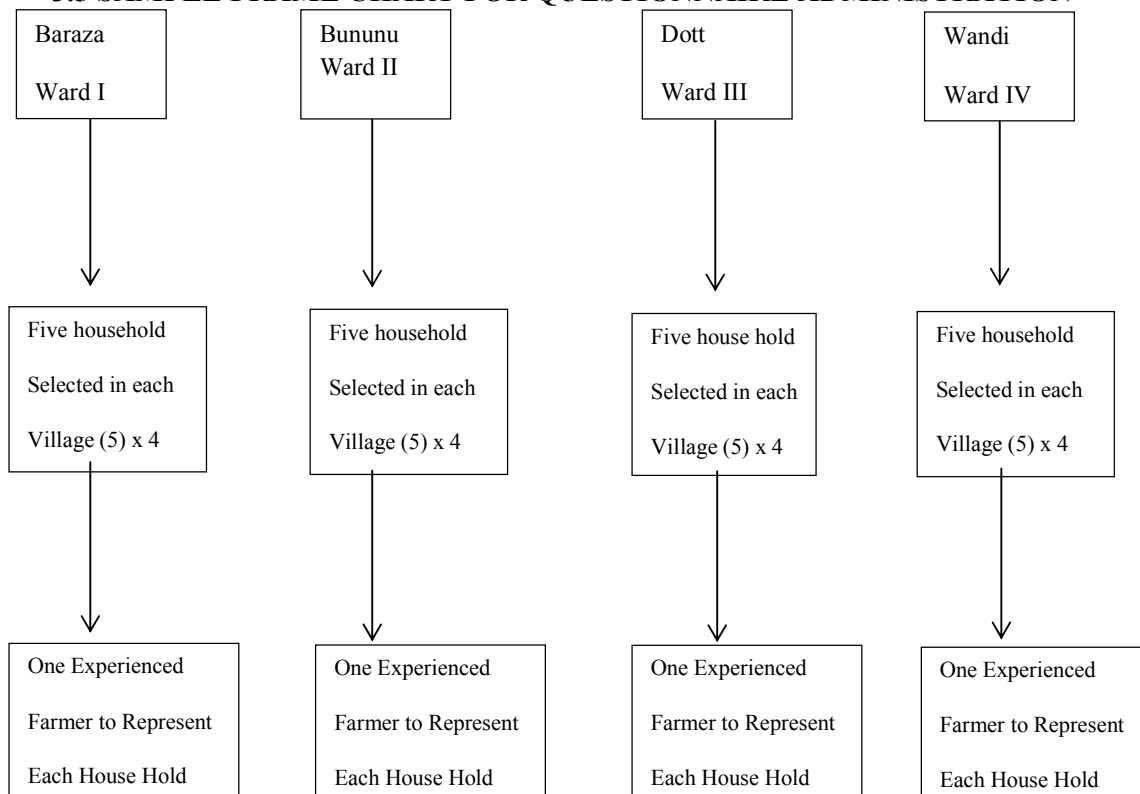


Figure 3: The Breakdown of the Sampling Fra

WARD SUMMARY

WARD 1	-	5 Respondents x 4	=	20
WARD 2	-	5 Respondents x 4	=	20
WARD 3	-	5 Respondents x 4	=	20
WARD 4	-	5 Respondents x 4	=	20

Figure: 3

Eighty (80) Questionnaire were

Produced to meet the above sample requirement;

3.6. METHOD OF DATA COLLECTION

Data collection is a way by which data required to be used in a research were obtained from their respective sources.

The data required for this study as earlier identified to be annual crop production data of sample crops for the study area (maize and rice) per metric sq, spanning for a period of 30years, and climate data (rain fall and temperature), for the study area also spanning for a period of 30 years from 1986-2015 were collected from Bauchi state agricultural development program and Nimet office respectively.

There were several procedures involved before these data were obtained from both sources. Several consultations were made at Nimet office Bauchi as to how the data could be obtained, the data base was apparently said to be under tied custody of the top officials and so it required official application, which was promptly written and forwarded. The climate data was released after an official approval of the request. Nimet itself collected the climate data temperature and rain fall, by means of instruments such as thermometer for temperature, and

rain guage for rain fall which are normally kept outside and exposed to temperature and rain fall respectively, but the instruments are always enclosed and protected from damage to ensure appropriate measurement of the two climate data.

Collection of crop production data from BSADP also involved certain procedures. An official request of the data was made through some of the top officers in charge of the data base. This also took quite sometimes before the data was released but, it was not complete at the beginning, an unwavering quest to obtain the remaining five years data from 2010- 2015 wasn't realistic until after about two years.

Bauchi state agricultural development program have several team of officers who are mandated to be taking crop production data of certain crops all over the LGA's of the state and, these involved active movement of the target areas and constant record keeping of crop performances. The crop data obtained from BSADP was the product of consistent service delivery on the part of BSADP officers.

3.7 DATA COLLECTION THROUGH QUESTIONNAIRE

Another method of data collection for this study was questionnaire survey instrument. An open ended questionnaire was specially designed to help in acquiring information regarding the farming history of the study area, information pertaining to crop production and its relationship with climate of the study area. The questionnaire was structured in such a way as to elicit the desired information from the respondents, especially on the behavior of climate influencing crop production as well as the perception of farmers on the impact of climatic variability on crop production in the study area. The questionnaire did not restricted respondents to its options only, but provided the opportunity for those who felt their opinion or perception on some farming challenges are not properly captured in the questionnaire, to express their thought in writing, or some issues not properly captured.

Inquiries on rainfall behavior such as, false onset, (which is a situation where rainfall starts normally but ceases abruptly or didn't continue even when the time is ripe to continue), delayed onset, rainfall cessation, drought and dry spell experiences in the course of their farming. Emphasis was laid on the timing, and frequencies of either their desired or undesired experiences emanating from climatic variability, see climate variability in pg1 of chapter 1.

3.8. ADMINISTRATION OF QUESTIONNAIRE

Farmers were contacted in their residences by the researcher, all of the sample villages were constantly patronized and requested to respond to the questionnaires, some were given the questionnaires and asked to take their times and carefully read through before responding. Inquiry was made on farming history of the study area, through the open ended questionnaire. Questions on the perception of farmers on rainfall variability challenges on crop production such as, delay in starting rain, true or false starting rain, delayed rain cessation and early cessation, possible variability in cessation and starting rain, drought, dry spell or excess rainfall leading to flood, how frequent they occur and their effects on crop production over the past 30 years, and the likes. The questionnaire also sought to capture information from more experienced farmers, those farmers who couldn't read nor write, interpreters who speak the same dialect were directed by village head or title holders' to assist in interpreting the questionnaires while the researcher was busy recording their views, this was done to circumvent the obvious language barrier. Farmers were not limited to the options only, but provision was made for them on the questionnaire to state other views they felt should have been mentioned, which were also captured and discussed in this research. Proper timing on how to meet respondents in their residences was a priority. Weekends were mostly the appropriate time to meet them.

3.9 METHOD OF DATA ANALYSIS.

Descriptive statistics and regression was employed to analyze both climate and crop data obtained for this study. Descriptive statistics such as mean, coefficient of variance, standard deviation, range were found to be the most suitable statistical tool to produce the desired result for this research. Afore listed statistical tool were employed to describe climate data (rainfall and temperature) for the study area, spanning for thirty yeas period as earlier mentioned. This same method further summarized the analyzed data in a simpler format for easy understanding and interpretation of the result.

Linear regression was another powerful statistical tool employed to analyze the relationship between the independent variables (rainfall and temperature data), and the dependent variables, two crop production samples for the study area (rice and maize) for a period of three decade. The process went further and conducted regression analysis between rice & rainfall, maize and rainfall, rice & temperature, maize & temperature. See appendix III, IV, V, VI, VII and VIII for details.

Multiple regressions were also employed to run analysis between one dependent variable crop production data of rice vs independent variables temperature, and rainfall. Another was ran between maize production data vs rainfall and temperature which helped the research predicted at what significant or percentage level was the impact of climate (rainfall and temperature) on crop production of the study area over a period of 30 years. See appendix VII, VIII, for details.

The Statistic Formulae Employed;

1. Mean= $\bar{x} = \frac{\sum x}{n}$

2. Coefficient of variance= $CV = \frac{\sqrt{\frac{\sum(x-\bar{x})^2}{n-1}}}{\frac{\sum x}{n}} = \frac{\sigma}{\mu}$

3. Standard deviation= $SD = \sqrt{\frac{\sum(x-\bar{x})^2}{n-1}}$

4. Linear regression= $y = \frac{n \sum xy - \sum x \sum y}{n \sum x^2 - (\sum x)^2}$

5. Multiple regression= $b_1 = \frac{(\sum x_2^2)(\sum x_1 y) - (\sum x_1 x_2)(\sum x_2 y)}{(\sum x_1^2)(\sum x_2^2) - (\sum x_1 x_2)^2}$ $b_2 = \frac{(\sum x_1^2)(\sum x_2 y) - (\sum x_1 x_2)(\sum x_1 y)}{(\sum x_1^2)(\sum x_2^2) - (\sum x_1 x_2)^2}$

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1. INTRODUCTION

This chapter presents an analyzed data used for these studies in two different sections A and B; Section A presents an analyzed questionnaire data acquired from the study area which was subsequently discussed. While section B present an analyzed climate data (temperature & rainfall) for the study area which was achieved by means of descriptive statistics and regression. Crop data of maize and rice for the study area were analyzed concurrently with the climate data earlier mentioned by means of linear regression and multiple regressions which unveil the true relationship that has taken place between crop production and climate over the period of thirty years earlier stated. These results are presented and discussed subsequently.

4.1. DATA ANALYSIS AND PRESENTATION

4.1.1. Bio Data Analysis

Table 1; presents demographic characteristics of the respondents drawn from the sample areas of the study area. i.e. age, gender, marital status, as well as occupation of the respondents are presented.

The information on the age structure of the respondents captured through questionnaire was computed to produce percentages of the three age groups. The percentages as presented clearly revealed that the age group 36-45 constituted 50% of the total respondents, followed by 46-140, while the most youth full age group 30-35 years had 23.4%, the age distribution appears to have large number of labor force in the population. Gender distribution also revealed that females were surprisingly larger in number than the male respondents, which could be an indication that females are probably more actively involved in farming activity than males in the study area. The percentage of married respondents of (88.4%) which is clearly showing a wide margin against the (11.6%) unmarried respondents could explain the

culture, religion, and custom of the community which does not encourage late marriage as both religions being practiced there believed that prosperity is only realistic after getting married.

Respondent's occupation was also inquired, recorded, analyzed and, presented. The information captured as presented on table:8 revealed that number of respondents who depends solely on farming as their lone occupation constituted the highest number of's respondents with 36.4% followed by those who are civil servant and yet farmers, and host of others who are also said to largely depend on farming. The information therefore, indicate that all of the respondent are farmers, but more important information here is the fact that largest number of the respondents are farmers who can't depend on only one occupation without farming, and those who have farming as their only means of livelihood. This information provided a supportive evidence (kurukulasuriya and Nhemachemna's) assertion in which they stated that Sub Sahara, and Sudano Sahelian region of Africa are considered most vulnerable to the impacts of climate changes and variability, because of their overdependence on agriculture and natural resources.

Table 1: Demographic Characteristics of the Respondent

Age	Frequency	Percent
30-35years	18	23.4
36-45	39	50.6
46-140	20	26.0
Gender	Frequency	Percent
Male	29.9	23
Female	70.1	54
Total	100	77
Marital	Frequency	Percent
Single	12	15.6
Married	65	84.4
Occupation	Frequency	Percent
Civil Servant	7	9.10
Farmers & Civil	19	24.70
Farming Only	28	36.40
Farming & Trading	15	19.50
Farming & Others	8	10.40

Source: (Field work, 2016/2017)

4.8.2. Drought Experience by farmers

Table 2; is the presentation of respondent's percentages and a table giving a clear picture of the respondent's reaction to the three optional questions. The questions as stated on the table, inquired farmer's experiences on drought in the course of their farming activity over a period of 30 years. This was done in order to have an idea of how frequent such phenomenon has been recorded.

