

**ASSESSMENT OF CLIMATE VARIABILITY ON RICE PRODUCTION IN
KEBBI STATE, NIGERIA**

BY

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DECLARATION

I hereby declare that the work contained in this thesis titled: ASSESSMENT OF CLIMATE VARIABILITY ON RICE PRODUCTION IN KEBBI STATE, has been sourced, researched, carried out, compiled and written by me in the Department of Geography, Bayero University Kano. The information derived from the literature has been duly acknowledged in the text and a list of references provided. To the best of my knowledge, no part of this project thesis was previously presented for another degree or diploma at this or any other institution.

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CERTIFICATION

This is to certify that this dissertation titled “**ASSESSMENT OF CLIMATE VARIABILITY ON RICE PRODUCTION IN KEBBI STATE**” was carried out by JUNAIDU ALTINE (SPS/17/MGE/00023), under my supervision.

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DEDICATION

This project is dedicated to the Almighty God who spare my life and sustained me with health to enable me complete this research work.

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ABSTRACT

Climate variability is believed to have deteriorating effects towards crop production in Nigeria. The study aimed at analyzing the effect of climate variability on rice production, and farmers perception on the effects of climate variability and their adaptation strategies in Kebbi State Nigeria. Mixed method of research design was employed for the study whereby climate data from 1988- 2018 was obtained from Nigerian meteorological station, YelwaKebbi State and rice production data from 1994 – 2018 was obtained from Kebbi State, Agricultural Development Project (ADP). Focus group discussion was conducted in five villages within three local government areas of Bunza, Suru and Bagudo. The climatic parameters used are rainfall, mean maximum and minimum temperature. The result shows that there is decrease in rice production with little development started in 2013. The trend also indicated increase in maximum temperature and the rainfall trend shows fluctuation pattern while minimum temperature showed stable trend. Rainfall anomaly index were employed and indicates that, drought was experienced in 18 years in the state. The findings also revealed that rainfall and temperature are the major climatic factors affecting rice production in the state. The correlation of climatic variables with rice production indicated that, maximum temperature was found to be negatively correlated with both total production and yield per hecter with correlation coefficient value of ($r=-0.20$) and coefficient of determination ($R^2=0.04$), also rainfall was positively correlated with total production with correlation coefficient value of ($r= 0.15$) and coefficient of determination of ($R^2=0.02$) but negatively correlated with yield per hecter with correlation coefficient value of ($r=0.0$) while minimum temperature showed moderate positive relationship with both yield and total production with correlation coefficient value of ($r=0.35$) and coefficient of determination of ($R^2=0.12$). Farmers revealed that the rice productivity were declining over the 15-20 years back annually with rainfall variability, dry spells, weeds, pest and diseases were found to be major factors responsible for the declining in their productivity. The study therefore recommends that Public enlightenment and awareness on climate variability and its effects on agricultural production specifically increase in temperature and rainfall variability should be carried out by extension workers to local farmers in the study area.

CHAPTER ONE

INTRODUCTION

1.0 Background to the Study

Climate variability refers to natural variation in climate that occurs over months to decades. El Niño, which changes temperature, rain and wind patterns in many regions over about 2 – 7 years, is a good example of natural climate variability, also called natural variability. Climate Change is “a systematic change in the long-term state of the atmosphere over multiple decades or longer (Uejio, Tamerius, Wertz, & Konchar 2015). Climate as a synthesis of weather is never static. Averages and standard deviation of climatic series do vary from one climatic normal period to another, often significantly. The consensus of scientific opinion is that climate is never static and cannot be regarded as constant. It is as variable as weather of which it is a synthesis. Climate variations occur on various temporal scales, varying from a few decades to millennia (Ayoade, 2002). Different nomenclatures are used to describe climatic variations depending on the time scales within which such variations occur. Thus, we have such climatic terms as climatic trends, climatic cycles, and climatic change in addition to such general terms as climatic fluctuations and climatic variability which emphasize the inherently dynamic nature of climate.

The main characteristics of climate change are increases in average global temperature (global warming); changes in cloud cover and precipitation particularly over land; melting of ice caps and glaciers and reduced snow cover; and increases in ocean temperatures and ocean acidity due to seawater absorbing heat and carbon dioxide from the atmosphere (United Nation Environment Programme Global Resource Information Database. UNEP/GRID-Arendal 2005). As a result of global warming, the type, frequency and intensity of extreme events, such as tropical cyclones (including hurricanes and typhoons), floods, droughts and heavy precipitation events, are

expected to rise even with relatively small average temperature increases. Changes in some types of extreme events have already been observed, for example, increases in the frequency and intensity of heat waves and heavy precipitation events (Meehlet *et al.*, 2007).

Climate change will have wide-ranging effects on the environment, and on socio-economic and related sectors, including water resources, agriculture and food security, human health, terrestrial ecosystems and biodiversity and coastal zones. Changes in rainfall pattern are likely to lead to severe water shortages and/or flooding. Melting of glaciers can cause flooding and soil erosion. Rising temperatures will cause shifts in crop growing seasons which affects food security and changes in the distribution of disease vectors putting more people at risk from diseases such as malaria and dengue fever. Temperature increases will potentially severely increase rates of extinction of many habitats and species (up to 30 per cent with a 2° C rise in temperature (UNEP, 2007).

Agriculture largely depends on climate. Hence, climatic factors such as precipitation, solar radiation, wind, temperature, relative humidity solely determine distribution of crops and their productivity. Kurkulasuriya and Rosenthal (2003) observed that changes in temperature and precipitation directly affect crop production and can even alter the distribution of agro-ecological zones, especially in Africa, and agricultural losses can result from climate variability and increased in frequency of changes in temperature and precipitation (including drought and floods). The effects of climate change can appear in the form of recurrent floods, drought and famine, shortage of food, non-supporting weather events, newly discovered diseases, rise of sea level and many other factors (Tisdell, 2008). The most exposed and susceptible sector to climate change is evidently, agriculture. A number of factors associated with climate change like the precipitation pattern, change in temperature. greatly impacts agriculture which includes reduction

in agricultural productivity and the growth time for different crops are also restricted (Alam, *et al.*, 2011). The climate change issue has been more frightening towards the healthier expansion of both socioeconomic and agriculture activities of any country (Adejuwon, 2004). Variation in local climate will force people's decision with penalties for their economic, personal and social environment ultimately affecting their livelihood (United Nation Framework convention on Climate Change. UNFCCC, 2007).

Rice is an important food item as it forms the main part of the diet of over one third of the world's population. It is among the most valued cereal crops of West African and has become increasingly used as a constituent of animal feed. Rice is rich in protein and carbohydrate, the outside layer of the rice grain which is removed during polishing is known as rice bran. Bran is rich in protein and vitamins and is widely used in the formulation of poultry feed (Molua, 2002). Besides, it is low in fat and protein, compared with other cereal grains. Rice also provides minerals, vitamins and fiber, although all constituents except carbohydrates are reduced by milling Intergovernmental Panel on Climate Change(IPCC, 2007).

Nigeria, with many countries across the world, has ecologies that are suitable for the production of different rice varieties. Therefore, proper exploitation of these ecologies can boost rice production to meet domestic demands, as well as to produce surplus for export. There is no gainsaying the fact that the country has a potential land area for rice production of between 4.6 million and 4.9 million ha. However, only 1.7 million ha, or 35 percent of Nigeria's total land mass, is cropped to rice. The cultivable land to rice is spread over five major ecologies - upland, inland or shallow swamp, irrigated rice, deep water or floating rice, and tidal mangrove or swamp. The latter is not fully developed because there is a lack of appropriate technology (Erhabor and Ojogho, 2011).

Rice growth cycle can be broadly divided into three stages, namely, vegetative, reproductive, and grain filling or ripening phases. Rice response to high temperatures varies according to different stages of its biological development (Krishnan *et al.*, 2011.). Existing knowledge on rice suggests an average threshold of 24°C: If rice plants are exposed to an increase of 1°C warming for a number of days, rice could experience a 10% reduction in yield and biomass (Penget *al.*, 2004). Rice is relatively more tolerant to high temperatures during the vegetative phase but highly susceptible during the reproductive phase, and particularly so at the flowering stage (Jagadishet *al.*, 2007). Rice field experiments suggest that an increase of 3.6 – 7°C could lead to 12.2 to 35.6% photosynthesis reduction (Oh-e *et al.*, 2007; Wassmannet *al.*, 2009a). An increase in temperature of up to 3°C (or beyond the limit of heat tolerance) may affect growth duration of the rice crop, reduce grain-filling duration and enhance respiratory losses, resulting in lower yields and lower-quality rice grains.

1.1 Statement of Research Problem

The impact of climate change on crop production globally has double-edged effects, the effects varies relatively depending on the climate change scenario and geographic location (IPCC 2007). But also extreme events (drought, floods, and cyclones) will significantly reduce food production (Rosenzweig and Parry, 1994; Reilly and Schimmelpfennig, 1999; Parry *et al.*, 1999; Gregory *et al.*, 2005;). For all areas across the globe. A number of empirical studies have demonstrated how agricultural productivity remains vulnerable to climatic perturbations (Nyang'auet *al.*, 2014). Nigeria is one of the countries in the world that has the potentials to produce rice in larger quantity. This is a fact because Nigeria has an estimated 4.6 million hectares of land that is suitable for rice production (Danbabaet *al*2013, Wassmann, and Dobermann, 2007).

Variability in the onset of the rainy season leads to variation in the start of the planting season in rain fed rice. Moreover, in freely drained upland, moisture stress severely damages or even kills rice plant in an area that receives as much as 200 mm of precipitation in 1 day and then receives no rainfall for the next 20 days. Complete crop failure usually occurs when severe drought stress takes place during the reproductive stages. Flood is the most important constraint to rice production in low-lying areas. Most rice varieties for rain fed lowland, irrigated and deep-water ecosystems can stand complete submergence for at least 6 days before 50 percent of them die. However, the mortality rate becomes 100 percent when submergence lasts 14 days. Floods also cause indirect damage to rice production through the destruction of property and farmers' production means, as well as of infrastructures supporting rice production (e.g. dams, dikes and roads). The changes in the pattern of rainfall distribution may lead to a more frequent occurrence of intense flood and drought in different parts of the world (Depledge, 2002).

1.2 Research Questions

- i. What are the trends of climate variability in the study area from 1988 – 2018?
- ii. What are the rice productions trends from 1988 – 2018?
- iii. What are the perceived effects of climate variability on rice production in the study area?
- iv. How do the farmers perceive the effect of climate variability on rice production?
- v. What are the adaptation strategies of the farmers in response to the effect of climate variability on rice production?

1.3 Aim and Objectives

Aim

The aim of this study is to assess the climate variability on rice production in Kebbi State over a period of 30 years.

Objectives

- i. To examine the trend of climate variability in the study area from 1988 – 2018
- ii. To examine the rice production trend from 1988 – 2018
- iii. To assess the effect of climate variability on rice production in the study area
- iv. To investigate how farmers perceived the effect of climate variability on rice production
- v. To identify the farmers' adaptation strategies in response to the effect of climate variability on rice production.

1.4 Justification of the Study

Climate has change in the past and nothing will suggest that, it will not continue to change. As studies by Furuya and Koyama (2005) reported that high temperatures would cause a marked decrease in world rice production. Furthermore, studies have demonstrated that the production and distribution of (thus the supply of and access to) rice food in different parts of the world might be affected greatly by the global climate changes. Therefore, understanding the potential impact of climate change on rice based production systems is important for the development of appropriate strategies to adapt to and mitigate the likely outcomes on long-term food security of interaction between rice production and climate change. Despite considerable variability and uncertainty about climatic phenomena, hence this research will serve as measures in understanding the climatic condition related to rice production.

Hence despite all these researches regarding the effect of climate change on agriculture and rice production in particular, similar studies have not been carried out in the study area despite the ecological differences and climatic condition. Hence this provide the need to carry out research of this kind, as the study intend to assess the climatic and production trends and the possible effects of climate change on rice production, the study also intend to investigate how farmers perceive the effect of climate variability on rice production as well as current adaptation strategies, as the study area have been noted for its large scale production of rice in Nigeria.

