EFFECTS OF RAINFALL VARIABILITY ON YIELD OF SOME SELECTED CROPS IN TSANYAWA LOCAL GOVERNMENT AREA, KANO STATE

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JUNE, 2019

DECLARATION

I hereby declare that this work is the product of my research efforts undertaken under the supervision of Dr. L.F. Buba and has not been presented anywhere for the award of a degree or certificate. All sources have been duly acknowledged.

………………………………

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CERTIFICATION

This is to certify that the research work for this dissertation and the subsequent preparation undertaken by **(Abdullahi Bawa - SPS/14/MGE/00031)** were carried out under my supervision.

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JUNE, 2019.

DEDICATION

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ABSTRACT

This research examines the extent to which rainfall variability determine crop yield in Tsanyawa L.G.A., Kano State. The objectives of the research are to: determine the temporal variability of rainfall; the trend in the yield of each of the selected crops (which include sorghum, millet, maize and soybeans); establish possible relationship between rainfall pattern and crop yield; and perception of farmers on rainfall variability and its effects on crop yield. The data for this study were daily rainfall record (mm) and yield (tons/ha) of the four selected crops for 20years (1995-2014). The data were sourced from Kano State Agricultural and Rural Development Authority (KNARDA). In addition, the research employed the use of questionnaire in order to get perception of farmers on rainfall variability/crop yield relationship. A multi-stage cluster sampling was used to get respondents for the questionnaire administration. The data obtained were analyzed using the SPSS and Microsoft excel softwares. Descriptive statistics, correlation and regression analysis were used in data analysis. The results obtained revealed that rainfall is variable in the study area over the years. The highest rainfall value of 1529.5 mm was recorded in 2011 while year 2001 recorded the lowest rainfall amount of 809.9mm. The study also shows that the trend in the yield of sorghum, maize and soybeans is on the increase while the yield of millet is decreasing. A multiple regression analysis was computed between yields of the four crops and 5 rainfall variability indices. These indices are: annual total rainfall, length of the rainy season, onset, cessation and seasonality index. The result of the analysis revealed that the co-efficient of the five variables are significant in the analysis of sorghum and soybeans which accounted for 70.3% and 82.0% respectively, whereas millet and maize have no significant relationship with rainfall indices. The finding shows that 96% of the respondents believed that rainfall is variable over years, and 58.4% of the respondents agreed that there is decrease in the yield of crops over the years due to rainfall variability. It is recommended that crop yield should be correlated and regressed with dry spell and also with other environmental factors such as soil nutrients availability and type, variety or cultivar of crops produced, and modern agricultural techniques used by farmers with a view to providing information for improving agriculture in the study area.

CHAPTER ONE

INTRODUCTION

1.1 Background to the study

In Africa, rainfall exhibits high spatial and temporal variability. Mean annual rainfall ranges from as low as 10mm in the innermost core of the Sahara region to more than 2000mm in the equatorial region. The rainfall gradient is largest along the Sahara where the mean annual rainfall varies by more than 1000mm over about 750km. The coefficient of rainfall variability in Africa is above 200% in the deserts, about 40% in most semi-arid regions and between 5% and 20% in the wettest areas (Abaje, et al., 2014).

Sudano-Sahelian zone of Nigeria is a region where rainfall exhibits notable spatial and temporal variability. Inter-annual rainfall variability is large over most of Africa, changes in extreme events, such as droughts and floods have major implications for numerous activities including agricultural. As such, most of the reviews of climate variability in Nigeria dwell extensively on rainfall distribution, aspects of climate variability that could significantly affect crop yield and even spells the success or failure of crops (Buba, 2017).

There is growing consensus in the scientific literature that in the coming decades the world will witness higher temperatures and changing precipitation levels. The effects of this will lead to low or poor agricultural products (Apata, 2010). Evidence has shown that climate change is already affecting crop yields in many countries (IPCC, 2007). This is particularly true in low-income countries, where climate is the primary determinant of agricultural productivity and adaptive capacities are low (Apata et al., 2009).

Agriculture which is the mainstay of local livelihoods and national Gross Domestic Product (GDP) in some African countries is the most vulnerable to rainfall variability. This is because in spite of recent technological advances, weather and climate are still the most important variables in agricultural production. As such, agricultural production processes, will be heavily affected by climate variability and change (Ayoade, 2004).

Rainfall uncertainty remains a critical challenge confronting smallholder farmers in sub-Sahara Africa. Rainfall provides the water that serves as a medium through which nutrients are transported for crop development. In view of this significant role, inadequate water supply has adverse effects on efficient crop growth, resulting in low productivity. The food shortages and famines that are experienced in sub-Sahara Africa are largely a result of rainfall uncertainties and associated drought and flooding (Ndamani and Tsunemi, 2015).

In Nigeria, over 60% of Nigerians are directly dependent on rain-fed agriculture and natural resources (FAO, 2003), Nigeria is therefore, very vulnerable to the impact of climate change and more particularly rainfall variability (Ayoade, 2003). Less rain and higher temperature shortens the growing season and reduce crop yields. Likewise there has been persistence of late onset and early cessation of rains in northern Nigeria in the last three decades (Sawa and Adebayo, 2010).

Rainfall is a very important resource in northern Nigeria as many human activities depend upon its availability (Buba, 2010). Rainfall is the most important element for crop production (Mkonda, 2014). It is undoubtedly the most limiting factor in crop production in north-western semi-arid zone of Nigeria where, currently, most crop production is derived from dry land farming. Hence, the determination of rainfall amount, intensity and pattern is of great importance and should continue to receive priority attention especially in northern Nigeria (Yamusa, et al., 2015). Being predominantly composed of Sudan-Sahel savanna bio-climate zone, northern Nigeria is characterized with alternating wet and dry seasons. Rainfall in this region varies from 1500mm per annum in the southern part to 400mm in the northern part.

The rainy season lasts from about 7months (April- October) in the southern part to as low as 3 months (July to September) in the northern part. The rainfall intensity is very high between the months of July and August, as a result crops are frequently lost through too much rain. It also results in rapid surface run-off, soil erosion and water- logging (Ati, et al., 2009).

Kano state where the study area is located, found in the north-western part of Nigeria, is rated among the top 5 states that produce millet, groundnuts and guinea corn, crops that are largely rain-fed in Nigeria. However, the production of these major grain crops today is faced with climatic challenges, one of which is the length of the hydrological growing season (Sawa, et al., 2014).

1.2 Statement of research problem

The climatic elements particularly rainfall limits plant growth and development in the study area in particular and the entire northern part of Nigeria in general. This is because rainfall pattern is confined to season which relatively occupy the shorter part of the year. This therefore makes rainfall to be a critical climatic element for agriculture in the study area. UNDP (2008) predicted that changes in precipitation and other related factors such as droughts, floods, sea-level rise and heat waves, could by 2080, push 600 million people into food shortages. Similarly, most of the reviews of climate variability earlier undertaken limited themselves to rainfall. This can be justified since the aspects of climate variability that could significantly affect inter-annual changes in crop yield in the tropical environment are limited to such elements that determined water supply to plants and animals (Buba, 2014).

Some researches such as Ati, et al., (2009), Oruonye (2014), Nwagbara (2015), Mohammed, et al. (2015), Abaje, et al., (2014) and many more, indicated that different parts of northern Nigeria are becoming wetter over recent years. However, it is not the total amount of annual rainfall that really matters, but rather the effectiveness of the rain in terms of its availability to crops as soil moisture, more especially during the blooming, pod setting, flowering and fruitening periods, which are the critical growing stages of crops.

The study area is very much vulnerable to rainfall variability because of its dependence on rain-fed agriculture. The erratic nature of rainfall makes it to spread in such a way that it becomes less useful to crops. Agricultural activities from planting to harvesting are dependent directly on rainfall due to the virtual absence of any large surface water body for irrigation over the entire study area. This makes the study area to be unique among its counterpart in the extreme north and western part of Kano State. For instance, Bagwai, Kunchi, Shanono, Dambatta, and Gwarzo are local governments that surrounds the study area, and each have one or more dams that is utilized not only for irrigation but also to support rain fed agriculture, while parts of Bichi form catchment area for Bagwai dam. In view of this therefore, rainfall variability will undoubtedly have a tremendous agricultural significance in the study area.

1.3 Research questions

i. What is the temporal variability of rainfall in the study area?

ii. What is the trend in the yield of crops?

iii. What is the relationship between the rainfall pattern and crop yield in the study area?

iv. What is the perception of farmers on rainfall variability and its effects on crop yield

1.4 Aim and objectives

The aim of this study is to explain the extent to which rainfall variability determine crop yield in the study area.

While the specific objectives are to:

i. Determine the temporal variability of rainfall in the study area.
ii. Examine the trend in the yield of each of the selected crops.
iii. Establish possible relationship between the rainfall pattern and crop yield in the area.
iv. Examine perception of farmers on rainfall variability and its effects on crop yield.

1.5 Justification for the study

A reliable and accurate determination of rainfall characteristics such as the onset of rain, cessation and length of rainy season, is very important to the determination of time to plant or transplant with minimum risk of crop failure, it is also important to the selection of crop varieties that will mature within the growing period. In view of this therefore, this study is important because its result could be used by farmers and equally by policy makers to update their knowledge on the nature of rainfall and how that may affect crop yield and by extension the entire agricultural activities in the study area.

The study area is underlain by lateritic type of soil. Laterite soils have high clay content, which means they have high water holding capacity. This is because the soil particles are so small, the water is trapped between them. After rain, the water moves into the soil slowly and this leads to increased runoff and consequently flooding. The study area is left dried up immediately after the rainy season due to rapid runoff. During runoff, nutrients are also washed away from the soil surface easily because the water stays on top of the soil and does not percolate easily. The need for water harvesting in the study area in order to ameliorate these problems therefore becomes very imperative.

Furthermore, this study also becomes significant because the study area is one of the local governments in the state that receive little attention with regards to research studies on crop-climate relationship. In fact, review of related literatures revealed that no comprehensive work has been done in the study area, specifically on how rainfall variability could affect agriculture.

1.6 Scope of the study

The study intends to find out the effect of rainfall variability on crop yield. It is however limited to the most common crops grown in the area, which includes maize, sorghum, millet and soybeans. Rainfall and crop yield data for a period of 20 years (1995-2014) was used for the study.

1.7 Study area

1.7.1 Location and size

The study area (figure 1) is located at the extreme north-western part of Kano state. The area lies within the Sudan savanna zone of Nigeria. It lies between latitude $12^0$09'N and $12^0$23'N and between longitude $7^0$52'E and $8^0$08'E.It shares boundary to the North and West by Katsina State, to the North-east by Kunchi L.G.A, to the East and South-east by Bichi L.G.A and Bagwai L.G.A. respectively. It is bounded to the South and South-west by Shanono L.G.A. with the total size area of 492km^2 and a population of 157,680 (NPC, 2007).