As can be seen on this table, the percentage of the number of respondents who agreed that such experience has been recorded “5 times in a decade” got the highest percentage of (49.4%), next to this was the option two which inquired, “less than five times in a decade “ with (36.4%), while the last option are the percentages of those who disagreed with the two options stated earlier, insisting that no drought has ever been recorded in the last one decade with “14.3%) only.

The result of the respondents presented on table 2, conformed to the findings of (Diop,1996, 1999, Hulme, 2001) in which they asserted that rainfall variability has been the major characteristics of Sudano-Sahellian climate ,which has resulted to dramatic reduction in mean annual rainfall since 1969.

Table 2: Drought Experienced by farmers

	Frequency	Percent
5 times & above in 10 years	38	49.4
Less than five times in 10 years	28	36.4
No drought experience in 10 years.	11	14.3
Total	77	100.0

(Source: Field Work, 2016/2017)

Table 3: Displayed the computed number of respondents to a question seeking to know if famers in the study area have been experiencing dry spell amid rainy season. The question as can be seen was designed to capture information in all the possible time within which such dry spell may have taken place starting from the possible rain onset to cessation time as well as capturing the frequencies of such occurrences.

As can be seen from the presentation “month of May” emerge the highest with the percentage of respondents of (44.2%), this confirmed the findings and assertion that many studies carried out within the sudano- sahellian region have shown a significant trend towards false onset (which is a situation where rain starts normally, and then ceases abruptly, creating a dry period of between the false onset and the true onset, (Hernandez, 1998, Ekpoh, 1999, Floyed and Ekpoh, 2007).

The “month of June” was next to month of May discussed subsequently, where respondents percentage was (27.3%), followed by “month of July” having (11.7%), which are further confirmation of the assertion made by Hernandez et al, (1998, 1999) below. The month of august came fourth when the month September-October had the least in this sequence.

As the responses for these question appears, it looks so apparent that dry spell experience in the study area have always taken place in the prime or mid of rainy season, if the information captured from the respondents are fair. It’s also worth mentioning that the study area having located at Gunea- Savannah and, at the Sahellian fringes, could never have been exempted from certain climatic extremes.

Table 3: Dry Spell experienced by farmers

	Frequency	Percent
May	34	44.2
June	21	27.3
July	9	11.7
August	8	10.4
September	5	6.5
Total	77	100.0

(Source: Field Work, 2016/2017)

Table 4; Presents number and percentages of responses to the questions, five options were provided for the respondents and the options were developed in such a way as to stimulate response from the respondents to provide the expected information on the frequency of occurrences of dry spell in the study area from (1986-2015).

As the result appears on table 4, the reaction of respondents to the options conformed to the assertion that most of the droughts that occur in the Sudano -Sahellian regions are found to be associated with late start of rainy season and early cessation of the rains, resulting in drastic reduction of the rainy season (Nicholson, 1985, 1983: Hernandez 1998). The percentage of respondents who went for this option provided a clear proof that the study area must have battled dry spell on several occasions in some rainy seasons in the past, as the respondents in the majority admitted such dry spell have been recurring “twice a year” or “thrice a year” with (39.0%) and (32.5%) respectively, these two options are closely related and got so close number of respondents. Behind the first two group of respondents, were respondents who believed that “dry spell occurs once in a year” with (22.1), while the option to capture the number of respondents that didn’t believe such occurrences have been taking place had as few as (6.5%).

Table 4: Dry Spell Frequency

	Frequency	Percent
Most of the years we have no Dry spell	5	6.5
Once in a year	17	22.1
Twice in a year	30	39.0
Thrice or more times in a year	25	32.5
Total	77	100.0

(Source: Field Work, 2016/2017)

Table 5, presents the percentages of respondents for the stated three questions seeking to capture from respondents the rate at which dry spell occurs in the study area, whether it increases or decreases over the past three decade.

As can be seen from table :5, option “20-30yrs” got the least percentage of respondents of (19.5%) , when the option asking of “11-19yrs” occurrence got the highest percentage with (51.9%), and second to this were respondents who agreed that the rate of occurrence has increased over “the last 10yrs” with (28.6%), comparing these two would give a viewer an insight to the fact that people in the study area widely believed that rate of occurrences has been on the increase for over a decade ,which point to the reality of rainfall variability. The information captured from the respondents are in perfect consonant with assertion of Hestenrath et al., (1984), who insisted that many of the continental regions bordering the Tropical Atlantic experience a sharp seasonal contrast in rainfall which halve of the year is wet and the other is dry : Some have abundant rainfall while some are semi- arid, it is in these semi- arid and those continents at their borders that are prone to have a delay in seasonal rainfall as well as significant drop in its total amount of rainfall which has always resulted to serious economic hardship. These findings described a lot of current climatic challenges in the study area.

Table 5: Dry Spell Getting severe or less

	Frequency	Percent	Valid Percent	Cumulative Percent
Last 20 - 30 year	15	19.5	19.5	19.5
Last 11 - 19 years	40	51.9	51.9	71.4
Last 10 years and above	22	28.6	28.6	100.0
Total	77	100.0	100.0	

(Source: Field Work, 2016/2017)

4.1.3. Drought Effects

Table 6; was a two optional question that captured information on the effects of drought on farmers, purposely to know from the respondents the possible effects of drought on crops and domestic water supply in the study. The number of respondents that reacted to the options was analyzed by, which produced a table that was not presented.

Majority of respondents of (71.4%) believed to have suffered crop failure, hunger, poverty each year they were stricken with drought, however some of them further explained that not all drought result to this condition, but drought that were so severe with wide spatial coverage. Water scarcity was said to have manifested in most of their domestic water sources, and such challenges were encountered when such seasons were preceded by extreme drought. While (28.6%) of the remaining respondents did not believe such phenomenon has been responsible for water scarcity. This condition as revealed by this finding is almost a replica of a climatic condition described by Houndenoun, and Hernandez, (1988), whose findings on climate issues in Africa, prompted them to assert that delayed and early cessation of rainfall is resulting in short rainy season, hence insufficient moisture for crops as well as reduction in water resources in the Sudan Sahel regions are clear products of climatic variability.

Table 7: Had two options inquiring respondent's views on the likely impact of dry spell on farmers during the rainy season, most especially on cropping area and cropping intensity. Only two options "Yes" and "No" were provided to which respondents reacted based on their individual experiences, but the table is not presented.

Almost 100% of respondents agreed to have been compelled severally by dry spell to change most of their plans towards farming, most especially when they are hit by early dry spell, their intended farm sizes are mostly reduced for fear of unpredictable rainfall behavior as well as the varieties of crops to cultivate, irrigation farming are also liable to be affected as asserted by some respondents. The number of respondents disagreeing to the influence of dry

spell on their farming plans was quite insignificant, with only (11.7%), when this is compared to (88.3%) of the respondents who admitted that dry spell signs have often determined what to produce, where to produce, when to cultivate, and where to cultivate as Nicholson, (2009) asserted. There can't be a ground for arguing that dry spell has not influenced crop productivity in many ways in the study area.

Additional remarks: some of us were often forced by dry spell to postpone some early farming projects due to fears of future dry spell.

4.1.4. Farmer's View on Rain Onset and Cessation Challenges

Table 8; Presents the percentages of respondents for each of the options, which were designed to aid in achieving the goal for the options stated which are inquiries on rainfall onset, and cessation in the study area. As the table presents, the largest percentage of respondents went for May with (67.5%), which gave the evidence that onset rain are mostly expected in May unlike in early and late 80s when onset rainfall use to commence in middle march-early April, this also confirmed the fact that some unknown factors must have forced rainfall behavior to change at the detriment of crop production, most especially when a reference is made on the findings of (Houndenoun and Hernanbdez, 1988), who asserted that, climate of Sub Saharan Africa has recently exhibited an undesired, strange behaviors by delaying onset rainfall, bringing false onset rain as the rainfall could start normally but ceases abruptly, only to be trailed by drought, unsteady rain, yet early cessation of the rain. Some of the respondents who believed that onset rain begins in March and April were not in any way close to May option, looking at the result on the table below you could see that both have (13.0%) and (10.4%) respectively, month of June came last but got almost the same respondents with April which got (9.1%). This result in my opinion confirmed that May is the month of onset rain yet, it's worth mentioning that some starting rain in March, April, May are mostly false onset, this is why June could be regarded by some farmers as month of rain

onset, as sometimes true onset are recorded in June, rainfall becomes more steady to provide sufficient moisture for crops, and all of these challenges are the result of rainfall variability bedeviling agriculture and livelihood.

Table 6: Onset Rain in the Study area

	Frequency	Percent	Valid Percent	Cumulative Percent
March	8	10.4	10.4	10.4
April	10	13.0	13.0	23.4
May	52	67.5	67.5	90.9
June	7	9.1	9.1	100.0
Total	77	100.0	100.0	

(Source: Field Work, 2016/2017)

Table 7: Presents respondents reaction to the options stated on the table, which were developed to prompt respondents give information on how regular onset rain has been experienced over 30 years period in a particular month. As can be seen, the table and a bar chart presentation of the respondent’s views on the inquiry revealed that, month of May is widely believed to have offered a regular onset rain than other months with a clear margin of (39.0%) ahead of other months. However, having recorded a significant number of respondent for March-April, and June (36.4%) and (24.7%) respectively, it’s worth asserting that, the onset rain has never been quite regular in a particular month but, may have roamed in between these months (May, June, March, April), this meant that onset rain may have been recorded sometimes or in any one of the month given as option at some seasons, compounding agricultural plans of the study area.

Added remark: Some respondents asserted that rain onset has exhibited irregular behavior for the past 15-20yrs,

Table 7: Irregular Starting Rain fall

	Frequency	Percent	Valid Percent	Cumulative Percent
Sometimes March -April	28	36.4	36.4	36.4
Sometimes may	30	39.0	39.0	75.3
Sometimes June	19	24.7	24.7	100.0
Total	77	100.0	100.0	

(Source: Field Work, 2016/2017)

Table 8: After an inquiry on rainfall onset regularity, it was deemed essential to also inquire of the effects changing rain onset within the months of the rainy season has posed on agricultural activities: As presented on this table, three options were developed to aid in capturing information from the respondents on the possible impacts as indicated by the options on table 8. The respondents in majority with (40.3%) agreed to have been affected by changing onset time because they are often forced to cultivate late as the onset time become uncertain leaving farmers in suspense, thereby resulting to low yield. This is so because late cultivation will lead to insufficient moisture as rain cessation time can neither be extended nor stopped against the course of nature.

There were still (28.6%) respondents who believed that situation of changing onset has mostly led to late cultivation of crops resulting to low yield because of insufficient moisture, as rainfall ceases at a time when they are not satisfied. A good number of respondents with (31.2%) almost equaling the highest, believed that changing rain onset has the potentials to predispose crops to disease and pest as, when onset is delayed farmers are forced to cultivate late. Looking at the response of farmers on this question, the information appears worth concluding that all the impacts stated below, are combined consequences of changing onset experienced by farmers in the study area.

Additional remarks: Some respondents added that delayed onset has been one of the greatest challenges of recent time, because crop growing days are reduced thereby, reducing our crop yield.