1.5 Scope and Limitation of the Study

The research was conducted to assess the effect of climate variability and change on rice production alone, and the research was designed to cover some part of Kebbi State which is noted as a high rice production area in Nigeria and also vulnerable to the effect of climate variability. Therefore, the research was covered three Local Government areas (Bunza, Suru and Bagudo) which produce larger percentage of rice production in the study area. The research was also uses inter annual trend of climate variability and rice production over the last 30 years as well as how these climate changes affect rice production in Kebbi State. The research will also focus on how farmers perceived the effect of climate variability on their rice production as well as the adaptation measures they put in to practice. The climatic variables used in this study are rainfall, maximum and minimum temperature

1.6 Description of the Study Area

The characteristics of the study area relevant to the study such as location, climate, soil ecological problem and drainages were review and presented.

1.6.1 Location and Extent of the Study Area

Kebbi State is situated between latitude 10°N and 13°N North of the Equator; and longitude 30°E. Kebbi State shares boundary with Sokoto state on the North Eastern axis, Zamfara State in the Eastern part, Niger state in the Southern part and Republic of Niger on the Western part. The state occupies a total land area of about 36,800 km². The location of rice field in the state was laid out on vast fadama area along River basin and also River system within the state. The selected study areas are Bunza which located around 12°N and 4°E it shares boundaries in the east with Kalgo, in the north with Dandi and Arewa LGA's and in the south and west Suru LGA. Bagudo Local Government was also located around 11° 24' 26" North and 4° 13' 59" East, it shares boundaries with Republic of Benin and Suru Local Government was located around 11° 55' 47" North and 4° 11' 13" it shares boundaries in the east with Bunza LGA, in the north with Bagudo and Dandi LGA's and in the west with Koko Bese LGA. The of the study area was shown on Figure 1

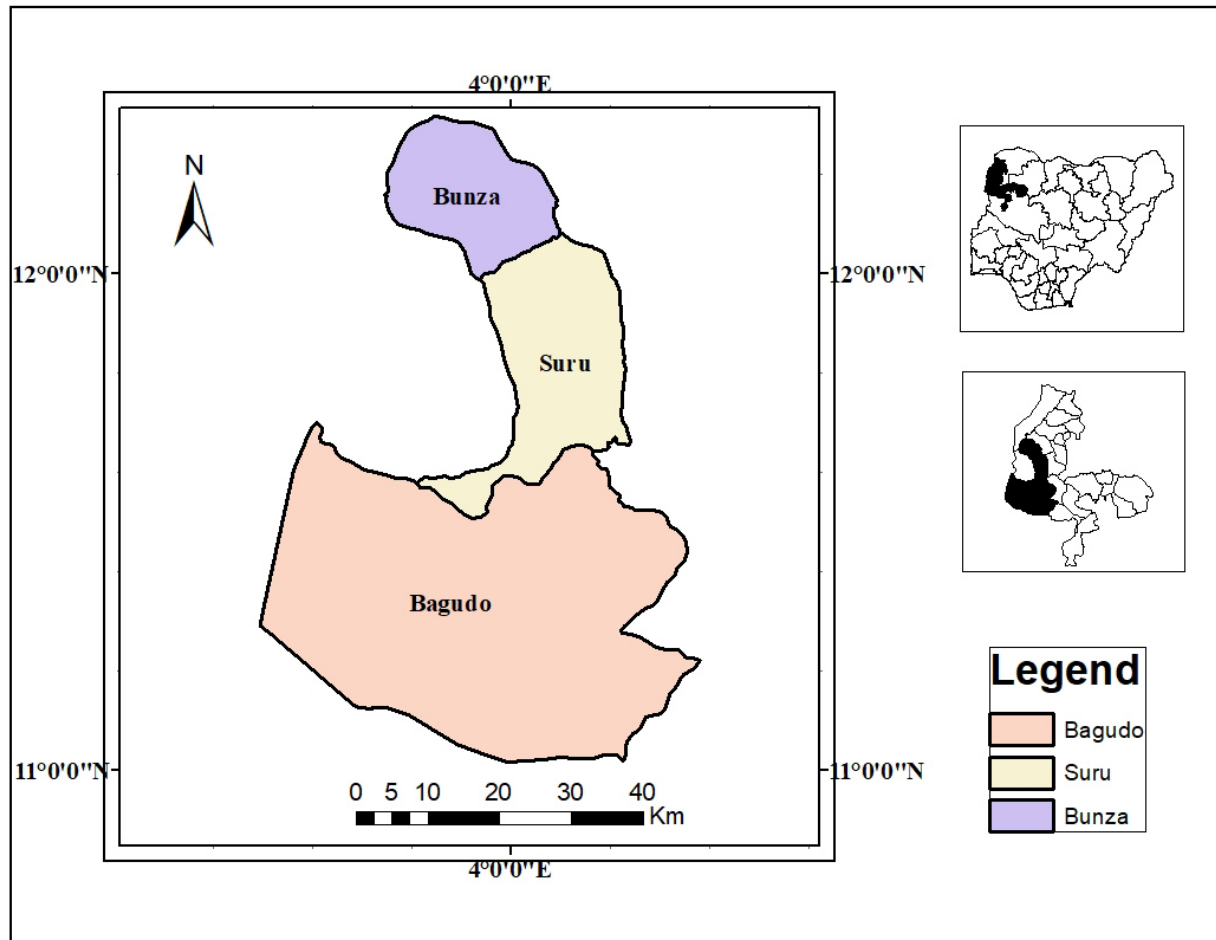


Figure 1: Kerbbi State showing study Area

Source: GIS Lab Bayero University Kano

1.6.2 Climate

Kebbi State enjoys a Tropical Continental type of climate. This is largely controlled by two air masses, namely Tropical Maritime and Tropical Continental, blowing from the Atlantic and the Sahara Desert respectively. These air masses determine the two dominant seasons wet and dry. The wet season lasts from April to October in the south and May to September in the north; while the dry season lasts for the remaining period of the year. Mean annual rainfall is about 800 mm in the north and 1000 mm in the south. However, during the harmattan season (December to

February) the temperature can go down to about 21°C and up to 40°C during the months of April to June. Night temperatures are generally lower. Relative humidity is generally low (40 per cent) for most of the year except during the wet season when it reaches an average of eighty percent. This explains the hot dry environment which is in sharp contrast to a hot humid environment in the southern parts of Nigeria. The study area was characterized by tropical continental type of climate which favored rice production farming system, but unfortunately the climatic condition in the state can vary widely annually causing large variations on Agricultural productivity and rice production in particular.

1.6.3 Geology and Relief

The geology of the study area was characterized by thick and vast sequences of sedimentary deposits of Sokoto Rima Basin which underlie about 50% of the area. The rest being underlain by Precambrian Basement complex rocks. The predominant soil type in the study area however is the ferruginous tropical soil. The main features include sandy surface horizon underlain by weakly developed clayey, mottled. The landscape of the study area is dominated by extensive flood plain (Fadama) of the inland river valley systems. The Niger river flows southwest across part of the state and the Rima river flows southerly through the Centre of the state to join the Niger.

1.6.4 Drainages

The drainage system in Kebbi State is dominated by River Rima system with major tributaries like Gawon, Zarnfara and GubinKa. These tributaries rise in the Basement Complex region of Sokoto State and flow westward to join the Rima. However, in the southern part of the state, there are other less important rivers such as Danzaki, Soda and Kasanu, all of which flow to join

the River Niger to the south of the state. Most of these rivers first flow through deep and narrow valleys with steep gradients on the Basement Complex rocks, and then through broad shallow valleys when they flow through the sedimentary formations. The Rima itself flows in a broad sweeping valley through the sedimentary area and then into the River Niger in the south west, creating extensive flood plains that are not similar to the present discharges. Thus indicating that it is a product of a more humid Quaternary period in the past. In terms of flow regimes, most of the rivers are storm channels maintaining bankfull discharges after individual rainstorm events only to dry out with the cessation of rainfall. This characteristic is also reflected in seasonal flow situations.

1.6.5 Soil and Vegetation

In the northern part of the State, two groups of soils can be identified, the upland and fadama soils. These two soil groups are generally characteristic of the entire Sokoto Rima Basin. While the upland soils are sandy and well drained, the fadama soils are generally clayey and hydro morphic, especially in the back swamps. In the south and southeastern parts, the weathering of the Basement Complex rocks has given rise to three types of soils. These are the ferruginous tropical soils, black cotton soils and lithosols. These soils are subject to stripping by erosion as a result of topographic characteristics typical of the area.

The natural vegetation of the State consists of a Northern Guinea Savannah in the south and southeast. They are characterised by medium sized trees such as *ParkiaClappertoniana* (locust bean tree) and *Butyrospenum* (Shea butter tree) and *Combretum* species. In the north, the Sudan Savannah consists of open woodland with scattered trees such as acacia aibida (gawo), *ParkiaClappertoniana*, *Porassus* and dum palms. The natural vegetation has however been altered in many areas by intensive cultivation, grazing, fuel wood harvesting and bush burning,

giving rise to a form of parkland dominated by trees like *Piliostigma*, *Ziziphus*, *Mangifera* Indica and Tamarindus, especially in the south. The practice of pastoralism by herdsmen in addition to browsing and bush fires in the dry season have done damages to young trees, thereby taking a heavy toll. The study area was comprised with group of soils i.e upland and fadama land which was characterize with Sokoto Rima Basin. The study area endowed with vast fadama land favorable for rice production.

1.6.6 Economic Activities

Agriculture is the mainstay of the economy in Kebbi State, with more than eighty percent of the people engaged in it. Rainfall is seasonal, as such most farming is carried out during the wet season on the upland during which food and cash crops such as millet, sorghum, maize, rice, beans, cassava, cotton, and tobacco are cultivated. During the dry season, farming is carried out in the vast fadama lands where crops such as tomatoes, onions, pepper, sugar cane, vegetable and sweet potatoes and wheat are cultivated. Farming is mostly based on indigenous techniques, using local inputs of seeds, family and animal labor and informal credits.

Animal traction is used among the Kambari, Dukawa and Dakarkaris. Indigenous forms of cultivation are however gradually giving way, as more farmers now use improved seed varieties, chemical fertilizers, formal credit facilities, and ploughs and tractors. Due to migration of family members, indigenous forms of farm labour also are gradually being replaced by hired labour. Some farmers rear cattle, sheep and goats to augment their income. These animals are fed with the stalk of grains, and leaves of legumes. For the most part, animals are grazed in the open field around the village and in the fadamas. Animal wastes are in turn used to manure the field. In essence, therefore, some form of mixed farming is practiced. Most animal rearing is done by the Fulani who oscillate from north to south. They migrate out of the area further south to the middle

belt during the wet season and return to the area during the dry season. These animals are the main sources of meat, milk, butter and manure. In search of water and pasture for their animals, the herdsmen have often run into conflict with sedentary farming communities. To reduce such conflicts, the state government has set up structures and facilities in strategic locations. It has carved out animal routes and set up conflict resolution committees between farmers and herders. The people also engage in other related activities such as collection of forestry products like fruits, wood, and ropes which are sold or used in making materials of arts and craft such as baskets, caps, mats and domestic appliances like mortar and pestles. Other activities are fishing, poultry keeping, blacksmithing, weaving and knitting. The people also engage in petty trading like hawking of kolanuts, water, cigarettes and meat (suya). The mainstay of economic activities of people in the study area was predominantly agriculture with majority of the residents engaged in rain fed agriculture. In contemporary years, rice production was the major production system practice in the state.

1.6.7 Population and Settlement

The study area has a total population of 3,238,628 as per 2006 Nation census comprises of 21 Local Government Area and four emirate councils. Of the total population, however male account for 1,617,498 or 49.9% while females are 1,621,130 or 50% of the population. The study area has diverse ethnic composition with major tribes and the Local Governments are mostly domiciled. These are Hausa all over the state but dominant in areas like BirninKebbi, Jega, Argungu, Bunza, Gwandu and Koko Local Government areas. DakarkariareeZuru, Danko-Wasagu and Sakaba Local Government Areas. Zabarmawa are Dandi, Arewa and Bagudo Local Government Areas respectively.