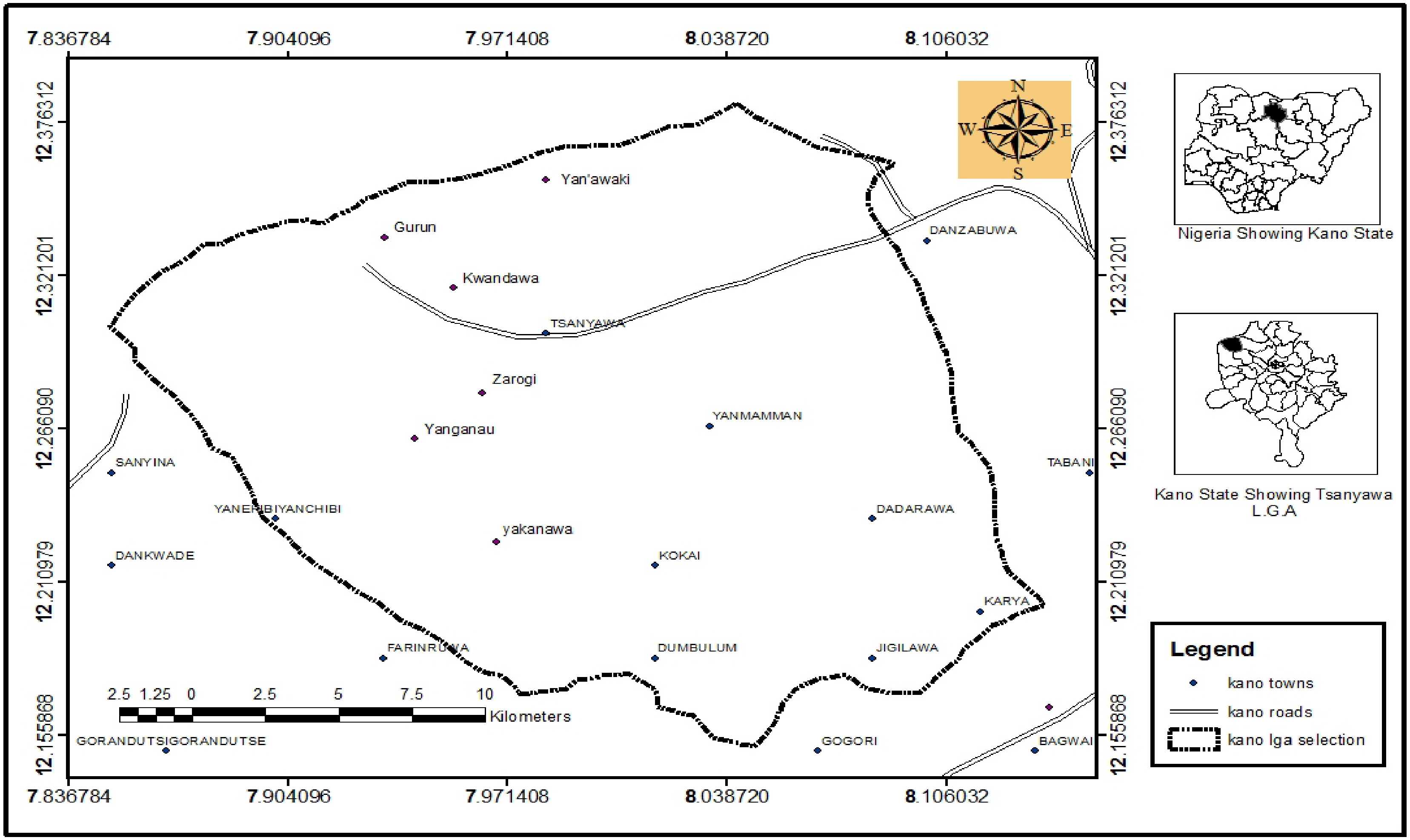


Fig.1: Tsanyawa L.G.A. (The Study Area)

1.7.2 Geology

The study area is underlain by igneous and metamorphic rocks belonging to the basement complex of Precambrian age, comprising migmatite-gneiss complex and schist of the younger meta-sediments which generally have a poor ground water terrain due to their lithological and structural characteristics (Emmanuel, et al., 2011). The granite rocks are seen out cropping in many places around the study area.

1.7.3 Relief and drainage

The topography of the study area is generally flat terrain. However, a narrow strip of the Chad formation which formed a relatively depressed portion occurs to the extreme north and also to the southern fringe of the study area (Olofin, 2008).

The drainage is generally surface water consisting of seasonal streams and ponds where water collects only during the rainy season and some few months immediately after rainy season. Due to rapid run-off the ground water accumulation is limited and very far away from the surface. Rivers and streams generally flow to the south-eastern part so as to follow the direction of the slope (Ahmed, 2011). Two major rivers exists in the study area, one flows from Katsina state in the northern part through Gurun into Kunchi LGA, while the other river flows from north-western part through Yanganau and Dumbulum into Bagwai LGA.

1.7.4 Climate

The climate of the study area is tropical wet and dry climate, coded as Aw by Koppen. It is characterized by a short rainy season of about 4 months (June-September), followed by a long dry season of about 8 months (October-May). The two seasons were brought about by the seasonal migrations of two air masses. The south-west trade wind from the Atlantic ocean, usually moist, which blows toward the north-east between June and September bringing rainy season. While the north-east trade wind from Sahara desert towards south-west blows between October and May bringing dry, dusty, harmattan period (Olofin, 1987). Rainfall is therefore very critical in the area because of its deficiency during the longer part of the year.

Rainfall in the study area is characterized by high temporal variability. The monthly rainfall distribution shows that rainfall is concentrated between the month of May and September. The month of August receives the highest rainfall for most years then followed by July, the area therefore receive a single maxima of rainfall in the month of August. Similarly, the annual rainfall distribution of the study area indicated a high variability, which ranges between 830mm in 1997 to as high as 1499 in 2013. Rainfall generally shows increasing trend towards the last years of the study period (Table 4.1).

Mean temperature ranges from 26^{O}C to 33^{O}C. highest temperature is recorded between March and May when diurnal temperature reached up to 40^{O}C, whereas the lowest temperature is recorded between mid November and February when diurnal temperature record goes below 20^{O}C (Olofin, 2008). The least relative humidity value of less than 20% is recorded between January and February, while the highest is between July and September with more than 70% (Emmanuel, et al. 2011).

1.7.5 Agriculture

Agriculture is the main economic activity of the people in the study area, predominantly subsistence in nature. The major agricultural practices in the area are crop production and animal rearing. Rain fed crop production exists, the irrigation activities in the study area is not significantly practiced. The dominant food crops produced are maize, sorghum, early millet, beans, late millet and upland rice. While the chief cash crops grown are maize, soya beans, cotton, groundnut, tomato, okra, pepper and bambaranut. Livestock production which is practiced by almost every household includes rearing of cattle, sheeps, goats and poultry.

1.7.6 Vegetation

The natural vegetation of the study area is the sudan savannah type. It consist of few and scattered tree species dominated by short seasonal grass which do not exceed 1m high, and exist only during the rainy season but dried up in the dry season. However, this natural vegetation has been modified over most part of the area by human activities such as intensive cultivation, livestock grazing, felling of trees/ deforestation for fire woods or for sell, etc. Many of these natural tree species are not replaced except those closed to the settlements, where they are only replaced with the exotic ones.

The sparsely distributed tree species in the study area which mostly do not exceed 20m tall consist of *Fadherbia albida* (Gawo), *Acacia nilotica* (Bagaruwa), *Adansonia digitata* (Kuka), *Anogeissus leiocarpus* (Marke), *Azadirachta indica* (Darbejiya), *Balanites aegyptiaca* (Aduwa), *Mangifera indica* (Mangwaro), *Parkia clappertoniana* (Dorawa), and *Tamarindus indica* (Tsamiya) among others.

1.7.7 Settlement, population and economic activities

The inhabitants of the study area are Hausa/Fulani with Hausa language as the common language spoken by all, Predominantly Muslims by religion but with a handful of Christians.

Their main economic activity is farming, however trading is equally widespread as evident by the existence of major markets in Tsanyawa and Dumbulum towns and even at the neighboring areas. Civil service, commercial driving and hawking also form part of the economic activities. Likewise many of the youth in the study area formed the habit of migrating to urban centers during dry season in order to earn a living, commonly referred to as '*ci rani'*.

The study area consist of small but clustered settlements which are scattered around the area especially along the major roads, while at the interior there exist dispersed and scattered settlements and hamlets.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

There are concepts/key terms used during this study. For better understanding, a number of meanings within the context of this research, as provided by different researchers who conducted studies on similar theme, were provided below.

2.1.1 Rainfall variability

Is defined as a departure from the normal pattern of rainfall in terms of amount, start and end of rainy season. (Kowal and Knabe, 1972).

2.1.2 Onset of the rainy season

This refers to the time a place receives an accumulated amount of rainfall sufficient for the growing of crops. It is not the first day of the rainfalls (Adebayo and Oruonye, 2013). Walter (1967), define onset of rains in Nigeria in terms of time of receiving an accumulated amount of rainfall in excess of 51mm. The onset of the rainy season determines the commencement of the growing season and date of planting for the farmer. A delay in the onset of the rainy season, particularly in the wet and dry environment, will delay the date of planting and will result in crops extending their growing period into the winter season, where the prevailing lower temperatures will negatively affect crop yield (Oruonye, 2014).

2.1.3 Cessation of rains

This is the termination of the effective rainy season. It does not imply the last day rain fall, but when rainfall can no more be assured (Adebayo and Oruonye, 2013). The end of the rains is that date after which no more than 51mm of rain is expected. Early cessation of the rainy season results in the cutting short of the growing season of crops and consequently results in crops failing to reach their physiological mature stage (Oruonye, 2014).

2.1.4 Length of rainy season (LRS)

It is the difference in the cessation date and onset date of rainy season. It is the period in days from the date of the onset to the date of the cessation of the rainy season. It therefore determines the length of the growing season (Oruonye, 2014). It is also referred to as Hydrological Growing Season (HGS), according to agriculturalists it is a period between the time crops are planted and the time they fully mature to harvesting stage. Length of the Rainy Season determines the type of crop(s) that can be grown at a place due to the varied crop water requirements (Sawa et al., 2014)

2.1.5 Dry spells

Dry spell is usually the number of consecutive days (Often 5 days) in each month without rainfall (Oruonye, 2014). A dry spell can extend up to 15 days. Dry spell therefore is a period of significant rainfall deficit. It causes poor germination, increase the need for re-planting and lead to wilting and drying out of crops. Early season dry spell usually occurred in May in the North-Western Nigeria, while mid season spells occurs around June and July. Early season dry spells affect soil water retention which would negatively impact on crop germination, while the mid season dry spells effects is more pronounced on late maturing crop varieties (Yamusa, et al., 2015).

2.2 Empirical studies

Rainfall variability is an important climate factor influencing agricultural activities. Rainfall can vary considerably even within few kilometers distance and different time scale. This implies that crop yield is exceedingly variable over space and time. It has biggest effect in determining the crops that can be grown, the farming system, the sequence and timing of farming operations (Adejuwon, 2005).

Several studies have been conducted at global, regional and local scales, on the influence of rainfall variability on the yield of crops.

2.2.1 Rainfall variability and crop yield in some parts of Africa

A study was carried out by Ndamani and Tsunemi (2015) on the influences of rainfall on crop production in the Lawra district of Ghana. This study analyzed annual and seasonal rainfall variability and their relationships with crop production. The results revealed moderate seasonal and irregular annual rainfall concentration. Correlation between annual rainfall and crop production were negative for all the crops studied which include maize, sorghum, millet, groundnut and cowpea. At seasonal level only sorghum, millet and groundnut were negatively correlated with rainfall. This result is not in conformity with findings by Amikuzuno and Donkoh (2012) which assessed how climate variability affects yields of major staple crops (millet, maize, sorghum, rice, groundnut and yam) in two distinct agro-ecological zones of northern Ghana. The result of the study indicated a high seasonal variability in rainfall with cyclical fluctuations above the mean of about 959mm, coupled with several episodes of floods and droughts over the study area. The results indicated that the yield of the selected staple crops have been influenced by the total amount of rainfall in the planting season.

Rugumayo, Kiiza and Shima (2003) carried out a research study that determined the reliability of rainfall in relation to crop water requirements, for different crops in climatic regions in Uganda. The findings revealed that the effective rainfall was insufficient to cater for the crop water requirements. Irrigation was therefore required in all the regions investigated. The reduction in the yields when irrigation requirements were not met was observed. In a related study on rainfall variability and crop production in Ethiopia, Bewket (2009) presented analysis of rainfall behavior and relationships between rainfall variability and fluctuations in crop production in the drought prone Amhara region of Ethiopia. The findings of the study show that there are significant intra-regional differences in rainfall amount, variability and trend. The findings also revealed that inter-annual and seasonal variability of rainfall is a major cause of fluctuations in production of cereals (tef, barley, wheat, maize, sorghum and millet) in the region. The correlation between cereal production and rainfall in the region is high, which suggest that farmers are vulnerable to food-insecurity related to rainfall variability.

In a study conducted by Mkonda (2014) in Mvomera district of Tanzania to assess the relationship between the trend of rainfall variability and that of crop production. Findings show that there is a direct relationship between the two variables, in years where rainfall is decreasing, the crop yields decreased too. The research findings also show that rainfall has been fluctuating over time in the similar pattern to that of crop yields. The crops selected for the study were maize, rice and sorghum. The findings further revealed that the trends of wet spells within a month are not uniform, but fluctuate over time. Due to these fluctuations, the area record poor crop production while in actual fact the amount of rainfall was high. This is because of the unfair distribution of wet spells within a month, as more wet spells can be experienced when crops are already affected adversely by drought.