Table 8: Changing Rainfall Onset Affecting Crop production

	Frequency	Percent	Valid Percent	Cumulative Percent
Late Cultivation	22	28.6	28.6	28.6
Late cultivation and low yield	31	40.3	40.3	68.8
Predisposition to diseases and pest	24	31.2	31.2	100.0
Total	77	100.0	100.0	

(Source: Field Work, 2016/2017)

Table 9: An inquiry was made on possible onset time variation across the study area. The percentage of the respondents for the three stated options was analyzed and presented on table, respondents in majority opted for “less than one month difference” showing a great disparity with others, followed by the second option “1-2month diff” with (15.6%) and lastly, only (1.3%) for option “more than 2month diff”. Looking at this result, the last two options got percentages that are not significant to warrant arguing with the views of the first set of respondents. This result proved that spatial variation in starting rain across the study area has never been recorded with greater time difference than 1-4 weeks. However, It’s worth mentioning that, it takes some agricultural crops small time to loss their vigor as well as fruiting ability, most especially the years when rain onset spatial variability become unusually pronounced.

Table 9: Possible Spatial Variation in Rain Onset

	Frequency	Percent
Less than one month difference	64	83.1
1 - 2 months difference	12	15.6
More than 2 months difference	1	1.3
Total	77	100.0

(Source: Field Work, 2016/2017)

Table 10; Presents the result of an inquiry on farmers most preferred onset time, on this table the computed percentages of respondents are presented fore suitable viewing. Three options were provided for the respondents and the percentage response for each was recorded.

As can be seen, majority of the respondents with (71.4%), preferred to have their starting rain by March-April. This according to farmers further views, “option March-April” use to be their best and constant onset time several years ago but, starting rain has gradually shifted to May and June, and yet, unpredictable. Some few respondents preferred May, and probably because they lose confidence on March and April. An insignificant percentage of (5.2%) was recorded for June-July which could be regarded as an indication that starting rain are not preferred in this month except when it becomes a necessary phenomenon. Hestenrath, and Nichol森, (1999), confirmed that climate of regions at Sahelian fringes are bound to have late starting rain, & frequent drought.

Table 10: The Most Preferred Rain Onset Time

	Frequency	Percent	Valid Percent	Cumulative Percent
March-April	55	71.4	71.4	71.4
May-June	18	23.4	23.4	94.8
June-July	4	5.2	5.2	100.0
Total	77	100.0	100.0	

(Source: Field Work, 2016/2017)

Table 11; After an inquiry on the most preferred onset time (month) from the respondents, the process proceeded to inquire of their current rain stopping time (month) based on their past experiences. The inquiry was made so the research could get direct information on their past experiences pertaining to rain stopping time, so that the information would be used for comparison with an analyzed climate data as well as literature reviews presented in the preceding chapters, to enable this research see how realistic and related are their information to these findings.

As presented on the table, the highest percentage of respondents (48.1%) believed to have their rain cessation time by October, however, a percentage close to this was recorded for people who believed that rainfall cessation time is now mostly recorded in September with (36.4%), this poses a strong argument against the former because they could be right if on several occasions or seasons such experiences were recorded. They may also have resolved to consider September their current rain stoppage time if rainfall recorded in the month of October in recent years have been far below the normal/preceding decades. “October-November” and “August-Early Sept” options got an insignificant percentage to stand as an evidence that cessation time are rarely recorded in these month given a current complain on rainfall behaviors.

Table 11: Rainfall Cessation time?

	Frequency	Percent	Valid Percent	Cumulative Percent
September	28	36.4	36.4	36.4
October	37	48.1	48.1	84.4
October – November	10	13.0	13.0	97.4
August – early September	2	2.6	2.6	100
Total	77	100	100	

(Source: Field Work, 2016/2017)

Table 12: An investigation was conducted on changing rain cessation time across the study area, by means of questionnaire, in which four options were provided seeking to know if rain cessation time have been changing and, by what time margin it has changed over the past 3 decades. Looking at the result as presented on table 12, largest percentage of respondents was divided between September and October with (55.8%) and (36.4), respectively. The result obtained, provided evidence that, rain cessation time has mostly been recorded in September in the last 10yrs, followed by October in the last 15yrs which, also got quite a good percentage. The months of November and December have rarely recorded cessation. As they appear on the table below, it shows that there are few among the respondents who may have witnessed cessation in months of November and December during the early or mid-80s.

Table 12: Changing Rainfall Cessation Time

	Frequency	Percent	Valid Percent	Cumulative Percent
Sept. Oct. against Nov. in last 10yrs	43	55.8	55.8	55.8
Oct. against Nov. in last 15yrs	28	36.4	36.4	92.2
Nov. the last 30yrs	5	6.5	6.5	98.7
Dec. the last 30yrs	1	1.3	1.3	100.0
Total	77	100.0	100.0	

(Source: Field Work, 2016/2017)

Table 13; is a presentation of respondent's views on three questions seeking to elicit valid information on the effects of changing cessation time across the study area. As the result appears, it is very clear that the highest percentage of respondents are those who believe that "diseases & poor harvest" has always trailed incidences of a changing rain cessation, as farmers assertion on the undesired experience revealed that when the changes occurs in odd time crops are affected, especially when cessation occurs much earlier than the expected time this is said to have the potentials to predispose crops to diseases as well as affecting their maturity. These all together reduces crop yield, second highest in percentage was an option "Disease only" with (36.4) trailing behind the (55.8%) discussed earlier. It is evident that respondents have acknowledged that deficiency of precipitation renders crops highly vulnerable to diseases, as good number of respondents believed that disease and pest are mostly encountered when farmers are stricken with a premature cessation. The smallest percentage of respondents was also recorded for those who believed early cessation is only reducing crop yield.

Table 13: Changing Rain Cessation Time Affecting Crop Yield

	Frequency	Percent	Valid Percent	Cumulative Percent
Disease and poor harvest	43	55.8	55.8	55.8
Disease and pest	28	36.4	36.4	92.2
Poor harvest only	6	7.8	7.8	100.0
Total	77	100.0	100.0	

(Source: Field Work, 2016/2017)

Table 14; presents respondents information on possible spatial variability of rain cessation time across the study area as stated, four options were provided for the questions as can be seen, in order to acquire the needed information. After a successful administration of questionnaire, the result was analyzed to produce percentage for all the options.

The various responses as compiled on table 14, shows highest percentage of respondents of (32.5%) for people who believed that the spatial variability of rain stopping time has always remained less than one month, next to this respondents were people who believed that rain cessation time remains virtually the same across the study area with (29.9%). If these results are studied carefully, the respondent's view has provided an evidence that spatial variability of rainfall cessation time has never occurred with a significant time margin. The time differences within which such variation may have taken place could never have been more than 1-4 weeks. Going by their responses, one could see that largest number of respondents agreed to have had the experience, yet , we have another good number close to this who did not believe such variability exist. Besides these group of respondents discussed earlier, there were yet another group of respondents, who said "often have slight differences" while some few among the respondents believed that 2-3months variability have been recorded.

The consequences of such spells as asserted by farmers, is the likelihood of massive crop failure, when crops in some areas were cultivated later than others owing to the influence of

late rainfall onset spatial variation, yet stricken with early cessation. In the other hand, areas where crops were cultivated much earlier than others because they were fortunate to have early rain onset are most likely to be ruined by an extended cessation, as such rainfall might be falling beyond the crop requirements.

Additional remark...The explanation the preceding table, is the description of some agricultural dilemma as asserted by good number of respondents.

Table 14: Possible Spatial Variation in Rainfall Cessation

	Frequency	Percent	Valid Percent	Cumulative Percent
Mostly less than one month difference	25	32.5	32.5	32.5
Mostly 2-3 months difference	9	11.7	11.7	44.2
We often have just slight differences	20	26.0	26.0	70.1
Virtually the same time	23	29.9	29.9	100.0
Total	77	100.0	100.0	

(Source: Field Work, 2016/2017)

Table 15; presented some inquiries on the effects of rainfall cessation variability across the study area, in order to capture information on how such spatial variation as perceived by some farmers may have affected crop production in the study, five options were provided and freedom given for respondents to offer more explanation if they didn't feel satisfied with the options.

The presentation shows so clearly that respondents expressed different views on the effects of variation in rainfall cessation time. As the presentation revealed, farmers in the study area

believed that such spell has always affected crops in many ways, this is why respondents were recorded for every option, however, the highest percentage was record for the first option with (37.7%), for farmers who believed that “variation in crop yield” is the commonest indicator of such spell, especially in areas where the cessation occurred too early. There are respondents who said that such a spell can determine the kind of disease and pest that can attack crops, because insufficient rainfall enhances disease and pest infestation with (11.7%) which is in conformity to Hastenrath’s assertion (1999). Another group of respondents with (36.4%) almost equaling the highest percentage stated earlier, held the believe that, such spell has resulted to slight variation in rainfall & consequently crop yield, yet some respondents believe that such variability has never been significant and so has only caused differential weather across the study area.

Table 15: Slight Spatial Variation in Cessation affecting Crop Production

	Frequency	Percent	Valid Percent	Cumulative Percent
Crop failure and poor harvest	29	37.7	37.7	37.7
Disease only	9	11.7	11.7	49.4
Slight variation in rainfall & crop yield	28	36.4	36.4	85.7
Variation of weather	11	14.3	14.3	100.0
Total	77	100.0	100.0	

(Source: Field Work, 2016/2017)

Table 16: Farmers were inquired to recall their past experiences of having normal rainfall that enhanced high yield at the end of some rainy seasons. The questions were prepared in such a way that the frequency of such occurrences would be captured within period of a decade. Four options were provided seeking to know how frequent such rainy seasons are recorded in a decade. Looking on the table you could see that majority of respondents believe to have been

recording such rainy season more than “5 times in 10yrs” with (42.90%), however, another group came close to this with (36.4%), believing such rainy season are “1-2 times in 10yrs”. With these two set of respondents agreeing to have recorded such rainy season with such frequencies, it gave evidence that despite the current challenges of frequent dry spells over the past years, normal rainy season have been recorded in some years back, resulting to high yield. Those respondents who believed they experienced such rainy season “3-5 times in 10yrs” were (15.6%) and only (5.2%) for respondents who do not believe they have been having such rainy season. The respondent’s reaction to the inquiry varying from one group to another could be blamed on lack of proper record keeping of such events.

Table 16: Normal Rainy Season Experience with High Crop Yield

	Frequency	Percent	Valid Percent	Cumulative Percent
1 - 2 times in 10 years	28	36.4	36.4	36.4
3 - 5 times in 10 years	12	15.6	15.6	51.9
More than 5 times in 10 years	33	42.9	42.9	94.8
None in 10 years	4	5.2	5.2	100.0
Total	77	100.0	100.0	

(Source: Field Work, 2016/2017)

Table 17: An inquiry was made to capture information on situations where excess rainfall was recorded but dry spell was also experienced the same rainy season such that, crops were affected. The responses captured for these inquiries revealed that, majority agreed to have had such an experience of recording excess rainfall in some seasons and yet a dry spell affected their crop production. This has been a common complain on the part of farmers which stands out as a proof that experiencing high rainfall is not a guarantee for improvement on crop production, and so consideration must be given to how the rainfall was experienced,

for instance if the rainfall is not recorded in good time, frequent break, heavy rains constituting catastrophes rather than what it is wanted for, early departure of the rain and host of others. This table however wasn't presented but only the respondents views captured were reported.

Table 18: Presents respondents view on the stated options designed to capture information on the impacts of certain flood disasters that may have affected farmlands, which forced farmers to take decision to flee the area and cultivate on a smaller scale elsewhere. To achieve this, respondents were requested to choose from the options as to the ways in which they are affected.

This investigation was carried out so that the research could see in what ways and to what extent has such conditions affected cropping area of the farmers in the study area. As the presentation reveals, majority of respondents with (39.0%) believed that such floods have destroyed crops on farmlands, which gave the evidence that some decision regarding an intended farming projects are affected as farmers could take a sudden decisions to postpone some farm projects when flooding signals are seen on the farmlands. Sometimes farmlands are abandoned after early stage of cultivation when flooding threat is noticed on the farmlands. This condition reduces cropping area.