1.6.8 Ecological Problems

One of the major problems associated with the physical environment Kebbi State is that of desertification. This phenomenon is a serious constraint to development in the northern part of the state. The areas mostly affected are Gwandu, Argungu, BirninKebbi, Jega, Maiyama, Arewa and Dandi Local Government Areas. In these areas, desertification manifests itself through incidence of wind erosion, dune accumulation and exposure of lateritic ironstone on the landscape. However, significant achievements have been made by the state towards finding solution to the problem. These efforts consist of establishment of shelter belts, woodlots, roadside plantations and forest reserves. Desertification is the product of a number of factors, both natural and Man-made. Some of these factors include, limited rainfall, indigenous methods of cultivation, excessive sourcing for fuel wood and indigenous grazing techniques. All these have combined to deprive the environment of its natural vegetation, thus accelerating the incidence of soil erosion. Related to the problem of desertification is that of drought occasioned by the below average annual rainfall and uneven distribution. Furthermore, there are no edicts to curtail bush burning and wood cuttings.

Other ecological problems afflicting the state include those of flooding, pest infestation and gullies. The problem of flooding is restricted more to the Rima valley, and it is caused by uncontrolled release of water from the Goronyo and Bakolori reservoirs stream in Sokoto and Zamfara States respectively. Flooding has become an annual event since 1988. It occurs when excess water is released from the Bakolori and Goronyo dams upstream. Flooding has caused devastation of croplands within the flood plains, of settlements bordering them and loss of lives.

Pest problems tend to be more pronounced during periods of long cessation of rains during the wet season. More recent ones are the 1986 and 1994 grasshopper invasions that destroyed many

crop lands. Since the creation of the state and the need to develop the state capital, the search for laterite for building and road construction had resulted in a number of deep trenches and gullies. These have consequently increased the rate of erosion. Ecological problem of pest and diseases become serious challenge which triggered agricultural productivity with rice production affected most with proliferation of pest and diseases in the study cause by increase in temperature and variability in climatic condition of the area.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The relevant materials such as climate change effects on crop production in Nigeria, rice production in Nigeria, effects of climate change on rice production, effects of increase in temperature on rice production, effects of changes in the pattern of precipitation on rice production, effects of rising sea level on rice production, and effects of drought on rice production respectively were reviewed and presented here.

2.2 Climate Change Effects on Crops Production in Nigeria

Climate change refers to any variation in climate over time, whether due to natural variability or as a result of human activity (Intergovernmental Panel on Climate Change, IPCC, 2001a; 2001b). Climate change is a global crisis – the inter-governmental panel on climate change estimates that there will be increase in global mean temperature of about 1°C above the present value by the year 2025 and 3°C before the end of next century (IPCC, 2002). Some of the critical challenges that agriculture will face under climate changes are obvious. Many of them are the amplification of the substantial challenges that the current climate already imposes; water availability is at the top of the list. Water is already scarce in many regions, increasing demand and competition for water will combine with changing and less predictable rainfall and river flows (USAID, 2008). In Africa, where so many people rely directly on the rain for their foods and livelihoods, any changes in rainfall present a major risk. Indeed, the IPCC's fourth assessment report suggest that some African countries may see yields from rain fed agriculture fall by as much as 50% by 2020, if production practices remain unchanged (IPCC 2002). Climate change in the form of higher temperatures, reduced rainfall and increased rainfall variability, reduces crop yields and net farm

revenues, and threatens food security in low income based economies, including African countries (FAO, 2007). Agriculture had its effect on climate change just as climate change had on agriculture. According to Sauchyn and Kulshreshtha (2008). At the recently concluded 10th Session of IPCC WG II and 38th Session of IPCC in Yokohama, Japan, the world was warned that climate change impacts are leading to shifts in crop yields, decreasing yields overall and sometimes increasing them in temperate and higher latitudes. In light of these, some indigenous communities are changing seasonal migration and hunting patterns to adapt to changes in temperature (IPCC, 2014). According to Shah *et al* (2009) the adverse consequences of climate change will take an irreplaceable toll on food production and food security especially in developing countries which have a low capacity to cope and adapt to these challenges.

Evidence from Singh *et al.*, (1997) confirmed the effects of climate change on farm net revenue in different parts of the globe through rainfall and temperature variability. These probably underlie the reason why International Food Policy Institute's 2013 Global Food Policy Report observed that current discussions on the post-2015 agenda are emphasizing the need to expand beyond the Millennium Development Goals (MDGs) by incorporating climate change alongside urbanization, conflict, and sustainable consumption and production patterns into the development framework. With nearly 6% of Nigeria's population dependent on agriculture and the sector contributing nearly 40% of the country's GDP, Nigeria remains vulnerable to climatic variability and long term climate change (Ajetomobiet *al.*, 2010).

It has been predicted that climate change will impact negatively on agricultural yield in the 21st century through higher temperatures, more variable rainfall and extreme climate events such as floods, cyclones, droughts and rising sea levels Danbabaet *al*(2013) . Idoma,.and Ismail 2014). Consequently, (Danbabaet *al.*, 2013) noted the vulnerability of agriculture to climate change has

made the scientific and policy communities to be doubtful of the capacity of farmers to adapt to climate change. In the same vein, (Danbaba *et al.*, 2013,) observed that The United Nations Framework Convention on Climate Change also identifies the threat to food production as a major worry. It is instructive to note that water scarcity is basically ascribed to factors such as climate change and population growth. Though, climatic changes manifested through weather extremes in the form of floods and droughts are likely to further increase the competition for water. However, it is population growth and the resultant increase in demand for food production that puts the greatest pressure on water availability. According to (Idoma and Ismail 2014), irrigated agriculture produces approximately 40% of the world's food crops. The water use required for this crop production accounts for 70% of all water withdrawals (Idrisal, 2012). Hence, to respond to the ever growing competition for water, researchers and policy makers resolve that the role of irrigated agriculture is germane.

Unfortunately, credible reports from Nigerian Metrological Agency, NIMET (2012a) did not offer much hope. The report indicated that Nigerian climate had shown considerable temporal and spatial shifts in its variability and change, making extreme climate and weather event (drought, flood, heat waves, ocean surges, etc.) a more regular event, exemplified by destructive flood of 2012 which occurred in many parts of Nigeria. Ebohet *al* (2006) observed that, while data limitations made it difficult to estimate cost of possible crop land degradation, the historic crop yield data showed that economic cost of degradation and poor management of renewable natural resources was at least 6.4% of GDP in Nigeria. They found that the annual cost of yield decline as a result of environmental or land degradation from 1995-2004 in Nigeria was estimated at 1.6 billion dollars. More than 60% of this cost was attributed to roots and tubers. In a similar way, IPCC (2014) warned that climate change adaptation could cost \$100 billion

globally. The emphasis is on smallholder farmers since they dominate the Nigerian agricultural sector, engaging about 65% of the population and contributing between 30-40% of the nation's GDP (Ajetomobiet *al*, 2010). Morton (2007) noted that although climate change issues were recently receiving a lot of empirical and documentary attention, especially as they affect rural areas of developing countries, there have been relatively insufficient discussions concerning the impact of climate on agriculture, specifically in the area of smallholder and subsistence systems. Most studies that have addressed the issues (e.g. Eneteet *al*, 2011; Umoh and Eketekpe, 2010) were either too location specific, used qualitative approach or just reviewed related literature only. The study's focus on staple crops (especially rice, yam, cassava, cowpea and maize) was instructive.

IFPRI and Nigerian Strategy Support Programme's report indicated that despite the fact that cereals, roots and tubers dominated Nigerian crop production at a time when the country was the world's leading producer of cassava, yams and cowpea, their productivities were still below potential yields while profitability varied across three broad agro-ecological zones. IFPRI (2009) also asserted that Nigeria was characterized by high reliance on food imports amidst growing level of malnutrition across the country, with rural areas being especially vulnerable to chronic food shortages, malnutrition, unbalanced nutrition, erratic food supply, poor quality foods, high food costs and even total lack of food. This situation can be exacerbated by risks of climate change if Nigeria remains aloof. The variation in weather and climate has led to a lot of devastating consequences and effects in various parts of the country (Kebbeh *et al*, 2003). These include flooding, deforestation, desertification, erosion, drought, sea level rise, heat stress, pests and diseases, erratic rainfall patterns, and land degradation. More specifically, the South-South geopolitical zone is mainly affected by sea level rise and deforestation induced changes; South-

East by erosion, flooding and land degradation; North-Central by changes due to de-vegetation and over-grazing; North-East by drought, desertification and heat stress, and North-West also by drought, desertification and heat stress (Ozor, 2009). The centrality of agriculture to Developing Economies (DEs) is not in dispute (Umoh, 2003). Nigeria, with over 140 million inhabitants, constitutes about a quarter of Africa's total population. Agriculture is the largest sector of economy, providing about two-third of the nation's workforce (National Bureau of Statistic, NBS, 2007a). In spite of this, Nigeria faces acute shortage of food as a result of its low agricultural productivity (Ukwuet *al*, 2003). This shortage, which varies seasonally or yearly, is reflected in the quantity of food made available for consumption by Nigerians. Rice remains an important component of that quantity; a major arable crop grown in Nigeria where supply is still considered insufficient to match the consumption increase (NBS, 2007a).

2.3 Rice Production in Nigeria

Nigeria, with many countries across the world, has ecologies that are suitable for the production of different rice varieties. Therefore, proper exploitation of these ecologies can boost rice production to meet domestic demands, as well as to produce surplus for export. There is no gainsaying the fact that the country has a potential land area for rice production of between 4.6 million and 4.9 million ha. However, only 1.7 million ha, or 35 percent of Nigeria's total land mass, is cropped to rice. The cultivable land to rice is spread over five major ecologies - upland, inland or shallow swamp, irrigated rice, deep water or floating rice, and tidal mangrove or swamp. The latter is not fully developed because there is a lack of appropriate technology (Erhabor and Ojogho, 2011). Rice is an important food item as it forms the main part of the diet of over one third of the world's population. It is among the most valued cereal crops of West African and has become increasingly used as a constituent of animal feed. Rice is rich in protein

and carbohydrate, the outside layer of the rice grain which is removed during polishing is known as rice bran. Bran is rich in protein and vitamins and is widely used in the formulation of poultry feed (Molua, 2002). Besides, it is low in fat and protein, compared with other cereal grains. Rice also provides minerals, vitamins and fiber, although all constituents except carbohydrates are reduced by milling (IPCC, 2007). According to (Reid *et al* 2007) and (Lisa, Pfeiffer and Cynthia Lin 2010), Nigeria is one of the largest rice producers in West Africa, producing an average of 3.2 million tons of milled rice for the past 7 years. In Nigeria, rice is also one of the key cereal grains taking the place of some of the grains and tuber crops. Rice was once reserved for ceremonial occasions in the Nigerian diet (Huffaker and Whittlesey, 2003). However, combinations of several elements appear to have triggered the structural increase in rice consumption. As stated by (Huffaker and Whittlesey, 2003), rising demand was partly the result of increasing population growth as well as increased income levels, following the discovery of crude oil.

The most important factor contributing to the shift in consumer preferences away from traditional staples and towards rice is rapid urbanization and associated changes in family occupational structures (Bale, and Masters, 2002). Instructively, (Poorter and Navas, 2003) and (IPCC. 2007) remarked that rice production in the country increased significantly in the periods 1980 to 1998 due to increase in land area put into rice production. The studies revealed that aggregate rice production in Nigeria increased from about 600,000 metric tons in 1980 to about 1,422,000 metric tons in 1989. In addition, (Tao, *et al* 2004) and (Kathmandu and SANDEE 2014) further showed that, out of the 4.6 million hectares of potential rice land across the country, the area put into rice production rose from 1.0 million hectares (22.3%) in 1988 to 1.8 million hectares (39.0%) in 1996 and 1998.

2.4 Effects of Climate Change on Rice Production

Globally the effects of climate change on rice base production are resulted on several parameters. Various studies suggested that increase in temperature, changes in rainfall pattern and distribution and rising seas are the significant result of global climate change which could lead to considerable changes in land and water resources for rice production grown in different part of the world. Yet, the challenge for rice production is double: coping with population growth while also facing climate change. The changes associated with global warming in temperature, carbon dioxide and rainfall are expected to impact rice production. Studies (Rahji and Omotesho (2006); Emeka and Ugwu (2015); Osagie, (2015) have revealed that increase in temperature due to climate change adversely affect rice crop physiology, ultimately decreasing crop yields and grain quality. Furthermore, uncertainty related mostly to anticipate precipitation spatial and temporal patterns caused by climate change, makes it difficult to project the full effect of intensified frequency of floods and severe droughts (Terwase and Madu (2014).