In a study conducted by Amikuzuno and Donkoh, (2012) which assessed how climate variability affects yields of major staple crops (millet, maize, sorghum, rice, groundnut and yam) in two distinct agro-ecological zones in northern Ghana. The data used for the study includes climate data (temperature and rainfall) time series from 1976-2010, and crop yield data from 1991-2010. The result of the study indicated a high seasonal variability in rainfall with cyclical fluctuations above the mean of about 959mm, coupled with several episodes of floods and droughts over the study period. The results also indicated that the yield of the selected staple crops have been influenced by the total amount of rainfall in the planting season.

2.2.2 Rainfall variability and crop yield in Nigeria

A study by Odjugo (2010) that look at a general overview of climate change impact in Nigeria, which covered a period of 105years (1901-2005), shows that temperature increased by 1.1^0c while rainfall amount decreased by 81mm. While rainfall amount is generally decreasing in Nigeria, the coastal region has been experiencing slightly increasing rainfall since the early 1970s. The result of the study also indicated that the short dry season in the southern part of the country, popularly known as August break is currently being experienced more in the month of July as against August. Sea level rise is observed to have inundated $3400km^2$ of Nigeria coastal region while desert encroachment is reducing arable lands from the northern part of the country by 1 to 10km a year. A shift in crops cultivated by farmers from long to short duration is also noticed. The crops grown changed from guinea corn, groundnut and maize by 1978 to millet, maize and beans by 2007.

In a similar study by Saul (2015), examined the impact of climate change on agriculture and food security in Nigeria, over a period of 86years (1914 to 2000). Between 1914 and 1970, only patches of the country, around Sokoto and Maiduguri and in the South-east, experienced late onset of rains. However, from 1971 to 2000 late onset of rains had spread to most parts leaving only a narrow band in the middle of the country with normal conditions. Similarly, only a small patch of the country in the south-west recorded early cessation of rains between 1914 and 1970, while from 1971 to 2000 early cessation of rains had covered most of the country. The result indicated that there were changes in the onset of rains and cessation. There was also increase in the intensity of the rains.

Similarly, Akinsanola and Ogunjobi (2014) conducted a study that investigates rainfall and temperature variability in Nigeria using observations of air temperature and rainfall from 25 synoptic stations for 30 years (1971-2000). Results indicated that there have been statistically significant increases in precipitation and air temperature in vast majority of the country. Analyses of long time trends and decadal trends in the time series further suggest a sequence of alternately decreasing and increasing trends in mean annual precipitation in Nigeria during the study period.

2.2.3 Rainfall variability and crop yield in northern Nigeria

A research study on the rainfall variation in the Sudano-Sahelian zone of northern Nigeria by Buba (2014) established that there has been an increased in variability of length of growing season in response to the trends of rainfall. Rainfall in the study area is highly variable in time and space subject to depletion or enhancement due to both natural and anthropogenic causes. The findings further asserted that rainfall is characterized by strong inter-annual variability. In the southern part of the study area rain start earlier and stop later where as in the northern most part it starts late and stops earlier. This result is in line with the work of Sawa and Adebayo (2011) who conducted a research study on the impact of climate change on six precipitation effectiveness indices in northern Nigeria between 1976 and 2005. The six derived indices are onset, cessation, length of rainy season, hydrologic ratio, seasonality index and occurrence of pentad dry spells. These indices were subjected to time series analysis, and the result of the analysis showed that the rains start late but end early, as a result length of rainy season is decreasing. Northern Nigeria is becoming drier as the rainy season is now spread within fewer months. This is also similar to findings by Danladi (2007) which examined rainfall variability in Gumel, and reported that rainfall in the study area is significantly variable in terms of its amount, frequency, period of onset and cessation. The findings also revealed that there is significant positive correlation between rainfall and crop yield.

Akinseye et al., (2013) conducted a research study to investigate the impacts of climatic variability (temperature and rainfall) on major crops (maize, millet and sorghum) in the Sudano-Sahelian region of northern Nigeria for a period of 1985-2006. In this study, two states (Bauchi and Sokoto) were used as a representative of the region based on the consistency of climatic and agronomic data. The findings of this study indicated that crops suffered low yield output during the years 1980s toward the early 1990s due to unfavorable climatic conditions. Generally, the result of the study shows that climate is a major determinant for the yield of the selected crops.

A study was undertaken by Francis and Kayode (2013) on temporal analysis of drought intensities and occurrences in northern Nigeria. The Bhalme and Mooley Drought Index (BMDI) was used to categorized drought occurrences into invisible, mild, moderate, severe and extreme. Results show that low intensity drought prevailed in northern Nigeria during the study period. It also indicated that extreme droughts were confined to the decades between 1971-2000.The data used for this study cover a period of 70 years 1941-2010.

Similarly, Yamusa, et al., (2015) conducted a study that examined the implications of rainfall variability on some major food crops of the semi-arid region of northern Nigeria. In this study, fifty years of daily rainfall data (1963-2012) were collected. Grain yield data for sorghum, maize, cowpea and rice were also sourced. Correlation analysis was employed to assess the relationship between crop yield and dry spells. The result indicated about 10days shift from the normal planting period. The result also showed negative relationship significant at 1% level of confidence for sorghum and maize and significant at 5% level of confidence for cowpea and rice. The result of the findings concluded that the effect of planting earlier than second week of June as a result of long dry spells of more than 8days after planting would cause significant damage to shallow rooted crops and planting more than once.

A study conducted by Ati, et al. (2009) determines the trend in annual rainfall for northern Nigeria. Rainfall data for a period of 50 years (1953-2002) were considered. The finding shows that there is significant increase in annual rainfall in the last decade of the study. The result therefore indicated that the Sudano-Sahelian zone of Nigeria is experiencing wetter conditions. This therefore creates a favorable condition for irrigation agriculture. This finding agrees with the studies by Akinsanola and Ogunjobi (2014) but contradicts some of the studies such as by Francis and Kayode (2013), and Adebayo et al. (2013) that show increasing dryness.

Atedhor (2015) conducted a study that examines the agricultural vulnerability to climate change in Sokoto state for a period of 1951-2010. The results show that while there were downward trends of annual rainfall and rain days in Sokoto, annual mean temperatures shows upward trend. Annual droughts were of slight and moderate intensities during the period under review. The result also revealed that unreliable rainfall, desertification, increasing temperatures, scarcity of pastures and inaccessibility to credit facilities accounted for 86% of the variation of agricultural vulnerability to climate change in Sokoto.

Again, Oruonye (2014) carried out a research that examines trend and pattern of climatic variables in Taraba state. Climatic data such as mean monthly temperature, rainfall totals, and rain days per annum for four meteorological stations in the state (Lau, Gassol, Ibi, and Gembu) for a period of 30-35 years was obtained. The result of the study revealed that annual rainfall show increasing trend in the southern and central part of the state with exception of Lau in the northern part of the state. All the four stations shows late onset of rain, while only

Ibi shows late cessation of rains. Length of rainy season show decreasing trend in all the stations except Ibi, where it is relatively stable. The implication of such a trend, especially if persisted, is tendency towards a drier condition, and hence reduced crop yield. In another related study carried out by Adebayo, et al., (2013) which examine the general level of awareness of climate change impact and adaptation in Adamawa state discovered that rainfall is decreasing and frequency and length of dry spells are on the increase.

Adamgbe and Ujoh (2013) examine the impact of variability in rainfall characteristics on maize yield in Gboko L.G.A of Benue State. The result of the correlation analysis showed that rain days and rainfall amount had strong positive relationships with maize yield. It was also observed that the rainfall characteristics jointly contributed 67.4% in explaining the variations in the yield of maize. Furthermore, a study by Umar (2012), an analysis of rainfall variability and its implication for some crops in Gombe State determined the spatio-temporal variability of rainfall in the study area for the period of 1977-2008. The study also assessed the impacts of this variability on some crops cultivated. The findings of this study revealed that there exist differences in the quantity of rainfall received between the north and the southern parts of Gombe State, the rainfall amount decreases northwards. Agricultural activities were more promising in the southern part due to more rainfall. The result also indicates that high moisture requirement crops such as maize and rice are cultivated successfully in the southern parts where the annual rainfall values range between 603.70mm to 1791.00mm, while in the northern parts where the rainfall values ranges between 325mm to 848mm such crops could hardly survive under rain fed conditions. Instead, crops such as millet, sorghum, groundnuts, cassava, etc. which have relatively low moisture requirements are grown. The study finally stresses the fact that insufficiencies of rainfall, uneven distribution, delay in its onset among other things result in crop failure, shortage and famines in the study area especially around 1980s when food production declined by about 20%.

However, a study conducted which examine the relationship between climate variability and crop production in Bauchi and its environs by Muhammad (2014) revealed that rice and cowpea shows significant relationship with rainfall at 0.05 level of significance, while maize, millet, sorghum and groundnut shows no significant relationship. Temperature and rainfall which are the climatic elements used in the research can explain only 10% crop yield of the selected crops. This therefore implies that other environmental factors such as soil fertility, agricultural inputs, etc may explain better the variation between the climatic variables and crop yield. This study used climatic variables and crop yield data for 30 years (1981-2010).

2.2.4 Rainfall variability and crop yield in Kano state

Nwagbara (2015) conducted a research which examined the rainfall and temperature trends as tools of climate change over Kano state, an area which is well known for agriculture. Under this study, rainfall and temperature data from 1971 to 2013 were collected and analyzed. Results obtained shows gradual but steady increase in both temperature and rainfall. The results indicated that Kano state is warming at an average annual rate of 0.011^0c and becoming wetter at a rate of 21.26mm per annum.

A similar study was equally carried out by Mohammed, et al., (2015). In their studies which examined the extent of climate change in Kano through rainfall data analysis, revealed that there is variability in both amount and length of rainy season. The findings further revealed that drought and near drought conditions were experienced in the 1970s and 1980s, the last two decades however recorded improvements in moisture conditions. The trend analysis generally revealed that the length of rainy season decrease on average within the period of the study, and this finding is similar and in line with the work of Nwagbara (2015).

Abaje, et al., (2014) in their study which determined the changing patterns of rainfall and its adverse impacts on transport infrastructures further re-emphasizes and agrees with the findings on rainfall pattern by Mohammed, et al. (2015) and Nwagbara (2015). The result of the study revealed that, contrary to the perceived decreasing rainfall, Kano has been experiencing decreasing number of dry conditions and consequently increasing wetness over recent years. This increase in the annual rainfall amount is predominantly as a result of the increased in the June, July and August rainfalls, and this may be responsible for the frequent occurrences of floods in the months of July and August. The relative seasonality index of rainfall series revealed that the rainfall is in 3 months or less. The study uses annual and monthly data of rainfall for a period of 100 years (1911-2010).

In another study by Bello (2012), examined the relationship between precipitation effectiveness indices and millet yield revealed that the coefficients of four rainfall indices are significant in the analysis. The four indices include; total rainfall, hydrologic ratio, length of the rainy season and onset. Findings show that the four variables accounts for 62% and 73.5% of the variations in the yield of millet at Kura and Danbatta local governments respectively. Dawha (2016) conducted a study that assesses the impact of rainfall distribution on crop yield in Kano state, reported a deviation from that of Bello (2012). Though Dawha (2016) confirmed the existence of temporal rainfall variability in the study area, the result however revealed that climate has little impact on crop productivity of the selected crops, which include millet, sorghum, maize, rice, cowpea and groundnut. The findings shows that the result of the correlation between rainfall amount and crop production indicated a negative correlation for all the crops except groundnut where a very weak correlation (r=0.267) is found.

Furthermore, Sawa, et al (2014) conducted a study that examined the impact of climate change on the hydrological growing season at Kano. The onset, cessation and length of rainy season at Kano were determined. These parameters were subjected to time-series analysis. The results show that the rainy season has progressively been starting late (late onset), and the rain ceases earlier in recent decades (early cessation). The implication of this is the shortening or decreasing length of the hydrological growing season, which has decreased from an average of 140±5days to about 120±5days in the state.

CHAPTER THREE

METHODOLOGY

3.1 Types and sources of data

The data on rainfall and crop yield were used in this study. The data on rainfall (in mm) and yield of the four selected crops; maize, sorghum, millet and soybeans (in tons/ha) for 20 years (1995-2014) was sourced from the local government agricultural and meteorological units and state office of KNARDA.