Those who agreed that flood condition has often caused waterlogging on farmlands to inhibit cultivation got (33.8%), while those that believed the impacts are limited to clearing top soil got (27.3%). All of these are evidence that farmers understand the consequences of flood on agriculture.

Table 18: Flood Disaster Forcing Farmers cultivate less

	Frequency	Percent	Valid Percent	Cumulative Percent
Clearing the top soil	21	27.3	27.3	27.3
Causing water logged on the farm land	26	33.8	33.8	61.0
Destruction of the cultivated crops	30	39.0	39.0	100.0
Total	77	100.0	100.0	

(Source: Field Work, 2016/2017)

4.1.5. Types of Crops and Challenges

Table 19; Presented information on an inquiry into the major crops being produced in the area, in order to use the data and gain an insight to the potentials the area could have for irrigation activity as well as using some crops as evidence of fair rainfall or moisture conditions for crops.

As the table presents, tomato and rice are the major crops being produced in the study area, probably due to fair rain and moisture or other agricultural attributes inherent in their areas. Maize and onion are the crops next to the former. Millet and others came last.

Table 19: Crop Production Ranking

	Frequency	Percent
Rice	28	36.4
Maize	10	13.0
Tomato pepper &	28	36.4
Onions	7	9.1
Millet and others	4	5.2
Total	77	100.0

(Source: Field Work, 2016/2017)

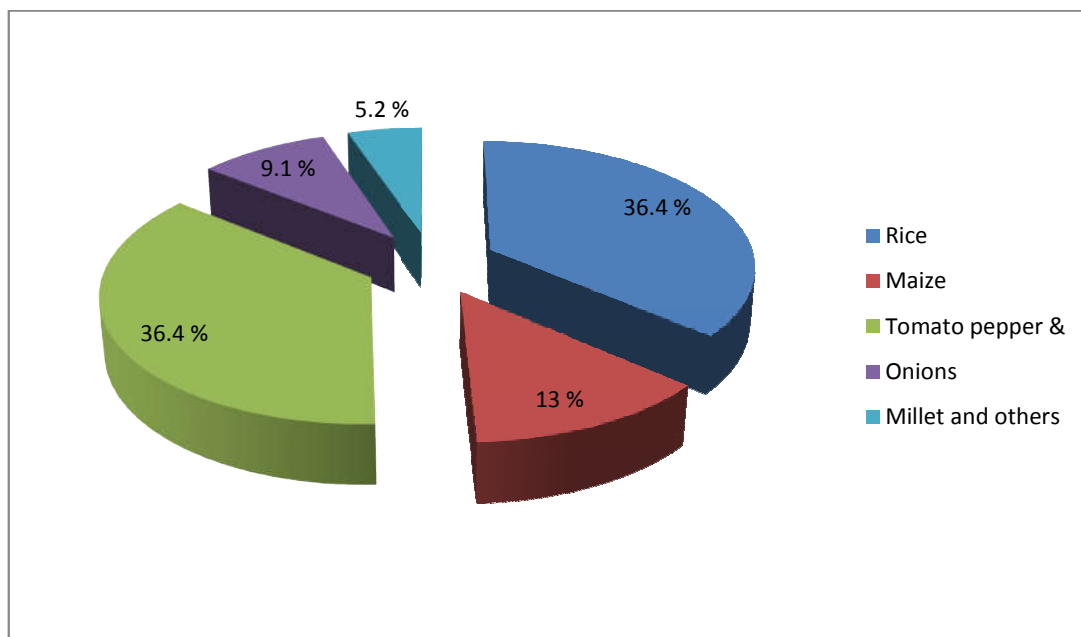


Figure 4: Crop Production Ranking

Table 20: presents reports on crops productivity status on sample of the listed crops. Respondents were requested to indicate on the options which crops are least produced. After the questionnaire survey, the result of the respondents were compiled and analyzed as presented, this result is confirming other findings in the preceding chapters where discussion on crops being cultivated at higher scale than others because of certain favorable factors in the study area were reported. As it is, those with the highest percentage are crops that are least produced, while the least on table are the highest. Crops least produced as revealed by the presentation are crops such as millet, sugarcane & others.

Table 20: Least produced Crops

	Frequency	Percent
Millet	19	24.7
Sugar Cane	16	20.8
Groundnut	18	23.4
Maize & tomato	3	3.9
Onion	5	6.5
Rice	6	7.8
Cowpea	10	13.0
Total	77	100.0

(Source: Field Work, 2016/2017)

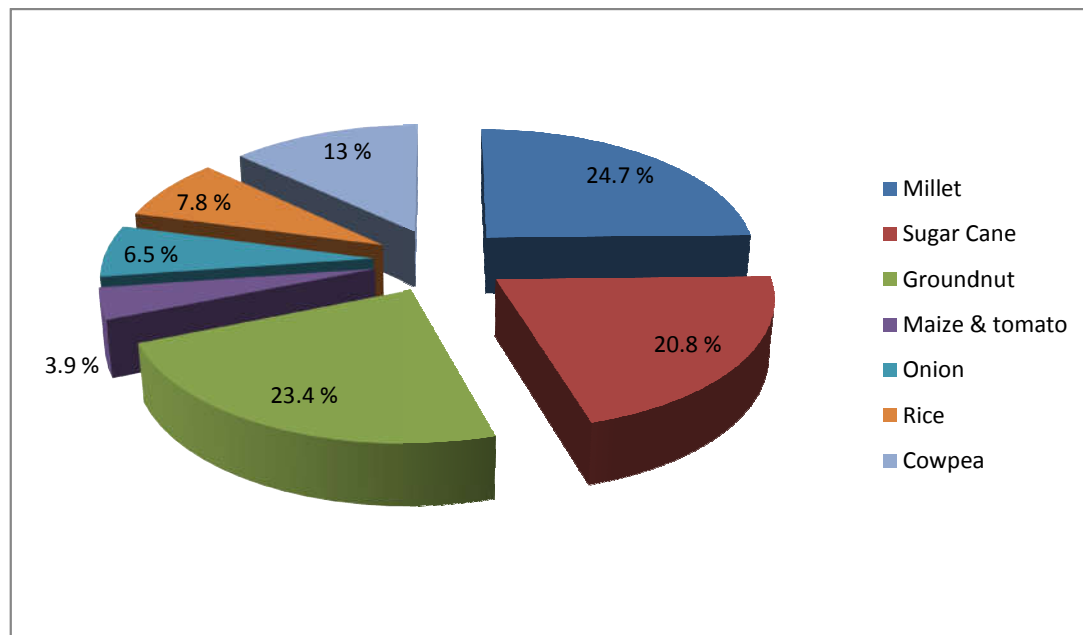


Figure 5: Least Produced crop

4.2 RELATIONSHIP BETWEEN CROP PRODUCTION AND CLIMATE

4.2.1 Introduction

This section presents an analyzed data used for these studies; climate data (temperature & rainfall) for the study area were analyzed by means of descriptive statistics and regression.

Crop data of maize and rice for the study area were analyzed concurrently with the climate

data earlier mentioned by means of linear regression and multiple regressions which unveil the true relationship that has taken place between crop production and climate over the period of thirty years earlier stated. These results are presented and discussed subsequently.

Table 21: Relationship between Rainfall and Rice production

Model Summary			ANOVA ^a			Coefficients ^a	
						Unstandardized Coefficients	
model	R	R Square	df	F	Sig.	B	Sig.
1	.431 ^a	.186	1	6.399	.017 ^b	-8330.895	.708
						46.284	.017

A simple linear regression was carried out to test if rainfall significantly predicted rice production for a period of 30 years in the study area. The results of the regression indicated that the model explained 18.6% of the variance and that the model was significant, $F(1,28) = 6.399$, $p < .001$. It was found that rainfall significantly predicted rice production ($\beta_1 = 46.28$, $p < .001$). The final predictive model was: proportion of rice production = $-8330.90 + (46.28 * \text{rainfall})$

The r^2 value of .186 x 100 produced 18.6% as rainfall degree of impact on rice production for 30 years period, but was confirmed at low significant level as presented on table 21; summary, see appendix II

Table 22: Relationship between Rainfall and Maize production

Model Summary			ANOVA ^a			Coefficients ^a	
						Unstandardized Coefficients	
Model	R	R Square	df	F	Sig.	B	Sig.
1	.186 ^a	.035	1	1.003	.325 ^b	794594.450	.129
						-422.786	.325

A simple linear regression was carried out to test if rainfall significantly predicted maize production for a period of 30 years in the study area. The results of the regression indicated that the model explained 35.0% of the variance and that the model was significant, $F(1,28) =$

1.003, $p < .001$. It was found that rainfall significantly predicted maize production ($\beta_1 = -422.79$, $p < .001$). The final predictive model was: proportion of rice production = $794594.45 + (422.79 * \text{rainfall})$.

The r^2 value of 0.035×100 produced 3.5% as the degree to which rainfall affected maize production in 30 years period as presented on summary table 22, see Appendix III for details

Table 23: Relationship between Temperature and Rice production

Model Summary			ANOVA ^a			Coefficients ^a	
model	R	R Square	Df	F	Sig.	Unstandardized Coefficients	
						B	Sig.
1	.031 ^a	.001	1 28	.027	.870 ^b	48971.907	.031
						-7.502	.870

A simple linear regression was carried out to test if temperature significantly predicted rice production for a period of 30 years in the study area. The results of the regression indicated that the model explained 1.0% of the variance and that the model was significant, $F(1,28) = .027$, $p < .001$. It was found that temperature significantly predicted rice production ($\beta_1 = -7.502$, $p < .001$). The final predictive model was: proportion of rice production = $48971.91 + (-7.50 * \text{temperature})$.

The r^2 value of 0.01×100 produced 1% as the degree to which temperature has affected rice production in 30 years period, this value was found to be the least amongst all the regression analysis conducted on crop data. See appendix iV for details.

Table 24: Relationship Between Rainfall and temperature vs Maize

Model Summary			ANOVA ^a			Coefficients ^a	
model	R	R Square	Df	F	Sig.	Unstandardized Coefficients	
						B	Sig.
1	.393 ^a	.154	1 28	5.109	.032 ^b	1215696.417	.007
						-1994.723	.032

A simple linear regression was carried out to test if temperature significantly predicted maize production for a period of 30 years in the study area. The results of the regression indicated that the model explained 15.4% of the variance and that the model significant, $F(1,28)=5.109$, $p<.001$. It was found that temperature significantly predicted maize production ($\beta_1 = -1994.72$, $p<.001$). The final predictive model was: proportion of rice production = $1215696.42 + -1994.72 \times \text{temperature}$).

The r^2 value of .154 x 100 produced 15.4% as the degree to which temperature affected maize production in 30 years given on table 24, see appendix V For details.

4.2.2 Relationship between Rainfall and Temperature Vs Rice production

Rainfall and temperature (independent variables) jointly accounted for R^2 value of .196 x 100 to produce 19.6% as the degree to which the two climate variables have affected rice production in 30 years, see appendix VII for details.

4.2.3 Relationship between Rainfall & Temperature Vs Maize production

Rainfall and temperature jointly accounted for R^2 value of .170 x 100 to produce 17% as the degree to which the climate variables have affected crop production in 30 years period as presented, see appendix VIII for details.