Generally, researchers have acknowledged that climate change has a positive effect on rice grain yield. The effects of increase in carbon dioxide have been found to be invalid by the effects of increase in temperature (Imolehin and Wada (2000). However, multiple sources of bias make estimates of climate change impact on rice production uncertain. The magnitude of the bias is estimated to range between 1 to 32 percent. Uncertainty in projections results from climate models, spatial resolution, crop models and to add an additional level of complexity, rice cultivation strongly depends on farmers' management skills: rice variety, cropping pattern and infrastructure improvements (Adger *et al* (2009).

Ifeanyi-Obi *et al.* (2012) reported that adverse climate effects can influence output at any stage from cultivation to the final harvest. They further stated that changes such as steady increase in

night time temperature can lower rice yields. Also, irregularity in rainfall despite its sufficiency can affect yield adversely if, rains fail to arrive during the crucial growing stage of the crop. The effects of climate on rice crops do not stop at planting period but continues during harvest and post-harvest stages. Ideally, once rice is cut from the field, the process of threshing, drying, and safe storage should occur within 24 hours. Failure to achieve this ideal condition often leads to physical grain loss to farmers and loss of grain quality to consumers (Brolley, 2015). Rice growth cycle can be broadly divided into three stages, namely, vegetative, reproductive, and grain filling or ripening phases. Rice response to high temperatures varies according to different stages of its biological development (Krishnan *et al.*, 2011). Climate change may have an impact on freshwater systems there has been evidence of decline in the rice production in some parts of Asia due to water stress triggered by increasing temperature, reduction of number of rainy days and increasing dry spells (Wassmann *et al.*, 2009a, b; Cairns *et al.*, 2012). In the context of India, water stress is often manifested in the form of droughts (Udmale, 2015).

However, some rice cultivars may stand against drought better than other rice cultivars (Ward *et al.*, 2014). Rice is relatively more tolerant to high temperatures during the vegetative phase but highly susceptible during the reproductive phase, and particularly so at the flowering stage (Jagadish *et al.*, 2007). Unlike other abiotic stresses, heat stress occurring either during the day or night has differential impact on rice growth and production. With rapid increase in the minimum (nighttime) temperature during the last 2 – 3 decades compared to the maximum (daytime) temperature, and predictions that this trend will continue, impacts that, for now, are being identified in select vulnerable regions will be felt on a global scale (Welch *et al.*, 2010). Existing knowledge on rice suggests an average threshold of 24°C: If rice plants are exposed to an increase of 1°C warming for a number of days, rice could experience a 10% reduction in yield

and biomass (Peng *et al.*, 2004). An increase in temperature of up to 3°C (or beyond the limit of heat tolerance) may affect growth duration of the rice crop, reduce grain-filling duration and enhance respiratory losses, resulting in lower yields and lower-quality rice grains. Rice field experiments suggest that an increase of 3.6 – 7°C could lead to 12.2 to 35.6% photosynthesis reduction (Oh *et al.*, 2007; Wassmann *et al.*, 2009a). Septiningsih *et al.* categorised yield losses due to unpredictable flood events into three damage categories: first, complete submergence (often referred to as flash flooding), causing plant mortality after a few days, second, partial submergence over durations (often referred to as stagnant flooding), triggering substantial yield losses and lastly, water logging in directly seeded rice, creating anaerobic conditions that affect germination. Submergence is likely to increase considerably in the future given the increase in sea water level as well as increases in the frequency and intensity of flooding caused by extreme weather events (Septiningsih *et al.*, 2009; IPCC, 2014).

Salinity limits the growth of rice. However, certain rice genotypes can withstand a moderate salinity environment. Salt stress response in rice varies with the developmental stage. Furthermore, rice can be relatively more tolerant during germination, active tillering and toward maturity but sensitive during the early vegetative and reproductive stages (Asch & Wopereis, 2001). IPCC 2014 considers the increasing threat of salinity on rice, which is linked to the consequences of climate change in the form of sea level rise and coastal flooding, in the coming 50–100 years.

2.5 Effect of Increase in Temperature on Rice Production

Temperature regimes greatly influence not only the growth duration, but also the growth pattern and the productivity of rice crops. Extreme temperatures – whether low or high – cause injury to the rice plant. In tropical regions, high temperatures are a constraint to rice production. The most damaging effect is on grain sterility; just 1 or 2 hours of high temperature at anthesis (about 9 days before heading and at heading) result in a large percentage of grain sterility. Studies on rice productivity under global warming also suggest that the productivity of rice and other tropical crops will decrease as global temperature increases. Penget *et al.* (2004) reported that the yield of dry season rice crops in the Philippines decreased by as much as 15 percent for each 1°C increase in the growing season mean temperature. Similarly, Mohamed *et al.* (2002a and b) estimated that by 2005, climate change in Niger could lower yields of millet by 13 percent, groundnut by between 11 and 25 percent and cowpea by 30 percent. Temperature increases in subtropical and temperate climate areas may have a positive or negative effect on rice crops, depending on the location. For example, temperature increase would improve the crop establishment of rice in Mediterranean areas, where cool weather usually causes poor crop establishment (Ferrero and Nguyen, 2004). However, Ramirez (2010) opined that unforeseen changes associated with global warming in temperature (as increase in temperature due to climate change adversely affect rice crop physiology which ultimately decrease crop yield and grain quality), carbon (iv) oxide and rainfall are expected to impact on rice production.

Rice is most sensitive to high temperatures at heading and next most sensitive at about 9 days before heading. One or two hours of high temperature at anthesis has a decisive effect on the incidence of sterility. High temperatures before or after anthesis have much less effect on sterility. The risk of high temperature and water stress present in all rice production systems from

uplands to lowlands has been identified as one of the most important production constraints in Africa. Sterility was increased at high temperature of 35 °C (day) and 30°C (night) as a result of smaller pollens and non-dehiscence of anthers. Temperature exceeding optimum levels relates negatively with rice production potential, as it retards photosynthetic processes, increases respiration, reduces vegetative and periods of grain filling (Nyang'au et al., (2014). Nguyen (2004) also noted that the growth pattern, duration and productivity of rice crop is greatly influenced by temperature while severe moisture stress especially during rice reproductive stage may lead to complete crop failure. Even if plant growth is vigorous, temperature that remains at 14-16 °C for more than 3 days during the period from reduction division to heading will cause serious damage because of grain sterility (Toriyama and Heu, 2000). The rise in atmospheric temperature causes detrimental effects on growth, yield, and quality of the rice crop by affecting its phenology, physiology, and yield components (Singh 2001, Sheehy *et al.* 2005, Penget *al.* 2004). Yield losses under high temperature were attributed to spikelet sterility and reduction of grain weight (Prasad *et al.*, 2006; Shi et al., 2013). The decrease of grain weight is related to the formation of imperfect grains and the reduction in dry mass accumulation and translocation (Tashiro and Wardlaw, 1991). During the grain filling stage, high temperature worsens transparency, increases chalky rice, and reduces head rice rate (Ambardekaret *al.*, 2011; Lanning *et al.*, 2011). However, larger panicle rice varieties usually require longer flowering and grain-filling duration, and thus the positional differences among grains become more significant. When environmental fluctuations happen, their spikelet fertility, grain weight and quality are much more heavily affected than varieties with normal panicle size (Cheng *et al.*, 2007; Mohammed and Tarpley, 2010). The threshold of high temperature assumed to cause damage to spikelet

fertility is set at 30 °C for daily mean temperature or at 35°C for daily maximum temperature for three consecutive days (Tianet *et al.*, 2007).

Among all the environment factors, temperature and relative humidity play a major role in rice yield. The optimum temperature for the normal development of rice plant ranges from 27°C to 32°C. Morita *et al.*, 2004). However, (anthesis and fertilization) and booting (microsporogenesis) are considered to be the stages of most susceptible to temperature in rice Farrell *et al.*, (2006). Temperatures higher than the optimum induce floret sterility and thus decreased rice yield (Nakagawa *et al.*, 2003). Spikelet sterility is greatly increased at temperatures higher than 35°C which is the critical maximum temperature in rice. Night temperature of less than 19 °C is the critical low temperature for inducing grain sterility in rice (Abeyasiriwardena *et al.*, 2002). Weerakoon *et al.* (2008), reported that spikelet fertility was not always inhibited by high humidity, because at low temperature, fertility was high. Both higher maximum and higher minimum temperatures with high relative humidity decrease rice yields due to spikelet sterility (Peng *et al.*, 2004).

2.6 Effect of Changes in The Pattern of Precipitation on Rice Production

At present, about 40 percent of the total rice area is classified as rain fed (low and or upland), while about 3.5 million ha of rice-land are still being classified as deep-water or flood-prone (Maclean *et al.*, 2002). Variability in the amount and distribution of rainfall is the most important factor limiting yield of rain fed rice. Variability in the onset of the rainy season leads to variation in the start of the planting season in rain fed rice. Moreover, in freely drained upland, moisture stress severely damages or even kills rice plant in an area that receives as much as 200 mm of precipitation in 1 day and then receives no rainfall for the next 20 days. Complete crop failure usually occurs when severe drought stress takes place during the reproductive stages. Flood is

the most important constraint to rice production in low-lying areas. Most rice varieties for rain fed lowland, irrigated and deep-water ecosystems can stand complete submergence for at least 6 days before 50 percent of them die. However, the mortality rate becomes 100 percent when submergence lasts 14 days. Floods also cause indirect damage to rice production through the destruction of property and farmers' production means, as well as of infrastructures supporting rice production (e.g. dams, dikes and roads). The changes in the pattern of rainfall distribution may lead to a more frequent occurrence of intense flood and drought in different parts of the world (Depledge, 2002).

Variability in rainfall is associated with an untimely cessation at this stage, the yield reduction is severe. Wind damage to the crop at this phase was triggered by temporary water stress in the panicle spikelet and the injury was less when wind was accompanied by rain. Rice flowering was affected when rain occurred continuously for three days during flowering (Vijayakumar, 1996). Due to heavy rainfall, panicles have large number of blank florets and nitrogenous fertilizers are less effective. The response of paddy to rainfall during the sharp critical phase of panicle initiation is significantly favourable. Variability in rainfall is associated with an untimely cessation at this stage, the yield reduction is severe. Wind damage to the crop at this phase was triggered by temporary water stress in the panicle spikelet and the injury was less when wind was accompanied by rain. Rice flowering was affected when rain occurred continuously for three days during flowering (Vijayakumar, 1996). Ifeanyi-Obi *et al.* (2012) reported that, irregularity in rainfall despite its sufficiency can affect yield adversely if, rains fail to arrive during the crucial growing stage of the crop. Due to heavy rainfall, panicles have large number of blank florets and nitrogenous fertilizers are less effective. The response of paddy to rainfall during the sharp critical phase of panicle initiation is significantly favorable. Gupta *et al.* (2000) explained

the yield variations in rain fed rice by quantum of precipitation during the critical vegetative and reproductive phases. Deficit soil moisture during grain filling stage drastically reduces the grain yield even if there was normal rainfall during preceding phases.

2.8 Effects of Drought on Rice Production

Drought can be a result of an overall decline in rainfall in wet or dry season, a shift in the timing of the wet season, as well as strong local warming that exhausts water bodies and soils by evaporation (World Bank, 2013). As reported by Mannehet *et al.* (2007), rice when compared with other crops is very sensitive to drought which can reduce stand establishment, tillering, plant height, spikelet fertility and also delay flowering. The degree of impact on drought however, is dependent on the stage of growth of the crop. The major problems associated with rice production include drought, flooding, salt stress and extreme temperatures all of which are expected to worsen with climate change. Drastic changes in rainfall patterns and rise in temperatures will introduce unfavourable growing conditions into the cropping calendars. These changes modify growing seasons which subsequently reduce rice productivity (Ajetumobi *et al.*, 2010).