The rainfall variability characteristics examined over this period include;

- Daily rainfall amount
- Total annual and monthly rainfall amount
- Onset of rain
- Cessation of rain
- Length of rainy season
- Seasonality index

In order to get additional data that will compliment this record, a questionnaire was administered to farmers. Information regarding the study was also obtained from secondary sources such as relevant researches, theses and academic journals, published and unpublished projects.

3.2 Data collection techniques

Data collection technique adopted for this study is questionnaire design. Farmers from the study area formed the sampling frame for the questionnaire administration. Estimated figures of over 10,000 farmers who consider farming as their main occupation exist in the study area (KNARDA, 2008). However, enumerating the entire members of the target population of the study area exhaustibly is difficult if not impossible at least within the capacity of this research study, because the population of farmers is not only large but spread across the entire study area. However, the farmers exist in their respective towns and villages which are the naturally occurring clusters or groupings. So, the use of cluster sampling technique is employed in order to get the respondents for the questionnaire administration. Multi-stage cluster sampling is a method where the target population is divided into clusters, and then further sampling takes place within clusters, this process continues until individuals are sampled.

There are a total of 21 major communities in the study area, the study involved selection of 11communities out of the 21. Ten farmers were further selected from each of the eleven selected communities, making a total of 110 respondents. This number is substantially enough to make generalizations for the entire study area.

The information derived out of the questionnaire administration include perception of farmers on rainfall pattern, the onset, cessation, length of the rainy season and their trends and how that may affect crop yield, types of crops grown, how they are produced and whether there is increase or decline in the yield within the last 20 years, as shown in table 4.15 to 4.18 and fig. 4.7 and 4.8.

3.3 Characteristics of rainfall gauging station

Table 3.1: Rainfall Gauging Station

Station name	Year established	Latitude	Longitude	Rainfall record
Tsanyawa	1988	$12^o19^'$ N	$07^o59^'$ E	1995 -2014

The existence of rainfall gauging station in the study area allows a better opportunity to have relevant comparism between rainfall and crop yield.

3.4 Data analysis

The data obtained from the different sources was subjected to statistical techniques of analysis and interpretation. The data was analyzed using the Statistical Package for Social Sciences (SPSS) and Microsoft excel softwares.

Descriptive statistics with graphics was used for data presentation. Microsoft excel software was used to draw time-series graphs to show the annual variations and linear trends of rainfall variability indices in the study area (Fig. 4.1). A graph was also drawn to show the trend for each of the crop yield for the period under study (Fig. 4.6). Also using the Microsoft excel, Mean, Standard Deviation and Coefficient of Variability for each of the crop yield were computed for the period under study (Table 4.4), this is in order to determine the degree of variability of the yield over years. Correlation analysis was also done, using SPSS, to determine the relationship between yield of the selected crops and rainfall variability indices (Table 4.5). Regression analysis was equally done to determine the trends in the behavior of rainfall indices and crop yield (Table 4.6 to 4.9). Finally, SPSS software was also used to analyze the results of the questionnaire administered.

3.5 Computation of rainfall variability indices

The computation of Onset and Cessation of rain was done using Walter's (1967) formula. Length of the Rainy Season (L.R.S.) is computed using Adepolalu (1993) method, while rainfall Seasonality Index is calculated according to the method of Walsh and Lawler (1981).

e. **Onset of rain:**

The onset or start of rain refers to the time a place receives an accumulated amount of rainfall sufficient for the growing of crops. It is not necessarily the first day the rain falls. The formula for the computation of Onset is given as follows:

The number of days in the month x <u>(51- Accumulated rainfall of the previous months)</u>

Total rainfall for the month

f. **Cessation of rain:**

The cessation or end of rain refers to the termination of the rainy season. It does not necessarily mean the last day rain fall, but when rainfall can no more be assured or be effective. The computation of the cessation date is done in a similar way to the onset except that the computation is done backward from December. The formula is given as follows:

The number of days in the first month from December with the cumulative <u>monthly rainfall = 51- rainfall total of the previous month</u>

Total rainfall of the first month with cumulative rainfall greater than 51mm.

g. **Length of the rainy season**:

Is the period between the Onset Date (OD) of the rains and the Cessation Date of the rains. This is the number of days between the effective start (onset) of the rainy season and the termination (cessation) of the rainy season. The LRS can be obtained by subtracting the onset date from the cessation date.

LRS = Cessation date – Onset date

However, Onset Dates and Cessation Dates are converted into Julian Date Calendar before computing the L.R.S.

h. Seasonality Index (S.I.):

The Seasonality Index of rainfall is defined as the sum of the absolute deviations of mean monthly rainfall from the overall monthly mean divided by the mean annual rainfall. It is used to measure the spread and steadiness of rainfall during wet season. The higher the S.I. value the shorter the spread of the rainy season, implying the drier the place, and vice versa (Sawa and Adebayo, 2011). The computation of Seasonality Index is done by the use of the following formula:

$$S.I. = 1/R\ E(X_n - R/12)$$

Where; **S.I. = Seasonality Index, R= Mean annual rainfall, X_n= mean rainfall of the month n.**

The S.I. values obtained from the computation using the formula above were compared to the values given by Walsh and Lawler (1981) in table 3.2 for interpretation of the results and classification of the study area into the appropriate rainfall regime.

Table 3.2: Classification of Seasonality Index of Rainfall and Rainfall Regimes

S/No	S.I. Class	Rainfall Regime
1	Less than 0.19	Very equitable
2	0.20_ 0.39	Equitable but with a definite wet season
3	0.40 – 0.59	Seasonal with a short dry season
4	0.60 – 0.79	Seasonal
5	0.80 – 0.99	Markedly seasonal with a long dry season
6	1.00 – 1.99	Most rain in three months or less
7	More than 1.99	Extreme, almost all rain in 1- 2 months

Source: Adapted from Walsh and Lawler (1981)

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND DISCUSSION

4.0 Introduction

This chapter presents and discusses the results of this study. The chapter is divided into 2 sections. The rainfall and crop yield data is presented, analyzed and discussed first, and then followed by the presentation and discussion of the questionnaire result. In addition, the presentation and discussion follows the order in which the objectives of the study are presented.

4.1 Nature of temporal rainfall variability

This section deals with presentation and discussion of rainfall data. Using the daily rainfall records, the five rainfall variability parameters were computed. They include Monthly and Annual totals of rainfall, Onset, Cessation, Length of Rainy Season and Seasonality Index.

4.1.1 Monthly and annual total rainfall

The study area is characterized by a tropical climate, Sudan savannah type, as such the rainfall is seasonal in nature. The rainy season mostly starts in May and ends in September as indicated in table 4.1. The table presents the monthly and annual total rainfall data for the study area from 1995-2014. It also depicts the monthly and annual variations in rainfall during the period under review. It could be observed from the table that year 2011 recorded the highest rainfall value of 1529.5mm followed by 2012, 2013, 2014 and 2010 with 1503mm, 1499mm, 1404.5mm and 1345.5mm respectively. On the other hand, the year 2001 recorded the lowest rainfall value of 809.9mm. The table however shows that the rainfall fluctuates between the years 1995 to 2006, while the area generally recorded a wetter period between 2008 and 2014.

With regards to the monthly distribution of rainfall, it could be observed that the area has not recorded rainfall in April except in 2001, 2013 and 2014. Likewise years 1999, 2002, 2007, 2009 and 2010 experienced their first rain for the year in June.

Table 4.1: Monthly and Annual Total Rainfall Record for Tsanyawa L.G.A. from 1995 – 2014

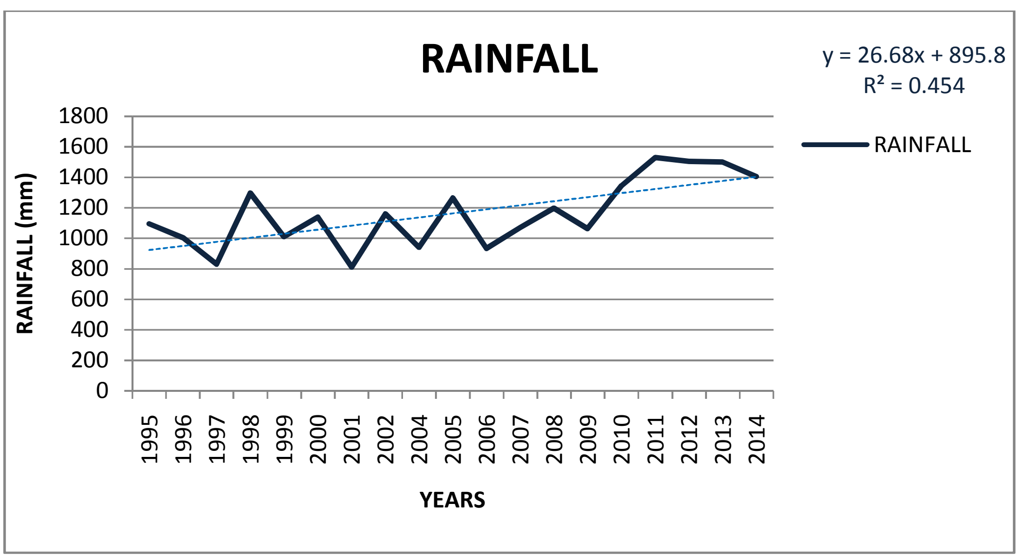
YEAR	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	TOTAL
1995		174.7	199.2	290	372.1	59.3		1095.3
1996		30	136	152	457	228		1003
1997		56	14	263	381	116		830
1998		97.6	98	434.2	361	305.2		1296
1999			105.6	387.8	366	132.8	18	1010.2
2000		43	139.4	497	355.6	103.8		1138.8
2001	6.2	87.4	70.7	187.6	361.7	77.1	19.2	809.9
2002			49.2	443.8	371.8	161.6	132.8	1159.2
2003								
2004		129.2	140.5	301.6	278.9	90		940.2
2005		125	118.4	171	696	154		1264.4
2006		44	101	314	324	150		933
2007			173.5	211.3	469.2	217.8		1071.8
2008		43.8	176	375.3	399	203		1197.1
2009			186.2	403.2	356.4	116.4		1062.2
2010			181.5	369	530	265		1345.5
2011		117.5	140	530	522	220		1529.5
2012		108	188.5	440	530.5	236		1503
2013	57.5	35	167	360.5	686	193		1499
2014	43.5	94	251	294.5	436.5	254	31	1404.5
TOTAL	107.2	1185.2	2635.7	6425.8	8254.7	3283	201	

Source: KNARDA

For all the other years rainfall starts in May. Also rainfall ends in September for all years except in 1999, 2001, 2002 and 2014 where they receive rainfall up to October. This therefore shows that variability in monthly rainfall totals is more pronounced than the variability in the annual rainfall totals. This corroborates with the work of Buba (2017) which indicated a lower variability in annual rainfall totals when compared to the monthly rainfall totals. The implication of this variability in monthly and annual rainfall is its effect on agricultural practices and yield of crops. Should all other factors remain constant, favorable rainfall characteristics could bring significant improvement in agricultural practices and crop yield.

Figure 4.1 is a time series graph which shows the annual variation of rainfall. The fig. shows that the rainfall fluctuates around the mean. However, the linear series depicts a gradual increase in the annual rainfall amount, which means the study area is gradually becoming wetter in recent years. This is in conformity with findings by Nwagbara (2015), Mohammed et al (2015) and Abaje et al (2014), Akinsanola and Ogunjobi (2014) and Ati, et al (2009), which all reported a significant increase in rainfall amount over different parts of Nigeria.

The implication of the increased rainfall for farmers is the opportunity to increase crop and animal production, this is because more rainfall can be harvested. Also, soil moisture, rivers, dams and ponds are being recharged more, making water more available and longer lasting for crops and animals especially if properly stored in ponds, dams and lakes.