4.3. RAINFALL VARIABILITY IN DASS

As can be seen, the time series plot revealed that rainfall has been on the increase in the study area since 1986-2015. Looking at the rainfall trend on the graph, it's showing so clearly that no extreme rainfall variability was recorded from the years (1986-1991). It was in 1992-1993 that a rise from the previous level was recorded, this trend continues until 2015. However, despite the rise in rainfall along the years, inter-annual variability was more pronounced between some years as the rainfall is seen rising and falling above the central mean line drawn on the time series graph which has an overall total of 1163.9 see figure 3. This observation closely relate with Buba's findings, (2017) in which he revealed that rainfall is characterized by strong inter-annual variability in the Sudano Sahelian Zone of Nigeria. A close look on the graph reveals that 1994, 2000, 2002, 2004, were years when rainfall anomalies were recorded compared to their counterpart years, because rainfall was recorded below average, the rest of the years showed that some were higher than the average and some within the average see figure 6; This fluctuation is expected to have exerted certain degree of influence on crop production. The rainfall time series shows variability despite its continuing rise, there were fluctuations not very far from the average see mean line (1163.9) in figure 6;. Monthly rainfall distribution shows that most of the rainy season's highest rainfall is received in August, which recorded the highest average of 331, see table 25, which conformed to the assertion that rainfall in the Sudano Sahelian Zone apparently has one peak (Single Maximum), Buba, (2017).

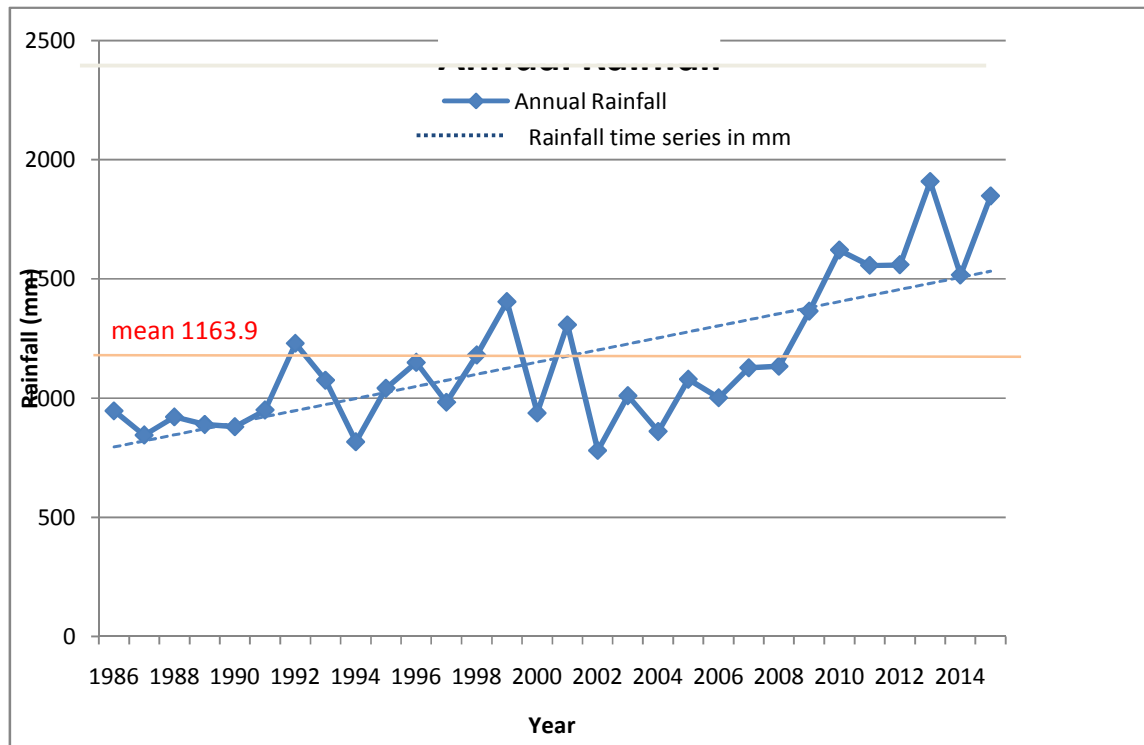


Figure 6: Time Series Graph Showing Rainfall Trend for the study Area

4.3.1. Mean Monthly and Annual Rainfall for the Study Area

Table; 25; is the summary of mean annual rainfall for all the months and totals for the entire thirty years period covered.

The summary revealed that January and December never recorded rainfall since 1986 – 2015, November and February are years that have recorded traces of rainfall of similar amount, while August, July and September followed by June and October in these sequence, are obviously months of peak rainfall, but the data seemed to show that rainfall is mostly more variable during the months of peak rainy season such as August, July, September, June and October in these sequence, with standard deviation values 154.1, 126.7, 105.1, 73.5, 44.9 respectively. It has also been observed that rainfall is mostly over concentrated within the period of 1-3 months of these peak period at the detriment of crop production, this happens whenever it rains excessively at the time when isn't really needed, and retreats at the time when crops are in their most critical months, this often let to some critical months receiving

smallest proportion at the detriment of most crops, most especially when attention wasn't paid timing of crop planting and sowing. This rainfall behavior can easily confuse superficial researchers who want to only look at the amount of rainfall received annually and expect corresponding response from crops without taking in to cognizance other anomalies involved.

The high level of skewness in rainfall distribution across the months of the rainy season is a great disadvantage to crop production, this is because, the concentration of rainfall in one or two months would meant some crops must have suffered rainfall deficiency and probably at a critical period. Some of the crops get excess rainfall when it is already late or too early, the C.V.of the months for the 30 years period covered are, evidences to this variability challenges. Standard deviation values for peak rainy season such as August September July also held evidence of wide dispersion about the mean, which also indicated variability.

Months of April, May and June looked to have been recording extreme drought conditions even after the rain onset. The statistic also Suggest that months of March – April may never have been a regular onset period in the study area.

Table 25: Mean Monthly Annual Rainfall Summary for the Study Area

	<i>Jan.</i>	<i>Feb.</i>	<i>Mar.</i>	<i>April</i>	<i>May</i>	<i>June</i>	<i>July</i>	<i>Aug.</i>	<i>Sept.</i>	<i>Oct.</i>	<i>Nov.</i>	<i>Dec.</i>	<i>TOTAL</i>
Mean	0.0	0.6	7.1	38.7	86.2	175.1	288.7	331.4	193.9	42.0	0.1	0.0	1163.9
Standard Error	0.0	0.6	5.5	7.2	8.1	13.4	23.1	28.1	19.2	8.2	0.1	0.0	56.0
Standard Deviation	0.0	3.1	29.9	39.6	44.4	73.5	126.7	154.1	105.1	44.9	0.5	0.0	306.7
Kurtosis	#DIV/0!	29.9	27.9	0.7	-0.6	-0.3	-0.2	2.4	0.9	3.2	30.0	#DIV/0!	0.1
Skewness	#DIV/0!	5.5	5.2	1.2	0.3	0.3	0.8	1.2	0.8	1.9	5.5	#DIV/0!	1.0
Range	0.0	16.8	162.6	149.0	157.1	302.1	453.6	713.3	457.8	186.3	2.7	0.0	1128.7
Minimum	0.0	0.0	0.0	0.0	13.4	35.0	115.4	28.7	31.2	0.0	0.0	0.0	779.8
Maximum	0.0	16.8	162.6	149.0	170.5	337.1	569.0	742.0	489.0	186.3	2.7	0.0	1908.5
Sum	0.0	17.3	213.1	1161.0	2585.6	5254.1	8660.9	9942.2	5818.3	1260.8	2.7	0.0	34916.0
CV	#DIV/0!	531.6	420.4	102.4	51.5	42.0	43.9	46.5	54.2	106.9	547.7	#DIV/0!	26.4

4.4. TEMPERATURE VARIABILITY IN THE STUDY AREA

Time series analysis carried on temperature on table....was to investigate the likely fluctuation of temperature below and above the mean. Time series graph as presented on figure 4; does not show extreme variability during the first eight years (1986-1992), but were actually above the mean line 25-26.69, it later dropped so sharply in 1994, from which year the annual fluctuation become more pronounced in the years 1994, 1995, 1998, 1999, 2002, 2003 whose values fell below the mean, however this trend came to a halt from 2004-2015, which seemed to remain at a fix level but all the values were above the mean which gave another evidence of variability above the mean. The time series graph gave a clear indication that temperature variability was not extreme in the first eight years, but seemed to show evidence of extreme variability in the subsequent years such as 1994 which had the lowest value of 14.7, 1995 had 23.9, 1998 had 16.8, 1999 had 19.4, 2002 had 23.3, 2003 had 15.1, all of these values were below the mean but, some values fell reasonably below the mean, thereafter, its early behavior of the first eight years resumed, with a continual rise for a straight 12 years from 2004-2015, however these values were not on the extreme. The linear (mean τ) which appears on figure 4; with a dot line in blue color denotes the average (mean), a careful observation on the mean τ line revealed that 24 years recorded temperature above average, and as few as six years recorded temperature below average.

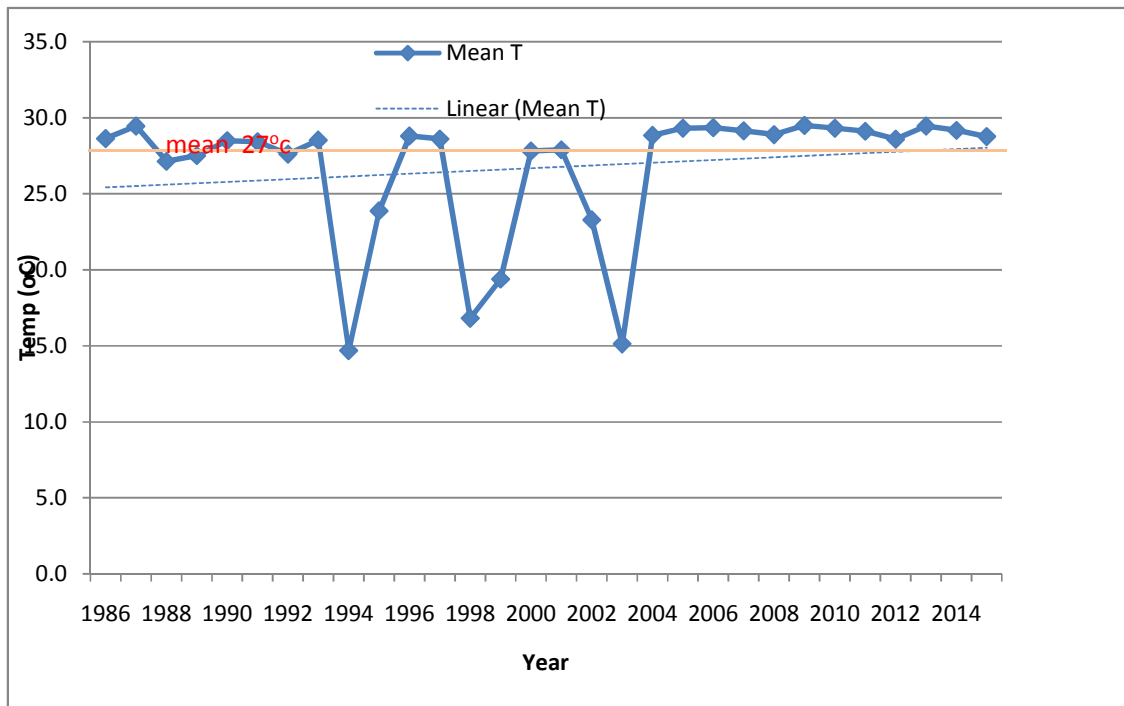


Figure 7: Temperature Time Series plot for the study area.

4.4.1. Mean Monthly Annual Temperature for the Study Area

Table 2: Presents the summary of computed values for temperature for the entire thirty years covered. A careful observation on the values reveals the behavior of temperature in the study area, where the standard deviation values of the peak rainy season months did not look close to one another. The month of July has the highest standard deviation value of 14.5, followed by month of September with 7.2, which indicated that temperature have been more variable in the months of July and September than August and October during the 30years period of this study. April has been recording highest incidences of variability more than all the early months of the years as indicated by its value of 7.6 above others. August, November, December, January, February, appears to have less variability. Research finding on temperature variability in Northern Nigeria seemed to explain the same temperature characteristics of the study area, which asserted that mean maximum temperatures are higher in Sudano-Sahelian Zone than what they are in the Gunea Savannah, varying between 30⁰cand 40⁰c, the highest maximum temperature for this zone are recorded between April

and May, while the lowest maximum temperature are experienced in December and January, Buba and Maigari, (2017).