Drought in general reduces the dry weight accumulation in all plant and shorting the life cycle of plants causing yield reduction (Blun, 2005; Kamoshita *et al.*, 2008). Although rainfall affects all stages of rice growth and development, water stress during during the flowering stage depresses grain formation more than the drought at other stages (Boonjunge and Fukai 1996). Drought also affects the phenomorphology and physiological characteristics of rice in various ways, all resulting in yield reduction, particularly in rainfed cropping systems. More specifically stomata closure and the leaf CO_2/O_2 is reduced under drought conditions. (Jason *et al.*; 2004). In rice, low water potential around the time of anthesis may lead to a failure of anther dehiscence which lead to male sterility (Saini and west gate 2000).

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter employed both the use of quantitative and qualitative approaches such as types, sources of data, method of data collection, sampling frame and techniques, research design, data collection and data analysis.

3.2 Research Design

The type of research design used in this research was cross sectional design. This is descriptive and explanatory study that employed mixed methods of data collection and analysis using both quantitative and qualitative method. The purpose of using a mixed method design was to use the responses obtained from the focus group discussion and climate related result to provide a comprehensive analysis of the research questions asked. Another reason was the possibility of using the results from one approach to confirm or corroborate findings from the other.

3.3 Types and Sources of Data

The primary data such as rainfall, maximum and minimum temperature was collected from Nigerian Meteorological Agency (NIMET) and Kebbi state, Agricultural Development Project (ADP) where rice production data were collected, also information such as planting data and rice varieties produced, rice rainfall requirement, rice temperature requirement, farmers perception about climate variability and its effect on rice production, years experienced decline in rice production and adaptation measures were obtained through focus group discussion (FGD). Secondary data were collected from the review of the relevant materials such as books, journals and conference proceedings.

3.4 Sampling Frame and Techniques

All rice farmers constitute the population of this study area, since it is not possible to undertake study for the entire population of rice farmers. However therefore base on FGD guide, 8 and above respondents with 30 years and above of rice farming experience was been selected in five villages notable for high rice productivity within the three local government areas of Bunza, Suru and Bagudo for the focus group discussion (FGD), conducted. Purposive sampling technique was used for this study whereby Bunza, Suru and Bagudo Local Government Areas are regarded as areas with high rice production in Kebbi State and hence purposively selected for the study.

3.5 Method of Data Collection

Historic climatic data (rainfall and temperature) for the period extending from 1988 to 2018 were collected from Nigerian Meteorological Agency (Yelwa station), also rice production data was obtained from Agricultural Development Project (ADP) for the period of 1994 to 2018. Focus group discussion (FGD) was conducted with rice farmers in five villages which are notable in rice productivity out of three local government area of Bunza, Suru and Bagudo, with the help of research assistant for note taking and also using voice recording whereby relevant information for the study were obtained from the respondents. The respondents were gathered with the help of village heads

3.6 Data Analysis

The data for this study were been processed and analyzed quantitatively and qualitatively. The quantitative data were analyzed using both descriptive and inferential statistics. Linear trend as well as table were used to analyze and present the trend of climatic variables and rice production. Pearson Product Moment Correlation analysis was also conducted to establish the relationship between climatic variables such as rainfall, maximum and minimum temperature and crop yield.

using SPSS package. Rainfall anomaly index (SPI) was also employed to analyze the wet and drought years. The qualitative data from focus group discussion were also described thematically.

CHAPTER FOUR

DATA PRESENTATION AND DISCUSSION

4.1 Introduction

This chapter presents the analysis and discussion of the results of the study which were analyzed using various methods and approaches to achieve the objectives stated in the previous chapters. The findings were discussed under the following sub-themes: the trends of climatic variables such as annual rainfall, maximum and minimum temperature, rice production trend, correlation analysis of climatic variables and rice production, farmers' responses on rainfall and temperature requirements for rice production, planting dates and seed varieties used, farmers' perceptions about climate variability and its effects on rice production as well as farmers' adaptation strategies.

4.2.1 ANNUAL RAINFALL TREND IN KEBBI STATE

The trends of rainfall amount and the variation in the study area are shown in Figure 2. The year-to-year variations were observed over the study period. The trend of annual rainfall varies over the years, which shows that rainfall was at its peak level in 1999 with 1566.20 mm, while in 1990 it was characterized by the lowest rainfall amount with 751.90 mm. However, in 1996, 885.9 mm was being observed. The annual rainfall was between 906.20 mm and 998 mm in the years 1989, 1993, 2000, 2002, 2005, 2006, 2007, 2012, 2013, 2015, 2016, and 2017. In the same vein, 1004.90 mm to 1507.20 mm was experienced in the years 1991, 1992, 1994, 1995, 1997, 1998, 2001, 2003, 2004, 2008, 2009, 2010, 2011, 2014, and 2018. Moreover, annual rainfall below 700 mm was not observed during the study time period.

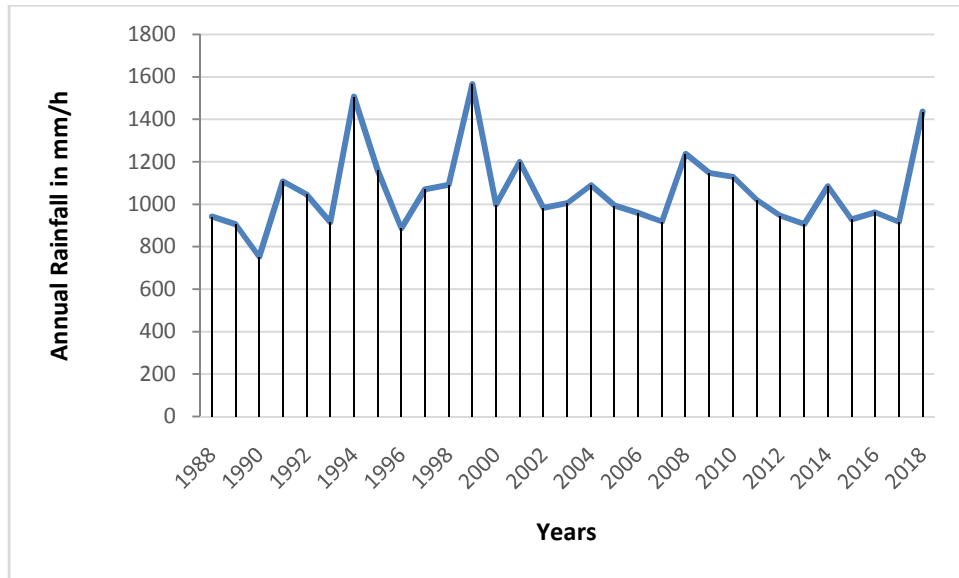


Fig. 2: Annual Rainfall Trend in Kebbi State

Source: Nimet, 2019

The trend of annual rainfall during the study period shows fluctuation pattern from one year to the other as presented in Figure 2. The pattern of seasonal rainfall within the study area clearly indicates that rainfall amount was between 800 mm to 1500 mm over the 30 years from 1988 to 2018, with inter annual variations which impacts rice production with flooding and also inadequately required for rice production sector over the period of study. This signifies the respondents, perception that rainfall received in their area was insufficient for their productivity. This study is in line with the work of Ogbuene, (2010) who revealed that extreme rainfall variability triggers environmental problems such as flood, gully erosion, drought, and desertification, which have serious effects on yield of rice. It is also in consistence with the work of Madu and Ayogu (2010) whom reported that rainfall variability has generated a lot of influence in the level of agricultural products.

4.2.2 Monthly Rainfall Trend

The monthly rainfall of the area was evaluated and presented in table 1.

Table 1 present the results of descriptive statistics of monthly rainfall variability in Kebbi State within the period of study, 1988-2018. The trend shows that rainfall is received from the month of April to October, having standard deviation values less than their corresponding mean values showing different variation in the distribution of rainfall over the months. Subsequently the values of standard deviation and coefficient of variation clearly indicates the variability in monthly distributions of rainfall in the study area.

Table 1. Monthly Rainfall (mm/hr)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
\bar{x}	1.29	0.90	1.12	38.03	95.33	161.81	206.45	277.45	206.95	66.37	1.55	1.19
$\pm SD$	1.18	5.03	2.77	31.26	46.14	58.91	63.11	112.33	58.95	49.43	8.62	6.28
CV(%)	91.5	558.9	2.47	82.2	48.4	36.41	30.57	40.49	28.49	74.48	556.13	527.73

Source: Nimet, 2019

From the finding it is believed that maximum average rainfall is received in the month of August followed by July and September which shows larger variations of rainfall over the months from May to October. It is also believed that, there is temporal and quantitative variation on monthly rainfall distribution during rice growing period over the 30 years (1988 to 2018), which influence rice growth cycles such as vegetative, reproductive and grain filling stages which response differently with regards to rainfall amount, pattern and duration during growing seasons. This finding corroborate with the work of (Machlean, *et al.*, 2002) who revealed that variability in the amount and distribution of rainfall is the most important factor limiting yield of rain fed rice. Variability in the onset of the rainy season leads to variation in the start of the planting season in

rain fed rice. Moreover, in freely drained upland, moisture stress severely damages or even kills rice plant in an area that receives as much as 200 mm of precipitation in 1 day and then receives no rainfall for the next 20 days. Complete crop failure usually occurs when severe drought stress takes place during the reproductive stages. Flood is the most important constraint to rice production in low-lying areas. It is also in line with the work of Depledge, (2002), who reported that, changes in the pattern of rainfall distribution may lead to a more frequent occurrence of intense flood and drought in different parts of the world.

4.2.3 Standardized Precipitation Index for Kebbi State

Fig 3 and Table 2 shows that, the study area experience more drought years (18years) 1988-2018 than wet years (13years). The SPI confirms wettest years as 1991, 1994 and 2018 as extremely wet years, while the years with list rainfall are 1990 as extremely drought, severely drought were experience in 2005,2006,2012,2013,2015,2017,2007,1993,1996,1988. And 1989. Further 12 years were experience in between moderately wet and drought years.

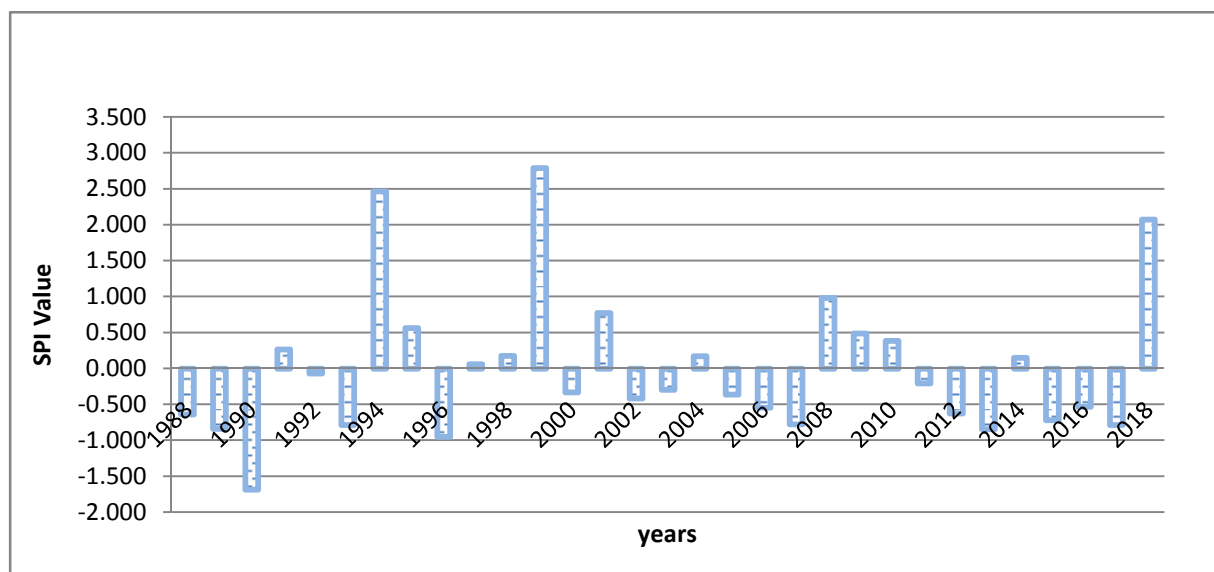


Fig. 3: Standardized precipitation Index (SPI) for Kebbi State

Source: Nimet, 2019

4.2.4 Standardized Precipitation Index of the Area

The standardized precipitation of the area was evaluated and presented in Table 2.