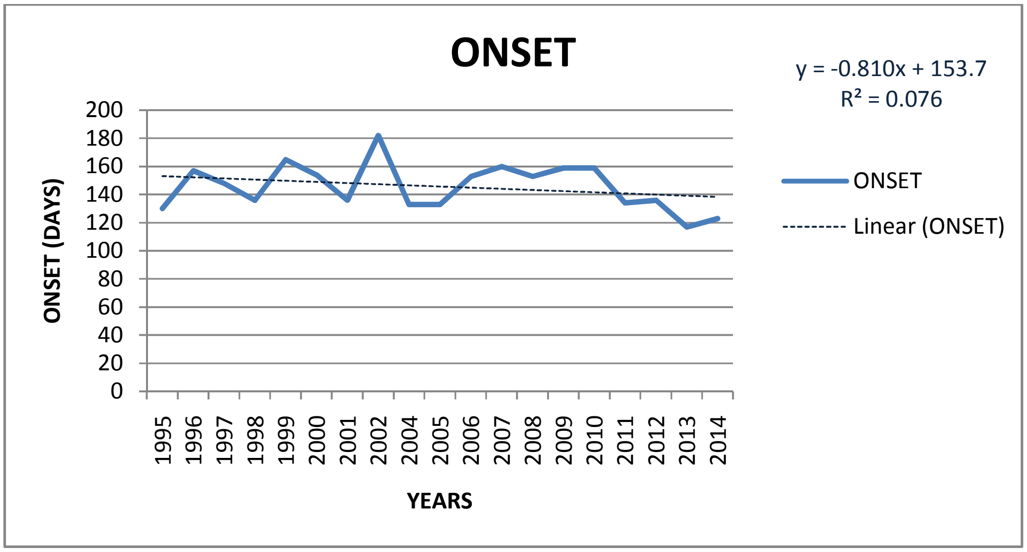
SOURCE: Data Analysis (2018)

Fig. 4.1: Annual Fluctuations and Linear Trend of Rainfall Distribution in the Study Area from 1995-2014

4.1.2 Onset and cessation dates of the rainy season

Table 4.2 shows the annual rainfall (mm) and computed rainfall parameters for the study area from 1995-2014. From the table, the onset ranges between 27th April and 1st July. This means in the year 2013 rainfall starts early (27th April) whereas in the year 2002 rain starts very late (1st July). By implication, planting of crops was early in 2013 and late in 2002, and this may translate into the yield of crops to be harvested. The table also indicates that the onset date is very variable which cut across 4 different months (April, May, June and July). It could however be noted from table 4.1 that increase in monthly rainfall amount from the onset until the peak is reached, is more gradual than the decrease from when the peak is attained to the cessation date. This is in line with the work of Buba (2010) which identifies a gradual increase in rainfall from onset to the peak but an abrupt decrease from the peak to the cessation.

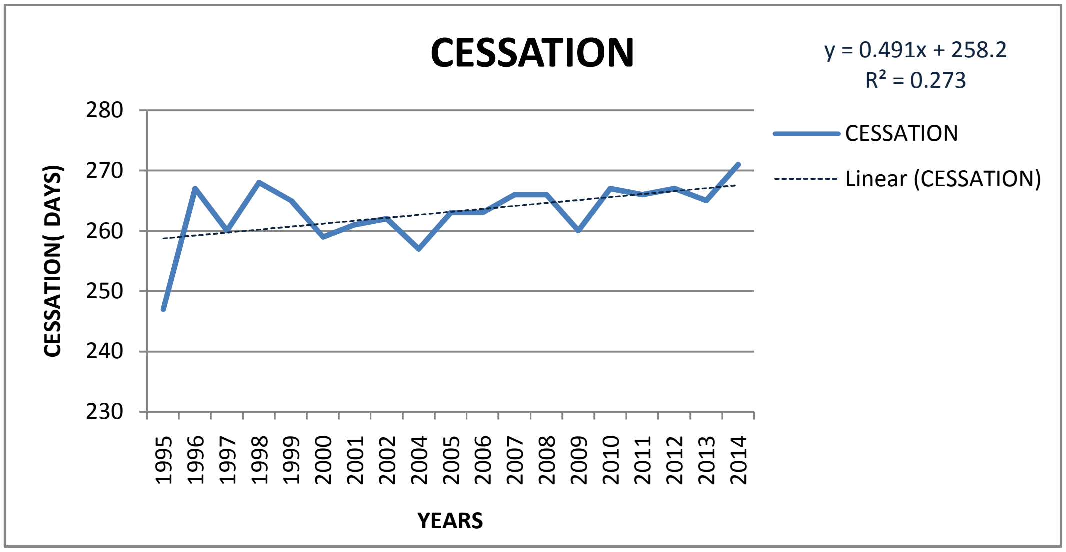
The linear trend line and the trend line equation for the onset dates of the rainy season in the study area are shown in Fig. 4.2. The figure shows that the trend in the onset dates of the rains is on the decline indicated by the negative trend line equation **($y=-0.810x+153.7$)**. This means decreasing Julian days and implies that rainfall progressively starts earlier in recent years in the area.



SOURCE: Data Analysis (2018)

Fig. 4.2: Trends in the Onset Dates

On the other hand cessation dates differ from the onset dates in terms of the degree of its variability over the years. The cessation dates are more uniform especially toward the recent years than the onset, this is because the cessation for the entire period of study is in September, and it ranges between 4th September and 28th September. This means there is early cessation in 1995 (4th September) while year 2014 recorded late cessation (28th September). Cessation dates therefore gives more favorable condition for farmers to prepare and plan for their farming practices, type of crops to be planted, etc than the onset dates. Fig. 4.3 is a trend in the Cessation dates of the rains in the study area, which indicates an increasing trend line. The best fit line equation is positive **($y = 0.386x + 260.8$)** and this means increasing Julian days which implies that rainfall stops slightly later in recent years.



SOURCE: Data Analysis (2018)

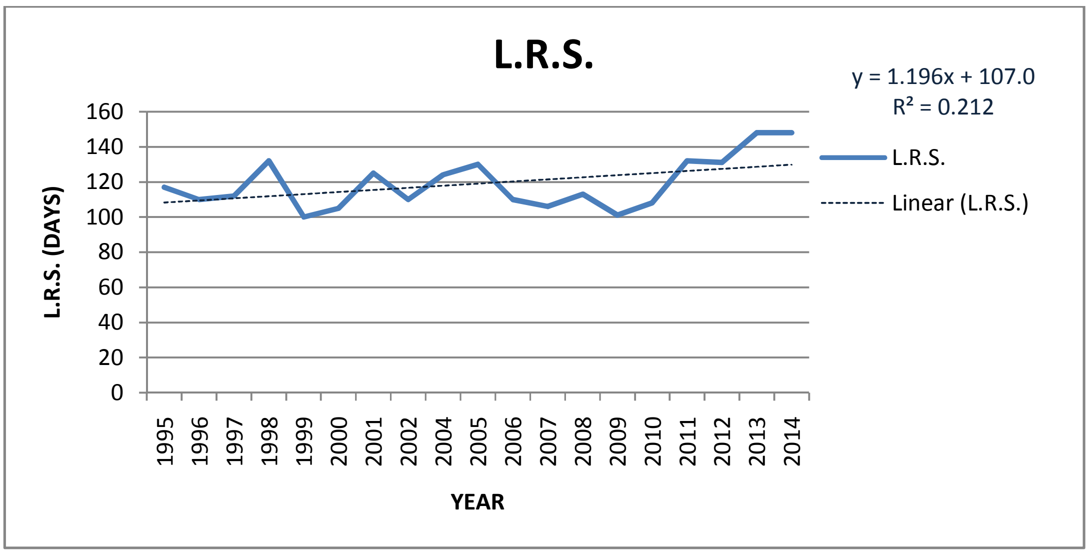
Fig. 4.3: Trends in the Cessation Dates

4.1.3 Length of the rainy season (L.R.S.)

The L.R.S. in the study area as presented in table 4.2 is between 100 days and 148days. Year 1999 recorded 100 days which is the least, while years 2013 and 2014 recorded 148 days each, which is the highest. The average L.R.S. in the study area is 119 days, this is 11days lower when compared to that of Sawa et al. (2014) and Sawa and Adebayo (2011) who reported average L.R.S. of 130days each. The L.R.S. indicates a wide variation and fluctuates between the years, without any definite pattern. However, the relevance of this is that farmers can consider the lowest LRS to set as a standard in planning their farming activities, so as to be on a relatively safer side. This is because L.R.S. affects the type and variety or cultivar of crops that can be grown in a rainfall dependent agriculture.

However, the LRS is not always and solely the determining factor in deciding the type and variety of crops to be grown. Onset and cessation being the measures of LRS, farmers were often deceived by the early onset in sowing their seeds. Unfortunately, the increasing frequency and length of dry spells, as indicated by Adebayo (2013) and Francis and Kayode (2013), compelled farmers to plant their seeds more than once before the stability of the rain is attained. This could be evidently clear when years with the highest LRS is compared with the yield of crops for the corresponding years. The years with highest LRS were 2013 and 2014 and their corresponding LRS is 148 days each. On the other hand, the year with the highest crop yield for sorghum and maize is 2010, for millet is 1998, while a soybean is 2013. It is therefore observed that only soybeans yield corresponds with the highest LRS.

Fig. 4.4 shows that the general trend in the Length of the Rainy Season in the study area is increasing. This is further supported by a positive trend line equation of **y=1.196x+107.0**. This signifies that the duration of the rainy season in the study area is gradually becoming slightly longer over recent years.

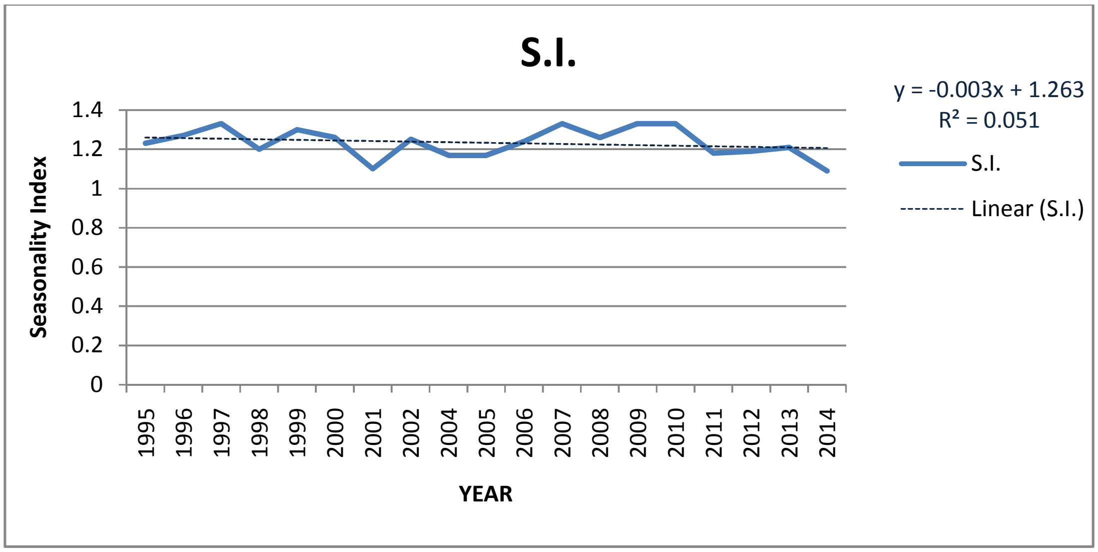


SOURCE: Data Analysis (2018)

Fig. 4.4: Trends in the Length of the Rainy Season

4.1.4 Seasonality Index (S.I.)

The seasonality index in table 4.2, when compared to the values of Walsh and Lawler's (1981) classification table (table 3.2), it would be concluded that the study area has fallen under S.I. class of 1.00–1.99, which is a zone where most of the rainfall is concentrated in three months or less. The spread of the rainfall in the study area is shown in Fig. 4.5. From the fig., the pattern or trend in the rainy season shows that rainfall occurs only within 3 months. This is further supported by Abaje et al (2015) which shows that the S.I. of rainfall in Kano state is in 3 months or less. The linear trend line indicates shortening the spread of the rainy season in the study area, and this is confirmed by the negative best fit line equation.