Table 26: Mean Monthly Temperature Summary for the Study Area

	<i>Jan.</i>	<i>Feb.</i>	<i>March</i>	<i>April</i>	<i>May</i>	<i>June</i>	<i>July</i>	<i>Aug.</i>	<i>Sept.</i>	<i>Oct.</i>	<i>Nov.</i>	<i>Dec.</i>
Mean	21.0	24.5	27.7	28.4	28.8	26.1	38.7	23.3	23.4	25.1	23.7	21.3
Standard Error	1.0	0.9	1.0	1.4	0.7	0.8	2.7	1.1	1.3	1.1	1.1	1.0
Mode	22.7	23.5	29.4	31.2	29.0	27.6	51.3	25.0	26.0	26.9	24.7	23.5
Standard Deviation	5.2	5.2	5.7	7.6	4.0	4.5	14.5	5.8	7.2	6.0	5.8	5.4
Kurtosis	9.9	17.7	20.3	6.8	12.6	5.0	-0.4	8.9	6.8	11.7	11.4	9.7
Skewness	-3.0	-3.9	-4.3	-2.6	-3.4	-2.4	-0.6	-3.0	-2.8	-3.4	-3.4	-3.0
Range	26.8	29.0	31.4	35.6	20.2	18.0	54.4	26.8	27.0	28.5	27.0	25.4
Minimum	xx	Xx	Xx	Xx	11.7	10.9	0.0	0.0	0.0	0.0	0.0	0.0
Maximum	26.8	29.0	31.4	35.6	31.9	28.9	54.4	26.8	27.0	28.5	27.0	25.4
CV	24.9	21.2	20.7	26.8	13.9	17.2	37.6	25.1	30.7	23.8	24.4	25.3

4.5 RICE PRODUCTION TREND IN THE STUDY AREA

Rice production trend displayed on time series graph on table....revealed that many of part of the 30 years of this study have recorded significant increase in crop production above the mean value of 600m²/tone. The years with a significant increase in were 2013, 1998, 1999, 2000, and 2014, the year 2013 recorded the highest among the years listed, while the with the least production were 1986, 1990, 1997, 2007, 2009, 2008 in these sequence. Most of the 30 years period recorded moderate production below the mean value of 6000m²/tone, these years are 1992, 2002, 2003, 2004, 2005, 2015, 1996, 2001, 2002, 2003, 2004, 2005, 2015, however some were observed to have fallen below the mean, and few years rose to the mean level, when so many had fallen below the mean value stated earlier. These production trend

on the time series graph clearly revealed that rice production couldn't rise correspondingly to the obvious rise in rainfall trend during these 30 years of this study.

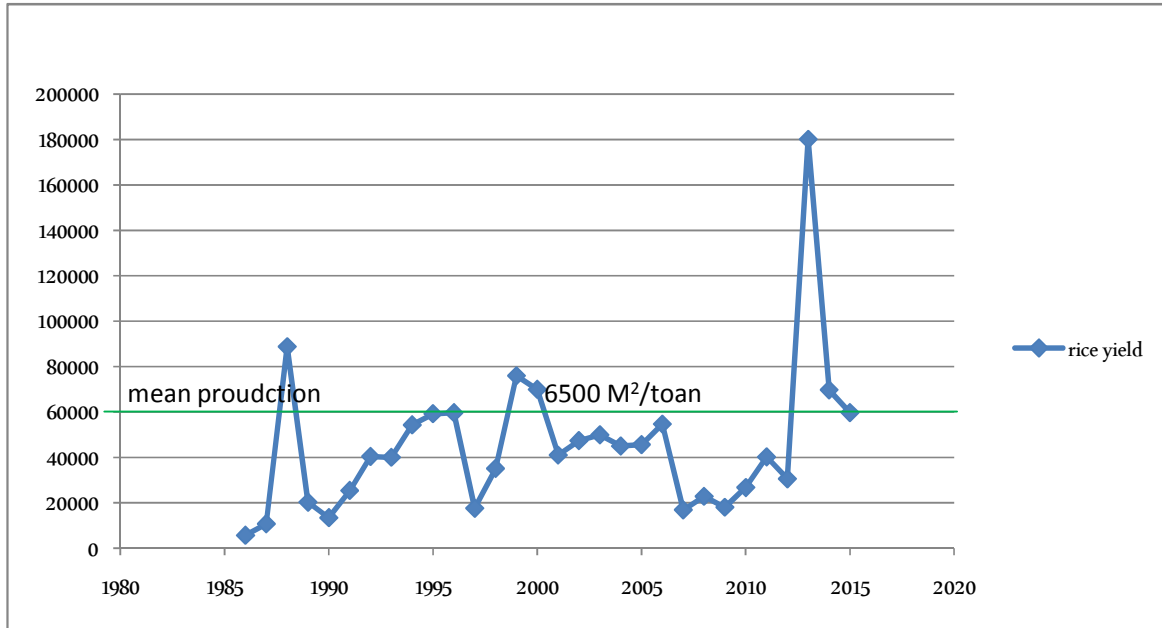
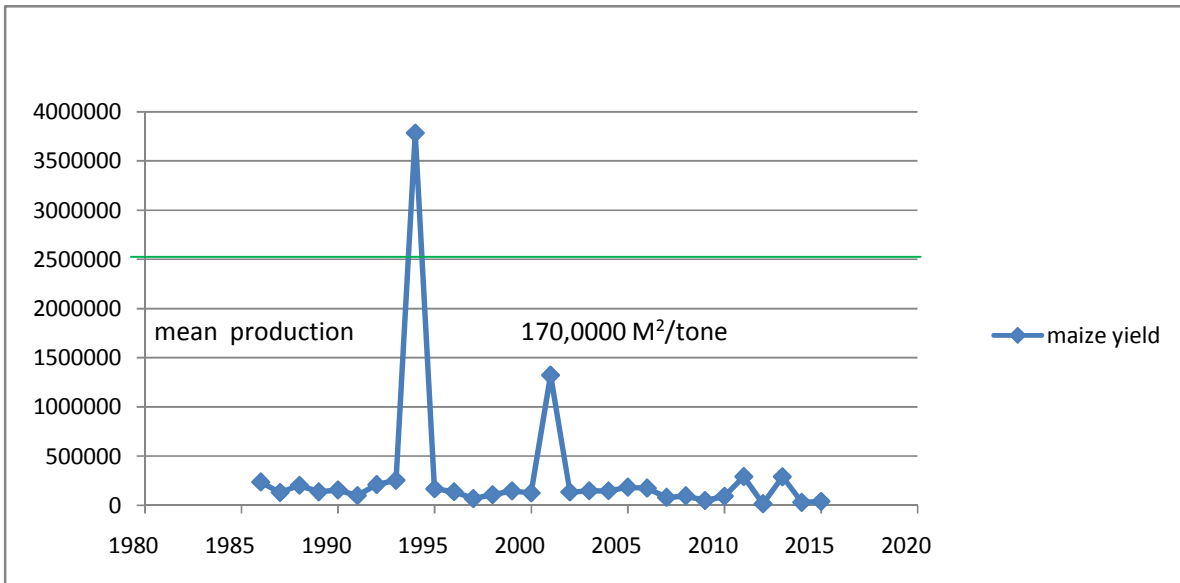


Figure: 8: Time Series Plot for Rice Production from (1986 – 2015) in the Study Area

4.6 MAIZE PRODUCTION TREND IN THE STUDY AREA

Maize production trend over 30 years period plotted on time series graph is clearly showing that maize production maintained affix production ratio was far above the mean value of 170000m²/tone. The remaining years from 1986-1993, 1995-2000 and 2002-2015 recorded almost the same quantity of maize production per metric² tone, which were clearly far below the mean value of 170000m²/tone. This production trend also concludes that maize production also failed to respond correspondingly to rainfall continual rise for 30years period in the study area.



Figure; 9: Time Series Plot for Maize Production from (1986 – 2015) in the study area.

Table 27; presents the analyzed summary of the entire data used in this study. The climate data (rainfall & temperature), and crop production data all were subjected to descriptive statistics, which produced the overall mean totals for all the data. Maize had much higher mean production value of 177418.49 ahead of rice with 31514.91. Climate data (rainfall & temperature) had 1163.87 and 26.73 over 30 years respectively. Standard deviation for temperature shows that temperature didn't varied as much as rainfall over 30 years period.

Table 27: Climate and Crop Data From (1986-2015) Described

	<i>Maize (MT)</i>	<i>Rice (METRIC TONNE)</i>	<i>Annual Rainfall</i>	<i>Mean T</i>
<i>Maize (MT)</i>				
Mean	177418.49	31514.91	1163.87	26.73
Standard Error	43677.57	4820.99	56.00	0.80
Median	144968.00	35162.00	1076.70	28.61
Standard Deviation	235210.89	25961.84	306.71	4.37
Kurtosis	21.67	-0.87	0.11	2.75
Skewness	4.38	0.38	0.96	-1.99
Range	1323027.52	88732.26	1128.70	14.82
Minimum	272.48	58.74	779.80	14.68
Maximum	1323300.00	88791.00	1908.50	29.50
CV	132.57	82.38	26.35	16.36

4.7 DISAGREEMENT BETWEEN FARMER'S PERCEPTION ON CLIMATE VARIABILITY AND THE RESEARCH OUTCOME

An investigation conducted in the study area through question survey to capture farmer perception on the impact of climate on crop production over 30 years period revealed that farmers have faced challenges related to climate. Some of the challenges were irregular rainfall onset and cessation, such as early cessation, delayed onset, unpredicted rainfall, dry spell and drought even during the peak of rainy season, some also asserted that sometimes they witnessed excess rainfall that resulted to destructive floods, yet their crops suffered insufficient rainfall at the end. However in the other hand when crop production and climate data of the study area were subjected to descriptive statistics and regression analysis the result for independent variables proved that, those challenges mentioned by farmers pertaining to climate were not the major factors that affected crop production over the period of 30 years,

but were rather to be blamed on other factors other than climate such as, soil fertility management, improper timing of application of pesticides, herbicides, wrong timing of crop planting, wrong choice of farming system and others conclusively, rainfall kept rising for almost three decade and so it was not to be blamed as temperature also didn't affected crop production up to 19%. Several studies have found out that continuous use of ancient farming strategies have stagnated crop production in many agrarian societies of SSA Hulme, (2007)

4.8 AGREEMENT BETWEEN FARMER'S PERCEPTION ON CLIMATIC VARIABILITY AND RESEARCH OUTCOME

Farmer's perception on climatic variability in the study area was captured by means of research questionnaire. Examining their complaint on the history of climate affecting crop production, some information seemed to agree with some of the outcome of the analysis conducted on all data.

Farmer's in majority believed that rain onset and cessation has never been regular. There were also complains on unpredictable behavior of rainfall which has posed serious challenges to crop production in the study area. Dry spell, destructive flood, drought, late onset and early cessation have also characterized the climate as asserted by some farmer's.

When a summary of descriptive statistics, and time series graph, carried on rainfall values are carefully examined, it looked evident that rainfall has been on rise, but most of the rainfall were not fairly distributed across the months of the rainy season, values on table 25 also shows that some months often suffer insufficient rainfall, which is indicating evidence of skewed distribution of rainfall during rainy season. It was also observed that rainfall was often received in excess when crops were not really in need of such amount, and the rain fall are mostly concentrated in 1-2 months of the rainy season while others remained erratic. Rain

fall values have also proved that some years get their heaviest rainfall towards the end of the rainy season against the requirement of most crops.