Table 2 shows that, the study area experienced more drought years (18 years) than wet years (13 years) from 1988 to 2018, this is due to the fact that high temperature prevails in the state, therefore it's certain that over the 18 years of drought condition experience in the state resulted from less amount of rainfall received in the area which is below the optimum requirement for rice production in the state. This finding in line with the respondents' perception in the area whom reveals that rainfall received in the area is not sufficiently enough for their rice production which makes them to relies on release on water supply from dams for the growth and development of their rice in the area.

Table 2. Standardized Precipitation Index for Kebbi State

Drought percentage% classes	SPI value	years of occurrence	frequency of occurrence (years)
Extremely wet	>2	1994, 1999,2018	3
Very wet	0.5 – 0.9	2001, 2008, 1995	3
Moderately wet	0.2 – 0.4	1991, 2009, 2010	3
Near Normal		1997,1998, 2004, 2014	4
Extremely drought	-1.6	1990	1
Severely drought	-0.4 to -0.8	2002, 2006, 2012, 2013, 2015, 2017, 2007, 1993, 1996, 1989, 2016, 1988	12
Moderate drought	-0.06 to -0.3	1992, 2000, 2003,2005, 2011	5

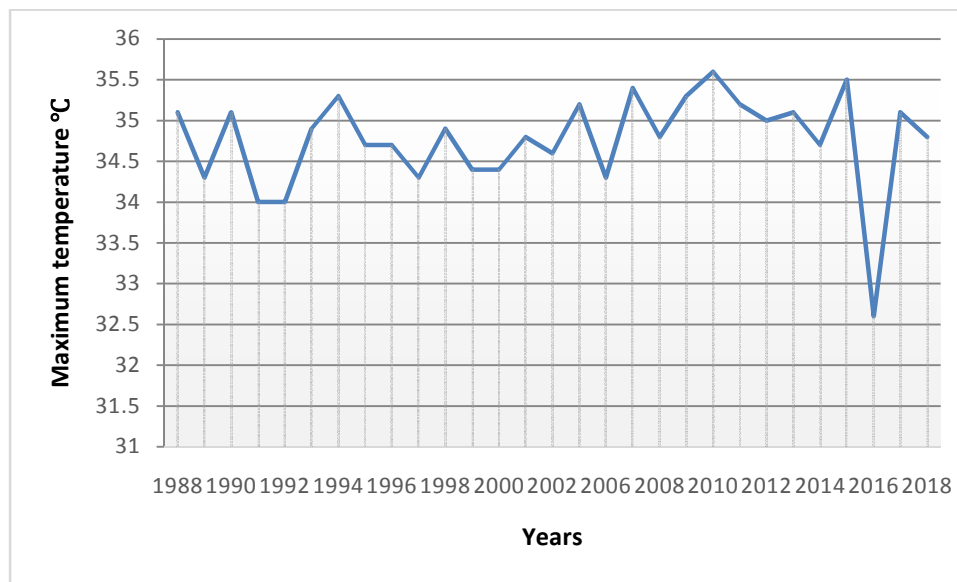
Furthermore, the finding also reveals that rice production was relatively low in 1994 which is the wettest year during the study period as confirm by SPI result and subsequently this would be the

influence of flooding that have occurred on September 1994 that leads to destruction and damages of farm lands and subsequently decline in rice production in the study area. However, the result also shows that, 2018 was the highest production year with 5.5 yield of metric ton per hecter and subsequently among the wettest year over the study period. More so in 1999 the rice production yield in the study area was nearly stable with 2.21 metric ton per hecter which is also equally the wettest year under study. The rice production data also indicated that, the total production of rice in the study area get highest attainment within severely drought years of 2015, 2016 and 2017 as well, and this could be attributed to the increased in land allocated to rice production within the years. Although it is observed that, increase in land devoted to rice production in the study area, there is also government involvement in given loan and fertilizer to local farmers through anchor borrowers program aimed at boosting rice production base, which leads to increase in rice production in the study area.

Subsequently it would be ascertained that dry spells/drought condition have directly affected the rice production in the state. For instance, the trend of rice production clearly shows that most of the years that experience low productivity falls between drought years and other few years were in between moderately wet and drought years. The finding of this study is in line with work of Jason *et al.* (2004) who revealed that, drought also affects the phenomorphology and physiological characteristics of rice in various ways, all resulting in yield reduction, particularly in rainfed cropping systems. More specifically stomata closure and the leaf CO_2/O_2 is reduced under drought conditions. The finding of this study also goes in line with the work of Saini and west gate (2000) whereby they reveals that, In rice, low water potential around the time of anthesis may lead to a failure of anther dehiscence which lead to male sterility.

4.2.4 Maximum Temperature Trend

The maximum temperature trend in the study area (Fig 4) indicates that, the study area recorded the highest annual mean of maximum temperature of 35.6°C in 2010 and lowest annual mean of 32.6°C in the year 2016 (Fig 4). The maximum temperature in the study area indicated seasonal migratory pattern, the trend revealed that with exception of 2010 and 2016 that experience highest and lowest annual mean, it has been notice that a value of 34.0°C to 35.5°C has been observed over the study period.



Figure, 4: Maximum Temperature Trend in Kebbi State

Source: Nimet, 2019

Moreover, the finding of this study indicated that, recorded maximum temperature from 1988 to 2018 shows positive linear trend indicating increase in temperature in the study area, this is in line with the assertion of Nimet (2018), whom reported that annual mean maximum temperature values of 1981 to 2010 normal shows positive biases from 0.5 - 1.1°C which indicates that study

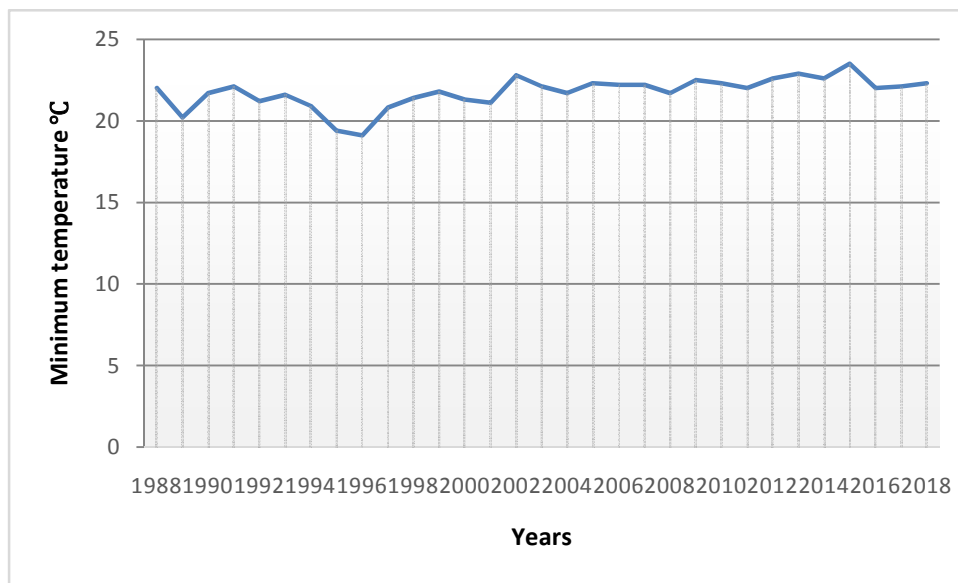
area were among the areas that experience warmer than normal annual mean maximum temperature. This implies clearly the evidence of climate variability in the study area, as the finding of this trend also goes in line with the work of Buba (2012) who reported that temperature distribution over Kano and its environs flows seasonal migratory pattern, it is also consistent with the report of Nimet (2018) whom reveals that, the highest mean value of maximum temperature range of 34.0 – 37.0°C was recorded over the extreme north extending to the north east, north west and Markurdi.

Therefore, based on this finding it could be deduced that variability in climate affect rice production in study area, this is due to the fact that, the study area had experienced temperature beyond optimum requirement for rice production at different stages of growth and development. For instance, from 1994 to 2010, rice production trend decline below the expected yield. This finding is in line with the work of Yoshida (1982) who reported that optimum temperature requirement for rice production is 30°C, while average maximum temperature in the study area exceed 30°C.

4.2.5 Minimum Temperature Trend

Results presented on Figure 5 shows the minimum temperature trend in Kebbi State. The annual minimum temperature values recorded over the years from 1988 – 2018 indicate stable trend, the trend over the years selected for the study were below 24°C. The highest annual mean value was 23.5° in the year 2015 and lowest value recorded are 19.1°C in 1996. The trend shows that all over the 30 years with exception of 1996 and 2015 are within the range of 20.0 to 22.9° respectively. Hence the trend revealed positive result as the finding indicated that, the recorded values are neither below nor beyond the threshold of minimum temperature requirement for rice

production. Furthermore, the finding of this study is also in consistent with the work of Ghadirnezhadet *al.*, (2014) who revealed that low of minimum temperature usually result to decrease in rice production. He added that exposure to cold temperature affects all phenological stages of rice and lower grain production and yield, critical stages for cold damage include germination, booting, flowering, and filling stages. The most sensitive stage for cold injury is the flowering stage, which occurs 10-12 days prior to the anthesis.

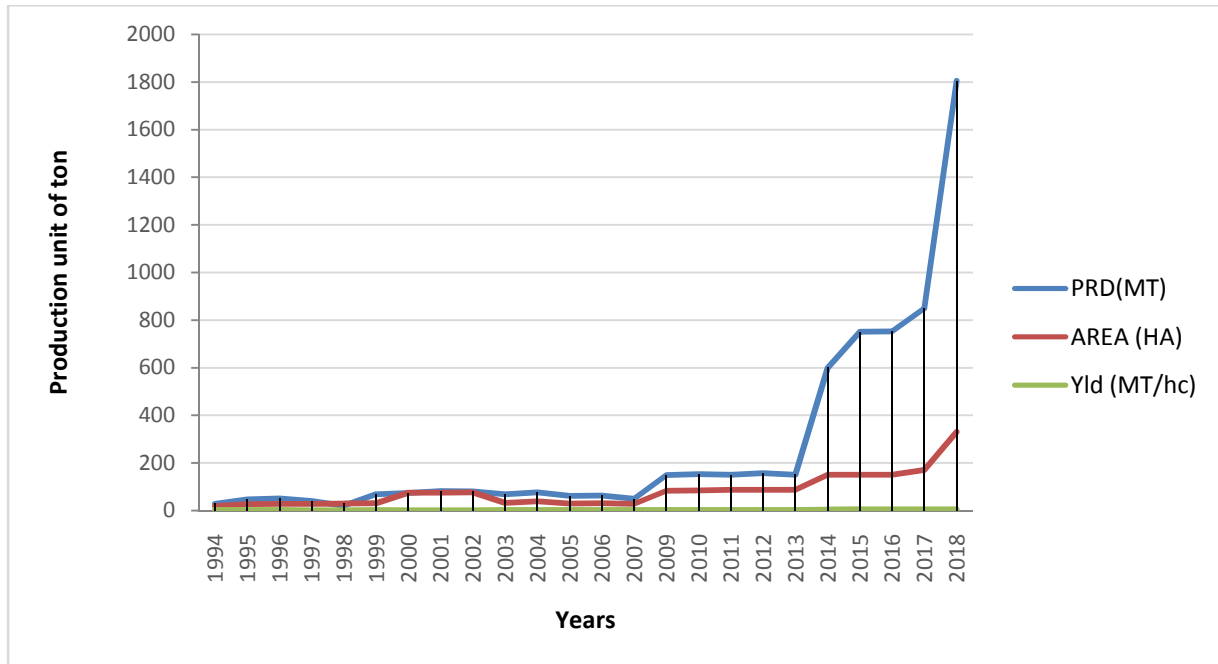


Figure, 5: Minimum temperature trend in Kebbi State

Source: Nimet, 2019

4.2.6 Rice Production Trend in Kebbi State

The accumulation of rice production data in Kebbi State was generally begin in the year 1994 by Agricultural Development Project (ADP). Figure 6 shows the productivity trend of rice by metric tons per land area (mt/area) as well as yield of tons per hectare t/ha. The rice productivity for the study area shows fluctuation in rice production during the study period; nevertheless it is noted that the rate of rice productivity increase was relatively low and insignificant in the area.