SOURCE: Data Analysis (2018)

Fig. 4.5: Trends in the Seasonality Index

Table 4.2: Annual Rainfall (mm) and Computed Rainfall Parameters for the Study Area

YEAR	RAINFALL	ONSET	JULIAN D.	CESSATION	JULIAN D.	L.R.S.	S.I.
1995	1095.3	9th May	130	4th Sept	247	117	1.23
1996	1003	5th June	157	23rd Sept	267	110	1.27
1997	830	28th May	148	17th Sept	260	112	1.33
1998	1296	16th May	136	25th Sept	268	132	1.2
1999	1010.2	14th June	165	22nd Sept	265	100	1.3
2000	1138.8	2nd June	154	15th Sept	259	105	1.26
2001	809.9	16th May	136	18th Sept	261	125	1.1
2002	1159.2	1st July	182	19th Sept	262	110	1.25
2003	-	-	-	-	-	-	-
2004	940.2	12th May	133	13th Sept	257	124	1.17
2005	1264.4	13th May	133	20th Sept	263	130	1.17
2006	933	2nd June	153	20th Sept	263	110	1.24
2007	1071.8	9th June	160	23rd Sept	266	106	1.33
2008	1197.1	1st June	153	22nd Sept	266	113	1.26
2009	1062.2	8th June	159	17th Sept	260	101	1.33
2010	1345.5	8th June	159	24th Sept	267	108	1.33
2011	1529.5	14th May	134	23rd Sept	266	132	1.18
2012	1503	15th May	136	23rd Sept	267	131	1.19
2013	1499	27th April	117	22nd Sept	265	148	1.21
2014	1404.5	3rd May	123	28th Sept	271	148	1.09

SOURCE: Data Analysis (2018)

4.2 Trend in the yield of crops

This section is concerned with the presentation and analysis of crop yield data of the four selected crops. The trend analysis in the yield of crops is an attempt to see the behavior in the yield of each of the crops over the period of the study. Table 4.3 shows the crop yield data for sorghum, millet, maize and soybeans, while fig. 4.6 shows the fluctuations and linear trends in the yield of Sorghum, Millet, Maize and Soybeans from 1996 to 2014.

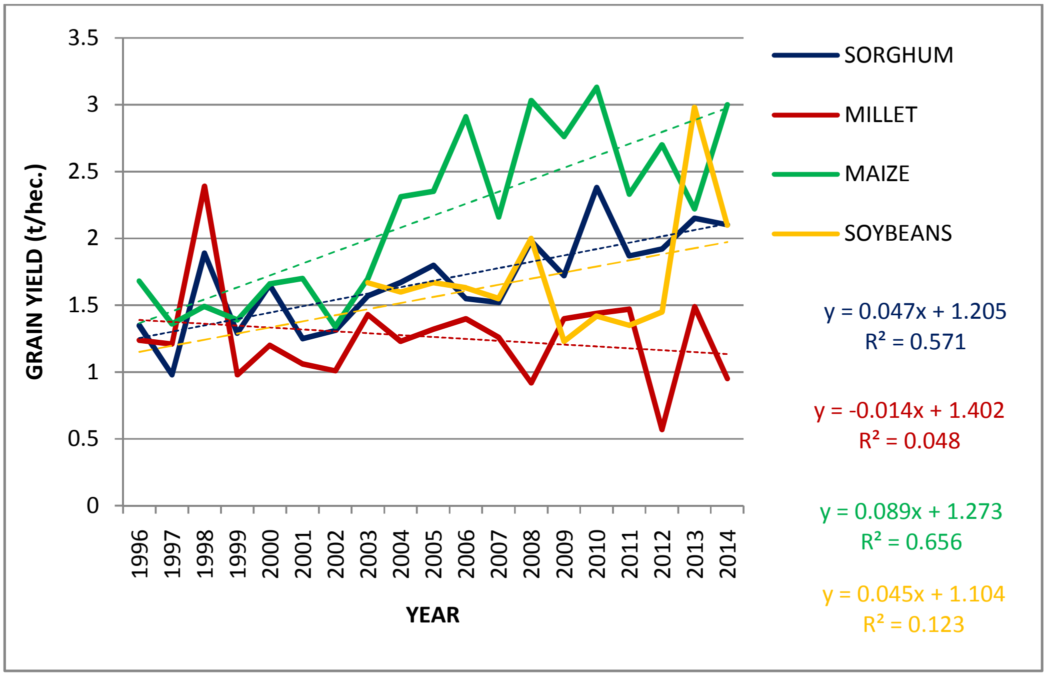
Table 4.3: Crop Yield Data in tons/hec.

S/No	Year	Sorghum	Millet	Maize	Soybeans
1.	1996	1.35	1.24	1.68	-
2.	1997	0.98	1.21	1.36	-
3.	1998	1.89	2.39	1.49	-
4.	1999	1.29	0.98	1.39	-
5.	2000	1.65	1.20	1.66	-
6.	2001	1.25	1.06	1.70	-
7.	2002	1.31	1.01	1.34	-
8.	2003	1.57	1.43	1.70	1.67
9.	2004	1.67	1.23	2.31	1.60
10.	2005	1.80	1.32	2.35	1.67
11.	2006	1.55	1.40	2.91	1.63
12.	2007	1.52	1.26	2.16	1.55
13.	2008	1.98	0.92	3.03	2.00
14.	2009	1.72	1.40	2.76	1.23
15.	2010	2.38	1.44	3.13	1.42
16.	2011	1.87	1.47	2.33	1.35
17.	2012	1.92	0.57	2.70	1.45
18	2013	2.15	1.49	2.22	2.98
19.	2014	2.10	0.95	3.00	2.10

Source: KNARDA

4.2.1 Trend analysis of sorghum

The fluctuations in the trend of sorghum yield shows a sharp decline in the year 1997 where the lowest yield in the study period is recorded, and then a sharp increase in 1998. The yield however continues to fluctuate up to 2009. In 2010 there was yet another sharp increase, were the highest yield is recorded. This is followed by yet a sharp decline in 2011 and 2012 and then a gradual increase in 2013 and 2014. The linear trend in the yield of sorghum generally indicates a steady and gradual increase (fig. 4.6).



SOURCE: Data Analysis (2018)

Fig. 4.6: Trend in the Yield of Crops over Years

4.2.2 Trend analysis of millet

The trend in the yield of millet indicates that there is a slight decline in the yield in 1997 and then followed by a skyrocketed increase in 1998, where a bumper harvest and the highest yield is recorded. This is immediately followed by yet another sharp decline in 1999, this pattern of fluctuation continues with a noticeable decline and increase in 2008 and 2013 respectively. In-between these years, a sharp decline to the lowest yield is recorded in 2012. The linear trend line of millet indicates a slight decline in the yield over the years (fig. 4.6).

4.2.3 Trend analysis of maize

Fig. 4.6 indicates a fall in the yield of maize from 1996 to 1997, and then the trend continues to fluctuate up to 2004 where a more pronounced increase is recorded. Two years earlier, in 2002, the lowest yield is recorded. In 2006, another significant boost is recorded, and this is followed by alternating sharp decrease and increases. The highest yield is however recorded in 2010. The linear trending pattern of maize generally shows a significant increase as indicated by the trend line.

4.2.4 Trend analysis of soybeans

Also Fig. 4.6 shows a trend analysis for soybeans from 2003 to 2014. The fig. indicates a relatively uniform pattern from 2003 to 2006. However, from 2007 there were alternating sharp increases and decreases up to 2014. Year 2009 recorded the lowest yield while the highest yield is recorded in 2013. The linear trend indicates a significant increase in the yield.

4.2.5 Descriptive statistics of crop yields

Table 4.4: Descriptive Statistics of Crop Yields

S/No	Crop	Mean	S.D.	C.V.
1.	Sorghum	1.68	0.35	0.21
2.	Millet	1.26	0.36	0.29
3.	Maize	2.17	0.62	0.29
4.	Soybeans	1.72	0.47	0.27

Source: Author's Computation

Table 4.4 presents descriptive statistics for the yields of Sorghum, Millet, and Maize grain crops for the study area from 1996 to 2014 and for Soybeans grains from 2003 to 2014. From the table, the Mean yield of Sorghum, Millet, Maize and Soybeans are 1.68, 1.26, 2.17 and 1.72 respectively. Their corresponding Standard Deviations (S.D.) are 0.35, 0.36, 0.62, and 0.47 respectively. The standard deviations of these crops therefore implied that during the period under review, the yield of Maize recorded the highest variation, which means it has the highest deviation from the mean, followed by Soybeans, and then Millet, and finally Sorghum recorded the least variation.

Furthermore, the Coefficient of Variation (C.V.) of these four crops; Sorghum, Millet, Maize and Soybeans are 0.21, 0.29, 0.29 and 0.27 respectively. This means the yield of Millet and Maize are more variable at 29% each, then followed by Soybeans which is variable at 27%, lastly Sorghum, which has the least variability of 21% among the crops. The yield of Sorghum is therefore more uniform over the years under review. Generally speaking, the descriptive statistics for the yield of these crops suggest that the variability in the yield across the years is moderate.

4.3 Implication of rainfall pattern on crop yield

The rainfall variability parameters were correlated and regressed with the yield of each of the crops. This is in order to establish the possibility of relationship between rainfall pattern and crop yield in the study area or otherwise.

4.3.1 Rainfall-Crop yield relationship

Rainfall variability indices discussed in section 4.1.1 to 4.1.4 were correlated with yield of each of the selected crops. A Pearson Product Moment Correlation (PPMC) was computed for the relationship between yield of Sorghum, Millet, Maize, and Soybeans at one hand, and rainfall variability parameters, which include; Annual Total Rainfall Amount (ATRA), Length of the Rainy Season (L.R.S.), Onset (OS), Cessation (CS), and Seasonality Index (S.I.) at the other. The result is presented in table 4.5.

a. Correlation between sorghum and the rainfall indices

The result of a correlation between yield of sorghum and rainfall indices in table 4.5 shows that a positively moderate correlation was found between sorghum and L.R.S. **(r =0.480, p=0.044)**, indicating a significant relationship at 5% level of significance (2=tailed). That means L.R.S. influences positively the yield of sorghum, meaning that the longer the L.R.S.

the more the yield of sorghum. Similarly, a positively strong correlation was found between yield of sorghum and A.T.R.A. **(r =0.798, p =0.000)**, indicating a significant relationship at 1% level of significant (2 tailed), that Annual Total Rainfall Amount influence yield of sorghum, meaning that more sorghum is produced with increase in rainfall amount. The result of the correlation further indicates that there is no significant relationship between sorghum yield and Onset, Cessation and Seasonality Index, meaning that the yield of sorghum could not be determined by these indices.

b. Correlation between millet and the rainfall indices

The yield of millet was correlated with Annual Total Rainfall Amount, Length of Rainy Season, Onset, Cessation and Seasonality Index. The result of the correlation at 1% and 5% level of significance shows that there is no significant relationship between them, which means these rainfall indices do not have significant influence on the yield of Millet (table 4.5). This also means that the yield of millet is determined by other factors not correlated.

c. Correlation between maize and the rainfall indices

The yield of maize was equally correlated with the rainfall variability parameters of Annual Total Rainfall Amount, Length of Rainy Season, Onset, Cessation and Seasonality Index, and the finding is similar to the correlation on millet, meaning that there is no significant relationship between maize yield and the rainfall parameters. The maize yield could therefore be explained better by other factors not correlated. An attempt should therefore be made to correlate yield of maize and millet with other factors.

d. Correlation between soybeans and the rainfall indices

A Pearson Product Moment Correlation was computed for the relationship between yield of Soybeans and rainfall indices, and the result shows that a moderate positive correlation was found between Soybeans and L.R.S. **(r=0.639, p=0.034)** indicating a significant relationship at 5% level of significance (2-tailed), that means Length of Rainy Season influences the yield of Soybeans, meaning that increases in the Length of Rainy Season could result in the corresponding increase in the yield of Soybeans and vice-versa. Likewise, a moderately negative correlation was found after correlating yield of Soybeans with Onset **(r=-0.585, p =0.046)**, indicating a significant negative relationship between them at 5% level of significance (2-tailed), meaning that even with late onset there could still be an increase in the yield of Soybeans, which also means that the late onset recorded in the study area is still within the requirement or accommodating range of the soybeans crop.

The result of the correlation however indicates no significant relationship between yield of Soybeans and Annual Total Rainfall Amount, Cessation, and Seasonality Index, meaning that these three variables do not play any significant role in determining the yield of soybeans.