Looking at this characteristics, it could mean there were years when dry spell were experienced at a critical period for crops, however this does not mean that those years did not recorded annual rainfall increase over the previous amount. Undesired experiences such as late onset or false onset, dry spell, early cessation, may have been encountered those same years were said to have been receiving higher rainfall than the previous years. This is to say rainfall can be erratic in some months and could rain excessively some months of the same year.

Many farmers complaint about uncertain onset and cessation affecting their cropping area and intensity which conformed to the findings of (Ekpoh, 1999; Hulme, 2001; Diop, 1996), whose studies discovered that rainfall uncertain behavior leading to false onset, drought, untimely onset, early cessation are combined challenges affecting farmers in the Sudano Sahellian Zone that has so often affected farmers plan to cultivate on a larger scale. Intergovernmental panel on climate Change (IPCC, 2001), also revealed that a rainfall decrease of 29 – 49 percent has been observed in the (1968 – 1997) period compared to (1931 – 1960) baseline period within the Sahel Zone.

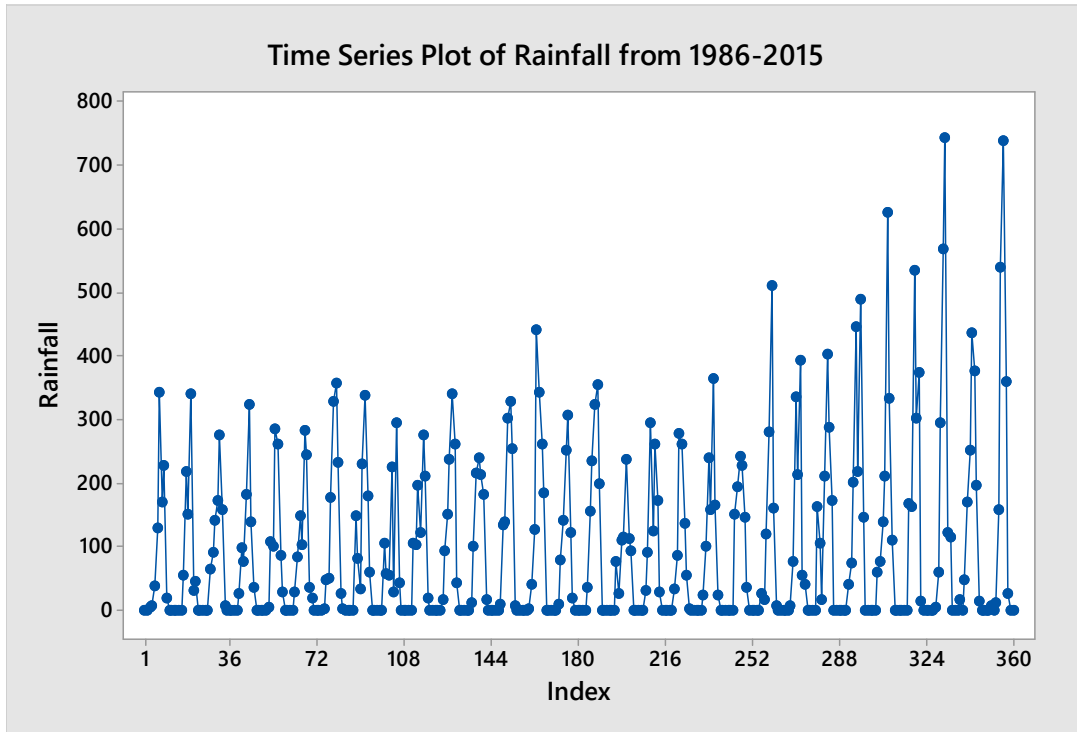


Figure: 10: Rainfall Overall Monthly Time Series Plot for the study area (1986-2015)

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 SUMMARY

This study focused on examining the relationship between climate and crop production for the study area, over a period of 30 years. In order to achieve the objective for this study, a sample of crop production data of (rice and maize) was collected alongside climate data (temperature and rainfall) both for the study area which spanned over a period of 30 year. After both data were subjected to descriptive statistic, time series, simple linear regression, multiple regression analysis, the analysis indicated the following results.

After conducting the first analysis on rainfall and temperature by means of descriptive statistics; it was observed on the time series graph and the overall summary of the computed values that rain fall has been on the rise for almost the three decade period covered in this study, the time series graph also revealed that, the few early years of this study received the lowest rainfall , while most of the subsequent years continued to experience an increase in rainfall except some 3-5 years that recorded slightly below the mean value of 1163.9. This trend continued until 2015 which eventually resulted to some years recorded rainfall above the mean value of 1163.9. The continual rise in rainfall amount over the period of 30 years above the mean value proved there were no cases of extreme fluctuation below the mean values, but a significant rise in rainfall values for most of the later years above the mean value of 1163.9 stand out as an evidence of extreme variability above average, when the values are compared with those of the early years of this study. The continuing rise in rainfall for a very long time was expected to boost crop production in the study area, but subsequent findings proved its impact on crop production was far below expectation. Further observation from the analysis conducted on rainfall revealed that evidences exist for rainfall over concentration in few

months of the rainy season, and values so much deviate from the mean at the detriment of crop production. There were marked temperature inter annual variability in six different years, while rainfall exhibited ascending inter annual variability in more than 17 years. Some analyzed values of climate data also proved intra annual variability was also experienced in many years.

Temperature variability trend revealed that, temperature has been on the rise above the mean value in most part of the 30 years period covered in this study. Time series analysis and the summary of descriptive statistics earlier conducted revealed that 24 years of this study have recorded temperature above the mean value, only six inconsecutive years recorded temperature values that were extremely lower than the mean value, which gave the prove there were few cases of extreme variability in the study area, while the rise in temperature above the mean during the 24 years were observed to be almost the same throughout, and were apparently not extreme to warrant a conclusion that there were generally extreme temperature variability, however evidences are very clear that variability has been experienced in but were not generally on the extreme, but are expected to have impacted either negatively or positively on crop production of the study area.

A further investigation by means of linear and multiple regressions did not show that temperature has affected so much of crop production. The multiple regression conducted between independent and dependent variables to determine the degree of their relationship, predicted that rainfall and temperature accounted for 19.6% & 17% of rice and maize production over 30 years period respectively.

Linear regression values between rainfall and rice, and rainfall vs maize revealed that rainfall accounted for only 18.6% and 35% of rice and maize production over 30 years period respectively. Rice production in the study area did not respond to continual rise in rainfall for almost the 30 years period. Rice production was highest in 2013 which is the only year that

coincidentally recorded highest rainfall unlike other years when crop production did not rise correspondingly to the continuing rise in rainfall. Maize production maintained almost a fixed or similar rate of production except the years 1994 and 2001 when a significant increase was observed.

Farmers were reported to have complaint of unpredicted rainfall behaviors, such as irregular or false onset (starting rain), early and late cessation, dry spell, flood, drought, affecting their initial plans for crop cultivation.

The various result of the analysis conducted on these data gave a great cause for inevitable thought on farm management system in the study area.

5.2 CONCLUSION

The result for various data collected and analyzed for this study, prompted conclusion that climate of the study area has not been mainly responsible for the major crop production challenges in the study area. The extent to which climate has affected crop production is clearly seen by regression values for all the independent variables vs dependent variables. Time series clearly revealed that rainfall has been on the rise for almost three decade, but its linear regression values for rice was surprisingly as low as 18.6% which proved that 81.4% of the rice production challenges lies on other factors such as, farm management systems, in compliance with contemporary farming systems, inability to afford modern farming implements, illiteracy and others. It is evident that rainfall has been rising above average for most part of the three decade covered, with clearly a slight degree of impact on crop production, but rice production failed to rise as expected. Multiple regression value also predicted climate data (rainfall & temperature) to have affected rice production by only 19.6%, and 1.0% respectively.

The linear regression value for rainfall vs maize was higher than rainfall vs rice, which meant that rainfall has been responsible for maize production by a higher percentage than rice. The regression values shows that Rainfall predicted maize production by 35% in 30 years period while the multiple regression values was 17% only, these two values are evidences that climate of the study area have actually affected crop production, but the impact were said to be much lower than expected. Looking at how rainfall has been on the rise for a period of 30 years in the study area, but crop production couldn't show a corresponding increase in crop production, this gave a great cause for a serious thought on how farming activities are being managed in the study area.

Rainfall has clearly exhibited an ascending pattern of variability in the period of three decades, its variability was more of continuing increase above the mean value and had less incidence of fluctuation below the mean. However it can generally be said to have exhibited variability since there were years when rainfall values fell below the mean, and rainfall continuous rise that led some years receive rainfall above the mean, are also inter annual variability behavior on the part of the climate of the study area, which were altogether found to have been slightly responsible for continuous stagnation and fall in crop production level of the study area, except a rise on few occasions.

Rainfall of the study area has also exhibited undesired characteristics that farmers have battled it for quite some years, these characteristics are such as concentration of rainfall in 1-2 months of the peak rainy season, erratic rainfall, frequent dry spell, unpredicted onset and cessation as well as being unsteady as some farmers asserted. These conditions may be very true because, any of these situations may have been possible at some years when the rainfall recorded was highly characterized by variability between the months (intra annual variability).

Temperature has for most part of the 30 years maintained a slight and fixed position of rise above the mean except in few years where temperature was recorded below average.

5.3 RECOMMENDATIONS

Various analysis and examinations conducted on all data collected for this study produced results that are alarming, which prompted suggesting an urgent intervention by the three tiers of government, community, Ngo's and other charity organizations.

Having witnessed such a complex farming challenges where rainfall was on the rise for almost three decade but was not found to have accounted for more than 18% of rice and 35% of maize productions in the study area. Temperature accounted for only 1% of rice production, and 15% for maize production. Bearing in mind these challenges, this study deemed it essential and important to recommend for various assistance to combat the current challenges of crop production in the study area under the following context.

1. The government should organize a team of experts in the field of agro climatology and soil science to conduct an in-depth research in the study area to identify as to why crop production couldn't record a corresponding increase to continuous rise in rainfall over a period of three decade.

2. The government should employ an effective channel of communication through mass workshop to educate farmers on contemporary farming strategies, most especially on the application of new farming technology. Issues like application of fertilizer, pesticide, herbicides, and host of others.

3. The government needs address challenges pertaining to complains on irregular onset, cessation of rainfall, dry spell and drought, floods, by educating farmers on new farming approaches such as, proper timing of planting, choice of crop varieties that can withstand current climatic vagaries, choice of farmlands for the intended variety of crops to be cultivated, new farming approaches amid challenges on climatic variability and, the rightful

ways to tackle and prevent weeds, pest, diseases believed to have been intensified by climatic variability.

4. Most importantly, the government should provide well subsidized loans for farmers in the community to encourage the poverty stricken masses operate farming on a larger scale. If these agricultural policies are intensified in the study area, crop production will improve significantly thereby, raising the income of the poor inhabitants, improving their living standard as well as curtailing crime rate.

5. The government should make it a top priority to improve livelihood, and personnel income of farmers through agricultural programs and policies in favor of the study area, as this could increase nations GDP, reduce the pressure being mounted on the government for job opportunities as well as curtailing rate of corruption.

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APPENDIX I
QUESTIONNAIRE

Dear respondents,

I am a post graduate student of the above institution, and wish to conduct a research on the topic “impact of climatic variability on agricultural production in Dass L.G.A of Bauchi State”.

RESPONDENTS BIO DATA

1. Age 30-35years [] 36-45 [] 46-140 []
2. Gender: Male [] Female []
3. Marital Status: Single [] Married []
4. Occupation: Civil Servant [] Farmers & Civil [] Farming Only [] Farming & Trading [] Farming & Others []

Research Questionnaire

5. Have you been experiencing drought in the course of your farming activities?
 - (a) Five times and above in 10 years
 - (b) Less than five years in 10 years
 - (c) No drought experience in 10 years
6. Have you been experiencing dry spell during your rainy season?
 - (a) Mostly June – July
 - (b) Mostly May and August
 - (c) Mostly June – September
 - (d) Mostly July – September
 - (e) It occurs during any month of the rainy season

Have you further apart from the above state option?