Figure, 6: Rice Production Trend in Kebbi State

Source (ADP) Kebbi State 2019

The highest rice production was 1,805 metric ton/h in 2018 with an average yield of 5.5 t/ha, the rise in rice production in the study area are began in the year 2014 with an average yield of 3.99 t/ha compare with the preceding years such as 1994, 1995, 1996, 2004, 2007, 2009, 2010, 2011, 2012, and 2013 with stable trend, regular yield within the range of 1.5 to 1.9 t/ha respectively with relatively little variation within the years.

The lowest productivity years observed within the study area was in 1998 and 2000 with total yield of 0.62 and 0.99 t/ha respectively followed by 2001, 2002 with rapid increase in production in the range of 1.05 and 1.09 t/ha respectively, moreover the subsequent years with moderate productivity are 1999, 2003, 2005 and 2006 recorded yield of about 2.09 to 2.21 t/ha. Hence it was not until 2015, 2016, and 2017 that a value of 5.0 t/ha was discovered during the study period.

The finding of this study implies that study area experience low rice production in some years with an average yield below the optimum or expected yield per hectare, this is in line with the work of Codoni and Angelucci, (2013) whereby they revealed that average rice yield in the country are low, ranging between 1 and 2.5 tons per hectare, though the fact that from 1994 to 2013 of rice yield per hectare in the study area are within this range. More so this is also similar to the work Teng, *et al* (2016) reported that, Growth in rice production depends on rice yields and expansion in arable land allocated to rice. Unfortunately, there is a declining trend in land allocation for rice cultivation. Today, everywhere in the world with exception of Africa, a declining trend in rice land has been observed Teng, *et al* (2016). Even though there is increase in land allocation for rice production in study area in particular hence there is no much significant increase in the production rate.

Moreover, according to Bossino and van Der Eng (2010) argue that “current discussions of climate change are overly focused on the science underpinning environmental impact, with little attention to socioeconomic consequences. The economics of environmental change in particular is insufficiently informed by the lessons that past experiences can yield.” In fact, agriculture has responded dynamically to variation and change in climate system. Worldwide, farmers and governments have made great strides in improving rice yield from 2.38 t/ha in 1970 to 4.49 t/ha in 2013 (on average, 2.1% annually). The highest yield growth occurred in the Americas, mainly North America, where the nation enjoyed a 3.7% increase annually, followed by Asia’s 2.1% annual increase. There is a variation in rice yield improvement in Asia where Southeast Asia recorded an increase from 2.02 t/ha to 4.19 t/ha per annum (2.5% annually) while South Asia increased its yield from 1.72 t/ha in 1970s to 3.72 t/ha in 2013. The lowest rate occurred in

Africa where the farmers have increased rice yield from 1.83 t/ha in 1980 to 2.64 t/ha in 2013 (it equals to 0.9% annually) Bossino and van Der Eng (2010).

The finding also reveals that the rate of production in the study area get highest attainment of rice yield of 3.99 to 5.5 t/ha from 2014 to 2018, and this could be attributed to the effort made by government in bringing the improve variety of rice and most importantly given loan to local farmers, through the program of anchor borrowers in the study area aimed at boosting rice production in the state. This finding also goes in line with the work of Bossino and van Der Eng (2010) whereby they revealed that, Worldwide, farmers and governments have made great strides in improving rice yield from 2.38 t/ha in 1970 to 4.49 t/ha in 2013 (on average, 2.1% annually).

4.2.7 Relationship between Climatic Variables and Rice Production

Relationship between climate variables and rice production in the study area were conducted using Pearson product moment correlation and presented in table 3. The analysis shows the relationship between rainfall, maximum and minimum temperature with total production as well as yield per hecter (table 3/appendix 2) at 0.01 significant level.

Table 3 Correlation analysis of climatic variables and rice production

Rice production	Rainfall	Maximum temperature	Minimum temperature
PRD(MT)	0.157*	-0.132	0.322*
P-value	0.464	0.559	0.125
Yld (T/ha)	0.000	-0.208	0.357*
P-value	0.998	0.353	0.087

*Significant at the 0.01 level (2-tailed) Production by Metric Ton. PRD (MT) Yield of ton per hacter. Yld (T/ha)

Source: analysis 2019

The finding of this study reveals that, the correlation analysis shows no significant relationship between maximum temperature and total production, and also shows negative relationship with yield per hecter. The implication of this findings is due the fact that higher than normal maximum temperature affects almost every stage of rice production. Notably from observed record of temperature in the the study area experience warmer than normal temperature from 1981 to 2010 as reported by Nimet (2018) which poses serious challenge to agriculture and rice production in particular, the finding of this research is in line with the work of yoshida (1978 and 1981) who reported that the threshold temperature at emergence is 40°C, which can delay and decrease seedling emergence the result also revealed that Poor growth of the seedling occurs at 35°C which is the threshold temperature at seedling. Also Satake& Yoshida, (1978) reported that Temperature of 32°C reduces tillering and height and floret sterility occurs at 35°C. Considering these figures, maximum temperature was categorized as optimum (27°C – 32°C) throughout the growing season, and threshold or critical (more than 35°C) which is the threshold level for the most critical stage of flowering. Also Jagadishet *al.*, (2007); Morita *et al* (2004).reported that, Threshold temperatures of 33.70°C and 34°C cause poor anther dehiscence, sterility and yield reduction respectively. With regards to the trend of maximum temperature in the study area its clearly shows that it was only in 2016 that a value of 32.6°C was recorded while all over the years recorded a values of 34.0°C to 35.6°C which are critical for rice production in growth and development at all stages.

It is certain that most growth stages and development of rice production in the study area is severely affected by high temperature condition, furthermore looking at the high temperature trend that prevails in the study area could be favorable condition for proliferation of growth and spread of pest and disease which have great effects on rice production and this could be

attributed to the view of farmers in the study area that pest and disease are among the factors affecting their rice production. More so, as for rice plant, there exist an optimum temperature range at which growth and development proceed, also rice production has maximum temperature required, beyond which might be affected which leads to poor grain and yield reduction.

The correlation analysis between minimum temperature and total production in the study area indicate low association (0.322), it also reveals similar relationship between minimum temperature and yield of ton per hector (0.357). It is observed that, minimum temperature of the study area was range from 19°C to 22.9°C throughout the years under study and subsequently not critical to the rice production, and is significantly correlated with rice plant in the study area. The assertion of the present study could be attributed to the work of Abey Siriwardena *et al.* (2002), who reported that Minimum temperature of less than 19°C is the critical low temperature for inducing grain sterility in rice.

The correlation coefficient between rainfall and rice production shows that, the correlation of annual rainfall and total rice production in the study area was positively correlated, furthermore the finding also shows no significant relationship between annual rainfall and yield per hector.

However, the present study reveals that, rice production was negatively correlated with climatic system of the study area. It is observed that maximum temperature and annual rainfall were the two climatic variables that shows no significant relationship with rice production yield in the study area, due to the fact that, maximum temperature was relatively beyond the optimum requirement for rice production which greatly influences not only growth duration but also growth pattern of rice plant. It is also believed that high temperature is one of the major factors that affects normal growth and of rice production. The finding of this study could be attributed to the work of Nyang'au *et al.*, (2014) Temperature exceeding optimum levels relates negatively

with rice production potential, as it retards photosynthetic processes, increases respiration, reduces vegetative and periods of grain filling.

More so, the changing pattern of rainfall in each year would found to be major impacts on rice plant which have immensely altered rice production growth and development in the study area. Subsequently this is in line with work of Eze and Bola, (2013) whom reported that too much rainfall and too little of it retard normal growth and yield of rice, hence they concluded that rice performs best at reasonable or sufficient precipitation distributed throughout the rice growth cycle (90-160days). Moreover, Gupta *et al.* (2000) explained the yield variations in rain fed rice by quantum of precipitation during the critical vegetative and reproductive phases. Deficit soil moisture during grain filling stage drastically reduces the grain yield even if there is normal rainfall during preceding phases.

The finding of this research on the effect of climate variability is in line with the assertion on Studies of Rahji, and Omotesho (2006); Emeka, and Ugwu (2015); Osagie, (2015) whereby they revealed that, uncertainty related mostly to anticipate precipitation spatial and temporal patterns caused by climate change, makes it difficult to project the full effect of intensified frequency of floods and severe droughts. Moreover, IPCC (2015) report that climate change affects agriculture in many ways with direct impacts on food production.

4.3 Farmers Perception of Climate Variability and its Effects on Rice Production

The perception of farmers about climate variability and it effect on rice production in the study area were derived through focus group discussion (FGD).

4.3.1 Planting Date and Varieties of Rice Produced

The selection of planting date can be an important tool for avoiding periods of high temperature during the sensitive productive phase, this would minimize the negative impact of temperature increases and monthly fluctuations in rice yield Penget *al.* (2004). The finding of this study reveals that, there was no uniform date or month for planting as reported by respondents because of locations distribution and rainfall variability (i.e from May to July), they also expressed that suitability of an area matters, in some location they plant their seed immediately after some ponds (*tapki*) dry up and other places like upland, low land, and flood prone areas it depends on the onset of seasonal rainfall and even after onset it should be after experiencing two to three rainfall event, while in some other places in Bagudo Local Government Area specifically revealed that late May and early June was mostly their sowing period.

Hence in terms of seed varieties, there was no difference in terms of varieties of seed they used, whereby almost all the three local government area used similar varieties. As of 25 to 30 years back there are some certain varieties they used such as *Danboto, Bakiniri, Karamarshinkafa, Yarfutuka, Yarliman and zabuwa* but after realizing a particular variety is no longer align with variability of climatic condition they turned to *Doguwa, Faro, Hajji kusa, Siffi, Jamila and Gargaza* as well, which are all improved variety

4.3.2 Responses on Rainfall Requirement for Rice Production

The finding of this study based on the information obtained through focus group discussion from farmers revealed that, in *Bunza, town like Raha and Maidahini* express that rice requires much water that is to say, rice needs much and stable rainfall pattern right from onset (germination stage) and needs to be fully in water up to maturity or grain filling stage. While in

Suru respondents perceived that rainfall and generally water requirement depend on the type of rice variety but both old and new (improved variety) demands much rainfall. Additionally, in both *Bunza and Suru* farmers explained that currently rice production does not only depend on rainfall but also required released of water supply from dams (Bakalori and Goronyo Dams) for the sustainability of their production. On the hand in some part of *Bagudo like Zagga* revealed that they only depend on rainfall for their rice production but also make known that rice requires much rainfall throughout production period. Hence, this finding is in line with the work of, Sridevi, and Chellamuthu (2015) whom explain that rainfall amount and distribution is the most critical weather component in rain fed rice ecologies (Upland, lowland and flood prone). Daily rainfall is more critical than monthly or annual rainfall. A rainfall of 100 mm/month distributed evenly during the growing period was preferable than 200 mm/month, which fell in two or three days. Availability of about 200-300 mm of water per month is considered minimum to produce good crop of rain fed rice. Furthermore, respondents also reveals that in contemporary years they experience decrease in rainfall amount explaining that both intensity and duration varies annually and subsequently insufficient for growth and development for rice production in their respective location.

4.3.3 Responses on Temperature Requirement for Rice Production

According to the information obtained from local farmers across all areas selected under study regarding the temperature requirement for rice production, there was some consensus about this particular phenomenon. Based on the FGD conducted to the farmers within *Bunza* communities reveals that rice need fairly high temperature immediately after germination to grow faster, they also added that rice requires too much temperature during grain filling stage (*kunshi*) the respondents also disclosed that during this period when temperature is low it affect rice yield.

Furthermore, farmers in Suru Local Government have similar thought that rice needs fairly high temperature right from germination stage up to maturity stage more especially these new varieties, while to some other parts of Bagudo like Zagga express that rice does not need much temperature in as much as rice get required rainfall in their various areas.