Table 4.5: Correlation between Rainfall Indices and Crop Yields

		SORGHUM	MILLET	MAIZE	SOYA B.	L.R.S.	S.I.	RAINFALL	Onset	Cessation
	Pearson Correlation	1	.182	.725**	.370	.480*	-.209	.798**	-.401	-.019
SORGHUM	**Sig. (2-tailed)**		.455	.000	.236	.044	.405	.000	.089	.939
	N	19	19	19	12	18	18	19	19	19
	Pearson Correlation	.182	1	-.186	.029	.120	.079	.082	-.189	-.093
MILLET	**Sig. (2-tailed)**	.455		.446	.928	.634	.755	.739	.440	.704
	N	19	19	19	12	18	18	19	19	19
	Pearson Correlation	.725**	-.186	1	-.103	.196	-.106	.393	-.194	-.205
MAIZE	**Sig. (2-tailed)**	.000	.446		.750	.436	.676	.096	.427	.400
	N	19	19	19	12	18	18	19	19	19
	Pearson Correlation	.370	.029	-.103	1	.639*	-.329	.315	-.585*	.187
SOYA B.	**Sig. (2-tailed)**	.236	.928	.750		.034	.323	.319	.046	.561
	N	12	12	12	12	11	11	12	12	12
	Pearson Correlation	.480*	.120	.196	.639*	1	-.793**	.600**	-.891**	.045
L.R.S.	**Sig. (2-tailed)**	.044	.634	.436	.034		.000	.008	.000	.858
	N	18	18	18	11	18	18	18	18	18
	Pearson Correlation	-.209	.079	-.106	-.329	-.793**	1	-.261	.712**	-.025
S.I.	**Sig. (2-tailed)**	.405	.755	.676	.323	.000		.295	.001	.922
	N	18	18	18	11	18	18	18	18	18
	Pearson Correlation	.798**	.082	.393	.315	.600**	-.261	1	-.398	.284
RAINFALL	**Sig. (2-tailed)**	.000	.739	.096	.319	.008	.295		.091	.239
	N	19	19	19	12	18	18	19	19	19
	Pearson Correlation	-.401	-.189	-.194	-.585*	-.891**	.712**	-.398	1	.327
Onset	**Sig. (2-tailed)**	.089	.440	.427	.046	.000	.001	.091		.172
	N	19	19	19	12	18	18	19	19	19
	Pearson Correlation	-.019	-.093	-.205	.187	.045	-.025	.284	.327	1
Cessation	**Sig. (2-tailed)**	.939	.704	.400	.561	.858	.922	.239	.172	
	N	19	19	19	12	18	18	19	19	19

***. Correlation is significant at the 0.05 level (2-tailed).**
****. Correlation is significant at the 0.01 level (2-tailed).**

4.3.2 Regression of crop yield on rainfall pattern

The rainfall variability indices were also regressed with yield of each of the four crops. The result of the regression is presented in tables 4.6 - 4.9.

a. Regression of sorghum

A Multiple Regression Analysis for the prediction of Sorghum yield was computed with Length of the Rainy Season, Annual Total Rainfall Amount, Seasonality Index and Cessation as predictors of Sorghum yield. The result shows that a significant regression model was found **(F=7.702, P=0.002)**, indicating Annual Total Rainfall Amount as the major predictor of Sorghum accounting for 93.6% of the yield. On the other hand, Onset is found to be not a significant predictor in the multiple regression analysis of Sorghum (Table 4.6). The result also revealed that the Co-efficient of Determination (R^2) is 0.703, implying that about 70.3% of the total variation in the yield of sorghum can be accounted for by the five rainfall variability indices.

The result of this study is however contrary to findings by Muhammad (2014) and Dawha (2016) which both indicated that rainfall has no significant relationship with the yield of crops. The difference in result may either be due to differences in the agro- ecological zone as is the case to Muhammad (2014) or may be due to the differences in the number of rainfall indices measured. Nevertheless, this result is in conformity with the findings by Akinseye (2013), Umar (2012) and Danladi (2007), who reported significant positive relationship between yield of sorghum and rainfall.

Table 4.6: Regression of Sorghum

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.238	3.331		1.272	.226
	L.R.S.	-.003	.008	-.126	-.368	.719
	S.I.	-.344	1.343	-.072	-.256	.802
	RAINFALL	.001	.000	.936	4.145	.001
	Cessation	-.013	.008	-.271	-1.672	.118

a. Dependent Variable: SORGHUM

R= 0.839, R^2=0.703, F-value= 7.702 P= 0.002

b. Regression of millet and maize

Table 4.7 and 4.8 shows a Multiple Regression Analysis for the yield of Millet and Maize yields respectively, with the rainfall variability indices. The result shows that no significant regression model was found with Millet **(F= 0.450, p= 0.770)**, and Maize **(F= 1.251, P= 0.338)**, indicating that the rainfall variability indices are not predicting millet and maize yields. Similarly, the co-efficient of determination (R^2) of millet and maize yields are 0.122 and 0.278 respectively, implying that only 12.2% and 27.8% of the variation in the yield of millet and maize is accountable for by the rainfall variability indices. This is in line with the study by Muhammad (2014) which established that Millet and Maize has no significant relationship with rainfall distribution.

Table 4.7: Regression of Millet

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-2.350	5.828		-.403	.693
	L.R.S.	.016	.014	.635	1.079	.300
	S.I.	2.673	2.350	.548	1.138	.276
	RAINFALL	.000	.001	-.126	-.325	.750
	Cessation	-.005	.014	-.101	-.361	.724

a. Dependent Variable: MILLET

R= 0.349, R^2=0.122, F= 0.450, P= 0.770

Table 4.8: Regression of Maize

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	12.364	8.994		1.375	.192
	L.R.S.	-.016	.022	-.381	-.714	.488
	S.I.	-2.017	3.627	-.243	-.556	.587
	RAINFALL	.002	.001	.668	1.896	.080
	Cessation	-.030	.021	-.355	-1.402	.184

a. Dependent Variable: MAIZE

R= 0.527, R^2=0.278, F= 1.251, P= 0.338

c. Regression of soybeans

Table 4.9 presents Multiple Regression Analysis which was computed for the prediction of Soybeans yield by Annual Total Rainfall Amount, Seasonality Index, Onset and Cessation. The result shows that a significant regression model was found **(F=6.811, P=0.020)** indicating that Rainfall amount, S.I., Onset, and Cessation are good predictors of Soybeans yield. However, individual analysis of the predictions reveals that S.I. is the major predictor (B= 1.386 P= 0.013) followed by Cessation (B= 0.809, P= 0.028), then Onset (B= -2.208, P= 0.003) and finally Rainfall amount (B= -0.939, P= 0.033).

Table 4.9: Regression of Soybeans

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-24.167	9.263		-2.609	.040
	S.I.	8.614	2.461	1.386	3.500	.013
	RAINFALL	-.002	.001	-.939	-2.758	.033
	Onset	-.070	.015	-2.208	-4.697	.003
	Cessation	.105	.036	.809	2.890	.028

a. Dependent Variable: SOYA B.

R= 0.905, R^2=0.820, F= 6.811, P= 0.020

4.4 Results of the administered questionnaires

This section examines the responses from the questionnaire administration; The respondents' socio-demographic characteristics, their views or perception with regards to rainfall variability and the extent to which it affect yield of the selected crops.

4.4.1 Socio-demographic characteristics of the respondents

A total of 110 questionnaires were distributed, however, 101 were retrieved (table 4.10). The socio-demographic characteristics include gender, age distribution, educational background and occupation of the respondents.

Table 4.10: No. of Questionnaires Administered to Communities

S/No.	Communities	No. Of Questionnaires Administered	No. Of Questionnaires Retrieved
1	Daddarawa	10	10
2	Dumbulum	10	10
3	Gurun	10	09
4	Harbau	10	10
5	Kabagiwa	10	10
6	Kwandawa	10	09
7	Tatsan	10	08
8	Tsanyawa	10	10
9	Yanmamman	10	07
10	Yanganau	10	10
11	Zarogi	10	08
12	**TOTAL**	**110**	**101**

Source: Field work, 2017

a. Gender of the respondents

The outcome of the questionnaire result revealed that all the respondents were male. This is not unconnected with the fact that male are the full time and more active participants in farming activities in the study area.

b. Age distribution of the respondents

In terms of age, 26.7% are 30-40 years, 29.7% are 41-50 years, and 30.7% are between the ages of 51-60 years, while 12.9% are more than 60years (table 4.11).

Table 4.11: Age Distribution of the Respondents

Age range	**Frequency**	**Percentage (%)**
30-40	27	26.7
41-50	30	29.7
51-60	31	30.7
More than 60	13	12.9

Source: Field Work, 2017

The age distribution from the table above implied that the respondents are at the active ages, and have adequate experience to respond to the issues relating to rainfall and crop yields.

c. Educational background of respondents

With regards to educational level of the respondents, 15.8% do not have a formal education, 32.7% have a primary education, 36.6% have secondary education while 14.9% have tertiary education, as shown in table 4.12

Table 4.12: Educational Background of Respondents

Educational level	**Frequency**	**Percentage (%)**
Informal education	16	15.8
Primary education	33	32.7
Secondary education	37	36.6
Tertiary education	15	14.9

Source: Author's field work

This therefore means that majority of the respondents (84.2%) have had one form of formal education or the other, this therefore enables them to respond to the questions meaningfully.

d. Occupation of respondents

In terms of occupation, 74.3% of the respondents chose farming as their main occupation, while 25.7% have other occupation as their main occupation with farming as their secondary occupation. The other occupations include trading 4%, students 5.9% and civil servants 15.8%, as indicated in table 4.13

Table 4.13: Occupation of the Respondents

Occupation	Frequency	Percentage (%)
Student	6	5.9
Trading	4	4
Civil servant	16	15.8
Farmers	75	74.3

Source: Data Analysis

The table shows that most of the respondents (74.3%) choose farming as their main occupation, which means they are in the rightful position to respond to the topic.

Generally speaking, the socio-demographic characteristics of the respondents show that the respondents have the adequate knowledge and experience, and therefore are in the appropriate position to respond to the issues on rainfall characteristics and farming activities.

4.4.2 Perception of farmers on rainfall variability and its effects on crop yield

a. Farmers length of stay and their farm sizes

Table 4.14 shows how long the respondents have been residing in the area and how that relates with the total area cultivated. From the table, it is discovered that 63.4% of the respondents have 1-3 acres, 30.7% have 4-6acres and 5.9% have more than 7acres. This means most of the respondents have between 1-3acres.

Table 4.14: Farmers Length of Stay and their Farm Sizes

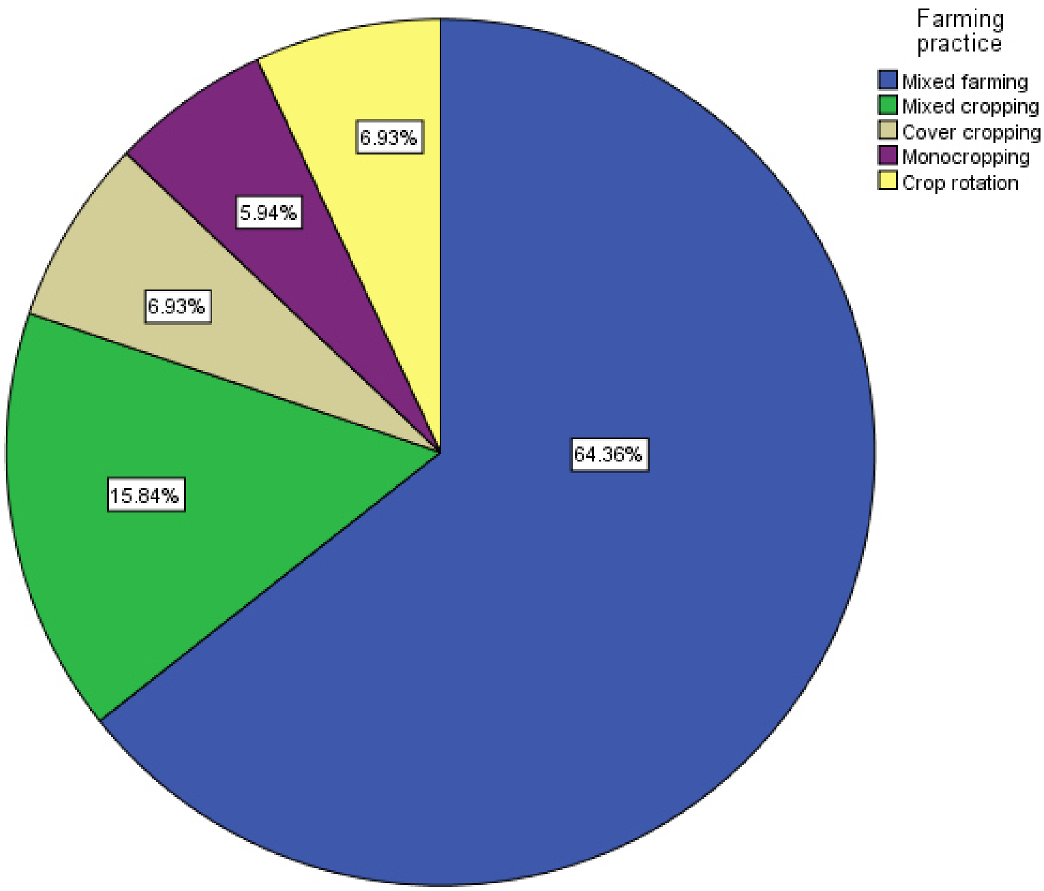
Acres	**1-3 acres**		**4-6 acres**		**More than 7 acres**		**Total**	
Length of stay	**Freq**	**%**	**Freq**	**%**	**freq**	**%**	**freq**	**%**
11-15 yrs.	7	6.9	1	1	0	0	8	7.9
16-20 yrs.	5	5	3	3	0	0	8	7.9
More than 20 yrs.	52	51.5	27	26.7	6	5.9	85	84.2
Total	64	63.4	31	30.7	6	5.9	101	100