-
7. How frequent have you experience dry spell in your areas?
 - (a) Most of the years we have no dry spell
 - (b) We have it once in a year
 - (c) Twice in a year
 - (d) Thrice or more times in a year.

Is there any way it has occurred other than the above options?

-
8. Has dry spell been on the increase in you areas?
 - (a) It has been on the increase in the last 20 – 30 years
 - (b) It has been on the increase in the last 11 – 19 years
 - (c) It has been on the increase in the last 10 years and above

Have you other information which you felt best explain the above question?

-
9. Has dry spell caused water scarcity in your arrears? (a) Yes (b) No
10. Has dry spell been influencing farmers to cultivate less than their initial plan? (a) Yes (b) No
No
Are there other ways you can describe the situation?
-
11. What are the coping and adaptation strategies amid the impact of drought?
(a) Early planting and timing
(b) Early planting of improved variety
(c) Early planting, timing and water drilling options
What other adaptation option have you apart from the above options?
-
12. What is your rainfall starting month?
(a) March
(b) April
(c) May
(d) June
What other months did you felt you have had your true starting rainfall in the past?
-
13. Have you been having regular rainfall on set time or have recorded changes in the past?
(a) Sometimes March – April
(b) Sometimes May
(c) Sometimes June
Have you other opinion other than these? _____
14. How does changing rainfall onset time affect your agricultural activities?
(a) Causes late cultivation
(b) Late cultivation and low yield
(c) Predisposition to disease and pest
What other impacts have you experienced _____
15. Have you been having variation in rainfall starting times across Dass areas?
(a) Less than one month difference
(b) 1 – 2 month difference
(c) More than two month difference
What better way can you describe the variation? _____
16. What is your most preferred rainfall starting time?
(a) March – April
(b) May – June
(c) June – July
17. What is your rainfall starting time?
(a) September
(b) October
(c) October – November
(d) August – September
18. Have you been experiencing changing rainfall stopping time (cessation time) across Dass area?
(a) September, October against November in last 10 years
(b) October against November in Last 10 years
(c) November the last 30 years
What other history can you _____

19. In what ways has rainfall changing cessation time affected your farming activities?
- (a) Disease and poor harvest
 - (b) Disease and pest only
 - (c) Poor harvest only
20. Have you ever recorded variation in rainfall cessation time across your areas?
- (a) Mostly less than 1 month difference
 - (b) Mostly 2 – 3 months difference
 - (c) We often have just slight differences
 - (d) Virtually the same
21. How does variation in rainfall cessation time affect your farming activities?
- (a) Crop failure and poor harvest
 - (b) Slight variation in rainfalls and crop yield
 - (c) Weather variation

State other effect you have experienced _____

22. Have you been having normal rainy season that resulted to high yield in your area?
- (a) 1 – 2 times in 10 years
 - (b) 3 – 5 times in 10 years
 - (c) More than 5 times in 10 years
 - (d) Non in 10 years

What other information have you on this question?

23. Have you been having excess rainfall at some seasons that resulted to flood disaster and yet had dry spell that affected your crop yield?
- (a) Yes
 - (b) No
24. Have you been having flood disaster that forced farmers to cultivate less than their initial plans?
- (a) Clearing the top soil
 - (b) Causing water logging on the farmland
 - (c) Destruction of the cultivated crops
- What other history have you on this?

25. What adaptation strategies do you embark upon to prevent flood spell?
- (a) Avoidance of flood areas
 - (b) Creation of water channels
 - (c) Tree plantation and contour cropping
- What are the other measures?

26. What are the major crops being produced in your areas?
- (a) Rice
 - (b) Maize
 - (c) Tomatoes, pepper and onions
 - (d) Millet and others
- What other crops do you think are major crops?

27. What are the crops least produced in your areas?
- (a) Millet

- (b) Sugarcane
- (c) Groundnut
- (d) Maize and Tomatoes
- (e) Onions
- (f) Rice
- (g) Cowpea

APPENDIX II

CROP AND CLIMATE DATA SUBJECTED TO REGRESSION ANALYSIS

S/NO	YERAR	Maize (MT)	Rice (MT)	Annual Rainfall	MeanT
1	1986	236525	5704	946.1	28.6
2	1987	130136	10772	844.6	295
3	1988	203246	88791	920.7	27.1
4	1989	136612	20296	889.4	27.5
5	1990	157047	13458	879.6	28.5
6	1991	99258	25447	949.6	28.4
7	1992	210808	40420	1229.4	27.6
8	1993	253497	40074	1074.9	28.5
9	1994	379334	54345	816.2	27.6
10	1995	167406	59288	1014.1	28.5
11	1996	138055	59698	1149.3	14.7
12	1997	69081	17618	982.4	23.9
13	1998	108181	35162	1180.8	28.8
14	1999	147400	76000	1404.4	28.6
15	2000	126200	70000	937.2	16.8
16	2001	1323300	41045	1307.2	19.4
17	2002	134910	47460	779.8	27.9
18	2003	147780	50000	1009.5	27.9
19	2004	147991	45054	1126.9	23.3
20	2005	184890	45639	1133.1	15.1
21	2006	174735	4717.5	1126.9	28.9
22	2007	80323.76	16877.40	1133.1	29.4
23	2008	96200	22865	1364.82	29.2
24	2009	49785	18069	1620.8	28.9
25	2010	92179.48	26762	1556.8	29.5
26	2011	292100	40260	1559	29.3
27	2012	15390.90	30590.70	1908.5	29.1
28	2013	290280	180190.70	1516.3	28.6
29	2014	29990.20	69760	1848	29.5
30	2015	39199.50	59769.92	1848	29.2

APPENDIX III

Linear regression =Rainfall Vs Maize

Variables Entered/Removed^a

Model	Variables Entered	Variables Removed	Method
1	Rainfall ^b	.	Enter

a. Dependent Variable: Maize

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.186 ^a	.035	.000	697185.73562

a. Predictors: (Constant), Rainfall

ANOVA^a

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	487644945483.022	1	487644945483.022	1.003	.325 ^b
	Residual	13609902598647.402	28	486067949951.693		
	Total	14097547544130.424	29			

a. Dependent Variable: Maize

b. Predictors: (Constant), Rainfall

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	794594.450	507493.114		1.566	.129
	Rainfall	-422.786	422.102	-.186	-1.002	.325

a. Dependent Variable: Maize

APPENDIXV

Linear Regression=Rainfall Vs Rice

Variables Entered/Removed^a

Model	Variables Entered	Variables Removed	Method
1	Rainfall ^b	.	Enter

a. Dependent Variable: Rice

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.431 ^a	.186	.157	30220.25885

a. Predictors: (Constant), Rainfall

ANOVA^a

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	5844233441.903	1	5844233441.903	6.399	.017 ^b
	Residual	25571393259.670	28	913264044.988		
	Total	31415626701.574	29			

a. Dependent Variable: Rice

b. Predictors: (Constant), Rainfall

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-8330.895	21997.830		-.379	.708
	Rainfall	46.284	18.296	.431	2.530	.017

a. Dependent Variable: Rice

APPENDIXVI

Linear regression= Temperature Vs Rice

Variables Entered/Removed^a

Model	Variables Entered	Variables Removed	Method
1	Temperature ^b	.	Enter

a. Dependent Variable: Rice

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.031 ^a	.001	-.035	33479.66316

a. Predictors: (Constant), Temperature

ANOVA^a

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	30767029.287	1	30767029.287	.027	.870 ^b
	Residual	31384859672.287	28	1120887845.439		
	Total	31415626701.574	29			

a. Dependent Variable: Rice

b. Predictors: (Constant), Temperature

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	48971.907	21610.401		2.266	.031
	Temperature	-7.502	45.278	-.031	-.166	.870

a. Dependent Variable: Rice

APPENDIXVII

Linear regression= Temperature Vs Maize

Variables Entered/Removed^a

Model	Variables Entered	Variables Removed	Method
1	Temperature ^b		Enter

a. Dependent Variable: Maize

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.393 ^a	.154	.124	652524.67997

a. Predictors: (Constant), Temperature

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2175470721004 .506	1	2175470721004 .506	5.109	.032 ^b
	Residual	1192207682312 5.918	28	425788457968. 783		
	Total	1409754754413 0.424	29			

a. Dependent Variable: Maize

b. Predictors: (Constant), Temperature

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1215696.417	421190.621		2.886	.007
	Temperature	-1994.723	882.476	-.393	-2.260	.032

a. Dependent Variable: Maize

APPENDIX VIII

2. Multiple Regression = Rainfall & Temperature Vs Rice Variables Entered/Removed^a

Model	Variables Entered	Variables Removed	Method
1	Temperature, Rainfall ^b	.	Enter

a. Dependent Variable: Rice

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.443 ^a	.196	.136	30585.64757

a. Predictors: (Constant), Temperature, Rainfall

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6157617098.671	2	3078808549.336	3.291	.053 ^b
	Residual	25258009602.903	27	935481837.145		
	Total	31415626701.574	29			

a. Dependent Variable: Rice

b. Predictors: (Constant), Temperature, Rainfall

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	793.048	27279.583		.029	.977
	Rainfall	47.979	18.748	.447	2.559	.016
	Temperature	-24.238	41.878	-.101	-.579	.568

a. Dependent Variable: Rice

APPENDIX

Multiple Regression = Rainfall & Temperature Vs Maize

Variables Entered/Removed^a

Model	Variables Entered	Variables Removed	Method
1	Temperature, Rainfall ^b		Enter

a. Dependent Variable: Maize

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.413 ^a	.170	.109	658213.07056

a. Predictors: (Constant), Temperature, Rainfall

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2399947495374 .186	2	1199973747687 .093	2.770	.081 ^b
	Residual	1169760004875 6.238	27	433244446250. 231		
	Total	1409754754413 0.424	29			

a. Dependent Variable: Maize

b. Predictors: (Constant), Temperature, Rainfall

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1507320.637	587065.483		2.568	.016
	Rainfall	-290.413	403.457	-.128	-.720	.478
	Temperature	-1893.415	901.227	-.373	-2.101	.045

a. Dependent Variable: Maize

Rice Production under Rain fed Cultivation from (1986 – 2015)

S/NO	YEARS	PRODUCTION (PER METRIC TONE)
1.	1986	5704
2.	1987	10772
3.	1988	88791
4.	1989	20296
5.	1990	13458
6.	1991	25447
7.	1992	40420
8.	1993	40074
9.	1994	54345
10.	1995	59288
11.	1996	59698
12.	1997	17618
13.	1998	35162
14.	1999	76000
15.	2000	70000
16.	2001	41045
17.	2002	47460
18.	2003	50000
19.	2004	45054
20.	2005	45639
21.	2006	54717.45
22.	2007	16877.40
23.	2008	2865
24.	2009	18069
25.	2010	26762
26.	2011	40260
27.	2012	30590.70
28.	2013	180190.70
29.	2014	69760
30.	2015	59769.92

Table 7: Maize Production Under Rain fed Cultivation From (1982 – 2015)

S/NO	YEAR	PRODUCTION (MT)
1.	1986	236525
2.	1987	130136
3.	1988	203246
4.	1989	136612
5.	1990	157047
6.	1991	99258
7.	1992	210808
8.	1993	253497
9.	1994	379334
10.	1995	167406
11.	1996	138055
12.	1997	69081
13.	1998	108181
14.	1999	147400
15.	2000	126200
16.	2001	1323300
17.	2002	134910
18.	2003	147780
19.	2004G	147991
20.	2005	184890
21.	2006	174735
22.	2007	80323.76
23.	2008	916200
24.	2009	99785
25.	2010	192179.48
26.	2011	292100
27.	2012	150390.90
28.	2013	290280
29.	2014	119990.20
30.	2015	250199.50