Hence the findings of this study goes in line with the work of (Singh 2001, Sheehy *et al.* 2005, Penget *al.* 2004) whom reported that, the rise in atmospheric temperature causes detrimental effects on growth, yield, and quality of the rice crop by affecting its phenology, physiology, and yield components. It is also in consistence with the work of (Prasad *et al.*, 2006; Shi et al., 2013) whom also reveals that, yield losses under high temperature were attributed to spikelet sterility and reduction of grain weight. Lanning *et al.*, 2011) also reported that, during the grain filling stage, high temperature worsens transparency, increases chalky rice, and reduces head rice rate. The threshold of high temperature assumed to cause damage to spikelet fertility is set at 30 °C for daily mean temperature or at 35°C for daily maximum temperature for three consecutive days Tianet *al.*, (2007)

Although despite the above findings, Yoshida (1981) also develop a response that highlight responses of rice at different growth stages for temperature requirement which would collaborate with both current study and existing findings (Table 4). Generally, the response would also aid in understanding the best temperature requirement for the growth and development of rice production at different stages.

Table 4: Response of rice to temperature at different growing stages

Growth Stage	Critical Temperature °C		
	Low	Optimum	High
Germination	10	20-35	45
Tillering	9-16	25-31	33
Panicle initiation	15	25-31	33
Anthesis	22	30-33	35
Ripening	12-18	25-31	30

Source (Yoshida, 1981)

4.3.4 Farmers Perception of Rainfall and Temperature Variability and its Effects on Rice Production Over the Period of 30 Years

Accordingly, farmers across the study area do perceived variability in climatic condition in their respective location. Seasonal rainfall variability is the most notable changes they observed over the past 30 years. Onset period, rainfall pattern and distribution differ annually that is to say they experience different seasonal rainfall with some years in the form of heavy rainfall, moderate and also low rain fall years as well and generally referred with this recent years, they make known that they had experience similar low rainfall in contemporary time and previous years. Dry spells (*farri*) and early cessation from month of June to September is part of their experience on climate variability, subsequently the aforementioned changes stated have negatively affected their rice production that resulted in low yield. This finding is in consistent with the work of

Vijayakumar, (1996) who reported that Variability in rainfall is associated with an untimely cessation at this stage, the yield reduction is severe. Wind damage to the crop at this phase was triggered by temporary water stress in the panicle spikelet and the injury was less when wind was accompanied by rain. Also Pradhan and Dixit, (1989) opined that, rice flowering was affected when rain occurred continuously for three days during flowering. Low yield was obtained due to continuous rain coupled with strong wind at flowering in wet season. Moreover, Sreenivasan, (1985), revealed that Due to heavy rainfall, panicles have large number of blank florets and nitrogenous fertilizers are less effective. The response of paddy to rainfall during the sharp critical phase of panicle initiation is significantly favorable. This beneficial influence persisted even when this factor was taken jointly with other climatic elements namely mean temperature and sunshine.

On the other hand, in terms of changing climatic condition the respondents were able to perceived, the rapid increase of pest, diseases and vigorous weeds plan. Pest attacks their rice frequently which affects growth and development of rice and ultimately affected their yield. The respondents added that some years back they only cleared the land and spread their seeds (*watsi*) and they may not go back to the farm until when rice reach maturity stage and ready for harvest which is contrary to the present-day condition where pest diseases and weed became great challenge to their rice production. Furthermore, in some years flooding have negatively affected their rice production due to prolong and heavy rainfall and subsequently dam exploded from Goronyo and Bakalori Dams. Usually similar changes they observed is even when rice get required water they find out the head of the rice will dry, reduction of weight or the rice heading became small, and this finding is in consistent with the work of Osadaet *al.*, (1973), where he revealed that, rice is most sensitive to high temperatures at heading and next most sensitive at

about 9 days before heading. One or two hours of high temperature at anthesis has a decisive effect on the incidence of sterility. High temperatures before or after anthesis have much less effect on sterility. The high sterility may be attributable to failure of fertilization caused by the imperfect splitting of anther or wilting of stigma induced by high temperature and low humidity. High temperature desiccated pollens and subsequently leads to lignification of rice plant.

In addition, the respondent of Suru Town disclose that as part of the climate variability they perceived, was high wind speed that affect their rice yield during the grain filling stage which resulted in making rice head to be empty (*anfalolo*), and this could be attributed the work of Ramirez (2010) who opined that unforeseen changes associated with global warming in temperature (as increase in temperature due to climate change adversely affect rice crop physiology which ultimately decrease crop yield and grain quality).

4.3.5 Decline Years of Rice Production and Factors Contributing for the Decrease

When respondents were asked about years they experienced decreases in rice yield their responses were entirely the same emphasizing that before a portion of land where they used to gain 100 bags of rice, now it is difficult to get 50 bags. Accordingly rain fed rice production in all the areas has considerably declined in yield, for instance in Bunza almost all the farmers declared that from now on to 15 years back they have encountered reduction in rice production annually while some respondents disclosed that over the 20 years back they have been experiencing decline in rain fed rice production. In addition, the respondent of Suru and Bagudo have similar thought where they revealed that about 20 years back there was a rapid decrease in rain fed rice production in their respective areas annually (*“kowaceshekaraabinbayabayakeyi”*). Subsequently respondents reveals that, the factors responsible for the decline in the production of rain fed rice are inadequate water requirement

(inadequate rainfall, RuwanCikowa(dams supply). Also dry spells alter growth and development, pest, diseases and weeds as well as early cessation has contributed immensely in decline of their rice production. Generally flooding pose much severe damages of rice production more in flood prone areas in Suru and some part of Bunza as a result of heavy and prolong rainfall event and uncontrolled release of dams from Goronyo and Bakalori Dams.

4.3.6 Farmers Adaptation Stratages on Rice Production

The farmers adaptation strategies on rice production in the study area were identified as early planting, changes the seeds, application of infested chemical and using hand dug wells to suppliment the inadequate water supply.

1. Early Planting: it was reported that, one of the important measures adopted by the farmers in the study area to adapt to the climate variability was early planting. They adopt this measures in order to cope with early cessation of rainfall.

2. Changing of seed from old varieties to improve varieties: another adaptation strategies adopted by farmers in the study area was use of improved variety of rice. They tend to use improve variety in order to cope with changing climatic condition. The improved variety are the varieties that can withstand the climatic condition and have high yield. Such improved varieties are *Doguwa, Faro, Hajji kusa, Siffi, Jamila and Gargaza* as well.

3. Frequent application of infested chemical: the respondent also adopted the spread application of chemical to the pest that hinder the rice growth and development.

4 Use of Hand dug wells to irrigate their rice to augment the inadequacy of rainfall during dry spels complete growth duration when experiencing early cessation, but only Raha under Bunza and suru practice this method: the farmers also use to create temporary wells to supplement the

problem of rainfall early cessation in the study area (especially in Raha under Bunza and Suru town under Suru L.G.A).

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of the Findings

The findings of the study reveals that there is variation in the trends of climatic variables, for instance the trend of rainfall in the study area shows fluctuation in the pattern of rainfall with 1999 had being the highest rainfall year with value of 1566.20 mm and the lowest rainfall year was 1990 with 751.90 mm, more so SPI indicated that drought were experienced in 18 years more than the wet years from 1988 to 2018. The increases of maximum temperature were found in the study area as the trend shows that the highest annual mean of maximum temperature recorded was 35.6° in 2010 and lowest annual mean of 32.6° in the year 2016. The highest annual mean of minimum temperature was 23.5° in 2015 and lowest value recorded is 19.1° in 1996. On the otherhand, rice production trend shows decreasing pattern with little development started in 2014. The highest production was observed in 2018 with value of 1805mt with an average yield of 5.5 t/ha, the lowest productivity year was in 1998 with total of 0.62.

Rainfall and maximum temperature were the factors affecting rice production in the study area whereby annual rainfall was positively correlated with total rice production but shows no significant relationship with yield per hecter. Maximum temperature shows weak negative relationship both with total rice production and yield per hecter. Farmers perception on climate variability and its effects on rice production revealed seasonal rainfall variability, onset period, rainfall pattern its distribution and intensity differs annually, dry spells and early cessation is part of their experience on climate variability. Respondents revealed that they have experience declined in the rate of production in contemporary years, when compared with the previous years

(15-20 years). The farmers adaptation measures revealed are early planting, changing of seed to improved variety, frequent application of infested chemicals and use of hand dug wells to supplement the problem of early cessation.

5.2 Conclusion

The research concluded that there is variation in the trend of climatic variables that subsequently resulted to variation in rice production in the study area, as the value of standard deviation and coefficient of variation clearly indicated variability in the distribution of annual rainfall. There is also increase in maximum temperature in the study area over the years. Furthermore, it can be concluded that majority of the respondent experienced climate variability in their respective areas, as dry spells, variation in annual distribution of rainfall, weed and pest and diseases greatly affected their rice production. Early planting, changes of seeds from old varieties to improved variety, frequent application of infested chemical and use of hand dug wells to argument the inadequacy of rainfall during dry spells were identified as adaptation strategies.

5.3 Recommendations

Base on the findings of this research, the following recommendations are made to improve the rice productivity in the state and also to improved measures of mitigating the effects of climate and variability in the study area.

- A. Public enlightenment and awareness on climate variability and its effects on agricultural production specifically increase in temperature and rainfall variability should be carried out by extension workers to local farmers in the state.
- B. Since climate variability is a continuous process therefore, different researches from research institute, individual and NGOs should be encouraged such as modeling for

subsequent years to reduce the effects of climate variability and also improved rice production sector as part of adaptation and mitigation measures in the state.

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STRUCTURED INTERVIEW GUIDE

FARMERS PERCEPTION ABOUT CLIMATE VARIABILITY AND HOW IT EFFECTS ON RICE PRODUCTION AND THEIR ADAPTATION STRATEGIES IN SOME SELECTED AREAS IN KEBBI STATE.

- ❖ Introductory Aspect: purpose and importance of the research, briefing about the issue of climate change phenomena, it's effects and magnitude on agriculture in general. Expressing their responses and co-operate will contribute in providing the possible solutions required.
- ❖ Introduction by the participant their names, age, and years of their farming experience
- ❖ Do you have knowledge about climate variability and change?
- ❖ How farmers do perceived the climatic variability and changes over a period of 30 years in terms of rainfall and temperature pattern and how its affect rice production.?
- ❖ Planting Date and what rice varieties used for your production over the years?
- ❖ What are the required rainfall in terms of pattern and distribution on rice production?
- ❖ What are the required temperature pattern i.e maximum and minimum temperature on rice production?
- ❖ What are the specific years that you have experienced declined in your rice production over the years?
- ❖ What are the major factors contributing to the decrease in your rice production?
- ❖ What are the adaptation strategies/measures do you practice over the years and currently now?

SPSS CORRELATION OUTPUT RESULTS

Correlations

		rainfall	PRD(MT)	Yld (MT/hc)
Rainfall	Pearson Correlation	1	.157	.000
	Sig. (2-tailed)		.464	.998
	N	24	24	24
PRD(MT)	Pearson Correlation	.157	1	.888**
	Sig. (2-tailed)	.464		.000
	N	24	24	24
Yld (MT/hc)	Pearson Correlation	.000	.888**	1
	Sig. (2-tailed)	.998	.000	
	N	24	24	24

** . Correlation is significant at the 0.01 level (2-tailed).

Correlations

		max_temp	PRD(MT)	Yld (MT/hc)
max_temp	Pearson Correlation	1	-.132	-.208
	Sig. (2-tailed)		.559	.353
	N	22	22	22
PRD(MT)	Pearson Correlation	-.132	1	.890**
	Sig. (2-tailed)	.559		.000
	N	22	22	22
Yld (MT/hc)	Pearson Correlation	-.208	.890**	1
	Sig. (2-tailed)	.353	.000	
	N	22	22	22

** . Correlation is significant at the 0.01 level (2-tailed).

Correlations

		min_temp	PRD(MT)	Yld (MT/hc)
min_temp	Pearson Correlation	1	.322	.357
	Sig. (2-tailed)		.125	.087
	N	24	24	24
PRD(MT)	Pearson Correlation	.322	1	.888**
	Sig. (2-tailed)	.125		.000
	N	24	24	24
Yld (MT/hc)	Pearson Correlation	.357	.888**	1
	Sig. (2-tailed)	.087	.000	
	N	24	24	24

** . Correlation is significant at the 0.01 level (2-tailed).