Source: Data Analysis

It is also discovered that 7.9% of the respondents have been residing in the area for a period of 11-15 years, a similar number of 7.9% resides for 16-20 years while 84.2% resides in the area for more than 20 years. This therefore implies that all the respondents have been familiar with the study area, and this is important in getting correct and reasonable responses that is based on experience.

b. Types of farming practice

Fig. 4.7 presents the respondents' views on types of farming practices. Most of the respondents (64.4%) practiced mixed farming, 15.9% practice mixed cropping, while 6.9% practice cover cropping, 5.9% mono cropping and 6.9% crop rotation.



Source: Data Analysis

Fig. 4.7: Farming Practices Adopted by Farmers

This therefore means that farmers in the study area adopted the practice of cultivating many crops and rearing of animals at a time.

c. Nature of rainfall and yield

Table 4.15 and 4.16 present the perception of farmers on whether there is change in the rainfall amount, the nature of change in the amount and number of rainy days per annum over the past 20 years.

Table 4.15: Change in the Rainfall Amount and Number of Rain Days

		Have you noticed a change in the rainfall amount?					
		Yes		No		No response	
		N	%	Count	Column N %	Count	Column N %
What is the nature of rain days per annum in the last 20 years?	Increasing	17	17.5%	0	0.0%	0	0.0%
	Decreasing	38	39.2%	0	0.0%	0	0.0%
	No response	42	43.3%	0	0.0%	4	100.0%
	Subtotal	97	100.0%	0	0.0%	4	100.0%

Source: Field work, 2017

Table 4.16: Nature of Change in the Rainfall Amount

		Have you noticed a change in the rainfall amount?					
		Yes		No		No response	
		Count	Column N %	Count	Column N %	Count	Column N %
What is nature of change in rainfall amount	There is increase in rainfall	8	8.2%	0	0.0%	0	0.0%
	There is decrease in rainfall	9	9.3%	0	0.0%	0	0.0%
	Rainfall is fluctuating	80	82.5%	0	0.0%	0	0.0%
	No response	0	0.0%	0	0.0%	4	100.0%
	Subtotal	97	100.0%	0	0.0%	4	100.0%

Source: Field work, 2017

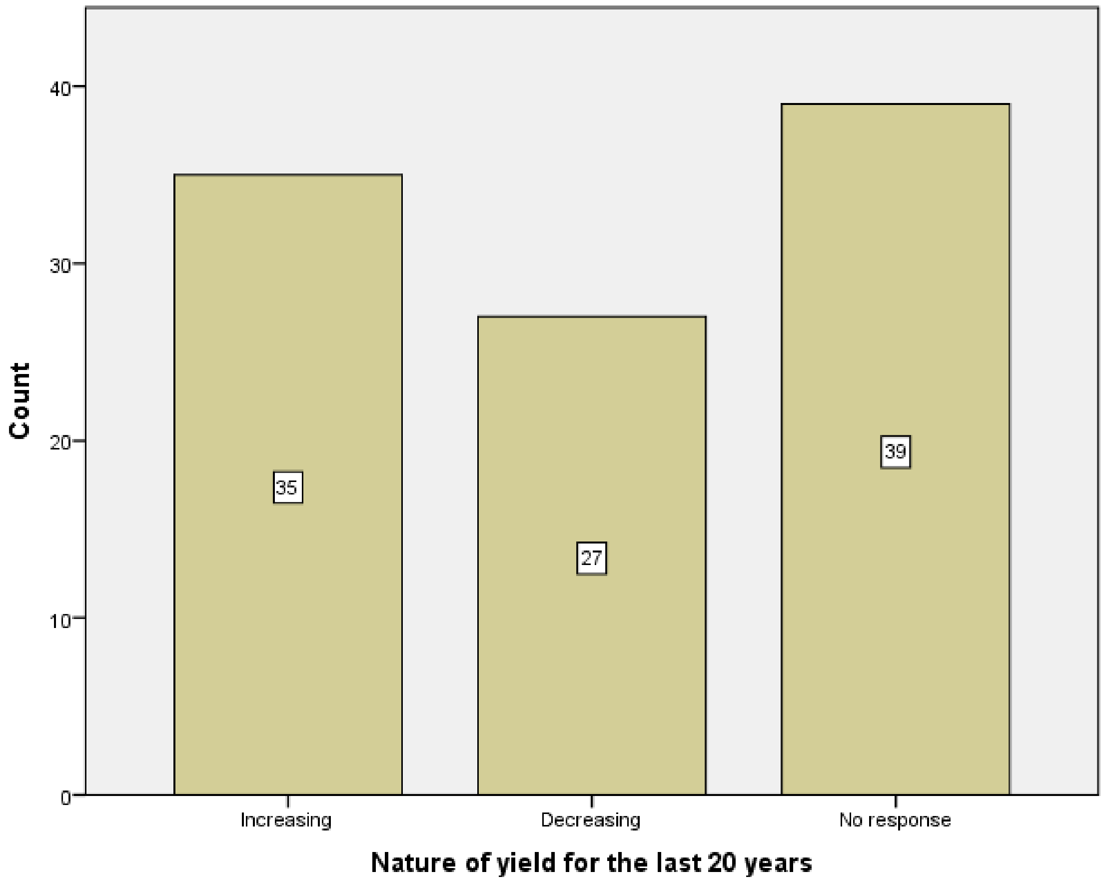
Table 4.15 indicated that 96% of the entire respondents indicated that they have noticed a change in the annual total rainfall amount over the last 20 years while the remaining 4% did not respond. Table 4.16 explains further the perception of respondents on the nature of change in the rainfall amount. 7.9% believed that rainfall amount is increasing over the past 20 years, 8.9% are of the opinion that the amount is decreasing, while 79.2% of the respondents says that the rainfall amount is fluctuating, 4% did not respond. Similarly, 16.8%

of the respondents are of the opinion that the number of rain days is increasing, 37.6% believed it is decreasing, while 45.6% did not respond.

Thus, the response in table 4.15 and 4.16 implies that majority of the respondents (96%) agrees that the rainfall amount is changing over years, and that the nature of change is fluctuating according to 79.2%. However, the respondents are not sure of whether the number of rainy days is increasing or decreasing as many of them (45.6%) did not respond. This is because farmers do not keep rainfall records over years.

Fig. 4.8 shows the nature of yield for the last 20 years. 34.7% indicated an increasing yield, 26.7% indicated a decreasing yield while 38.6% did not respond. This means there is no uniform pattern of trend in the yield of crops, but rather it fluctuates over years. There is also variation in the yield of each crop type by individual farmers due to variation in farming practices adopted by the individual farmers.

Similarly, table 4.17 indicated that 58.4% of the respondents agreed that there is change in the yield over years and that the change in the yield is due to changes in rainfall pattern, 1% are of the opinion that the change in the yield is not caused by change in rainfall pattern but by other factors, while 40.6% of the respondents did not respond to the question.



Source: Data analysis

Fig. 4.8: The Nature of Yield for the Last 20 years

Table 4.17: Is Change in Yield due to Changes in Rainfall Pattern?

		Is change in yield due to change in rainfall pattern?					
		Yes		No		No response	
		Count	Column N %	Count	Column N %	Count	Column N %
Nature of yield for the last 20 years	Increasing	34	57.6%	1	100.0%	0	0.0%
	Decreasing	25	42.4%	0	0.0%	2	4.9%
	No response	0	0.0%	0	0.0%	39	95.1%
	Subtotal	59	100.0%	1	100.0%	41	100.0%

Source: Data analysis

According to the responses in table 4.18, 58.4% of the respondents in the study area believed that changing rainfall pattern causes decrease in yield of crops, only 1% says change in rainfall pattern does not affect crop yield in the area, while 40.6% did not respond.

Table 4.18: Effect of Change in Rainfall Pattern on Crop Yield

		Is change in yield due to change in rainfall pattern?					
		Yes		No		No response	
		Count	Column N %	Count	Column N %	Count	Column N %
Effect of change in rainfall pattern on crop yield	There is increase in yield	0	0.0%	0	0.0%	0	0.0%
	There is decrease in yield	59	100.0%	0	0.0%	0	0.0%
	There is no change in yield	0	0.0%	1	100.0%	0	0.0%
	No response	0	0.0%	0	0.0%	41	100.0%
	Subtotal	59	100.0%	1	100.0%	41	100.0%

Source: Data analysis

4.5 Comparison between established relationship and perception of farmers on rainfall-crop yield relationship

1.) Analysis of rainfall data indicated that rainfall in the study area is variable in terms of amount, onset, cessation, length of the rainy season and seasonality index. This is in conformity with the perception of farmers, as 96% of the respondents agreed with variability in rainfall in the study area, and 79.2% believe that the nature of this change is neither decreasing nor increasing but rather it is fluctuating. However, contrary to the perception of farmers and to some findings is that there is an increase in rainfall amount and length of rainy season over years in the study area.

2.) Similarly, the analysis of crop yield data revealed that the yield of the four crops is variable over the years. But the linear trend line generally indicated a sharp increase in the yield of maize, a gradual increase in the yield of sorghum and soybeans and a decline in the yield of millet. This finding is also similar to the perception of farmers on the trend in the yield of crops over the years, as 34.7 of respondents reported an increase in the yield, 26.7 reported a decrease while 38.6 did not responded. This therefore means that the crop yield varies and fluctuates depending on the crop type and individual differences in farmers' treatment.

3.) The rainfall and crop yield data were correlated and regressed, and the result revealed that there is significant relationship between rainfall and yield of sorghum and soybeans crops, while yield of millet and maize has no significant relationship with rainfall indices. Farmers on their part believe that changing rainfall pattern affect yield of crops. 58.4% agreed that the change in rainfall pattern causes decrease in the yield while 40% did not respond because according to them, there are many other factors affecting crop yields.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

This chapter contains the general summary of the research work, conclusion and recommendations.

5.1 **Summary of findings**

Climate change is perhaps the most serious environmental threat to agricultural production in Nigeria. The direct impact of climate change on agricultural systems are: changes in rainfall and temperatures which could impact on agro-climatic conditions, altering growing seasons, planting and harvesting calendars, water availability, pest, weed and diseases populations and land suitability for agricultural production (Saul, 2015).

The aim of this study is to explain the extent to which rainfall variability determine crop yield in the study area. Daily rainfall data and yield of four selected crops; sorghum, millet, maize and soybeans for 20 years (1995-2014) was sourced from the local government agricultural and meteorological units and state office of KNARDA. Questionnaire was also used to get additional information on rainfall-crop yield relation. Descriptive statistics, time-series graphs, correlation and regression analysis were used to analyze the data with the help of SPSS and Microsoft Excel software programmes.

The research work for this study established that rainfall is variable in the study area over years. The highest rainfall value over the period of the study was 1529.5mm which was in 2011 whereas the lowest rainfall value was 809.9mm in 2001 (table 4.1). The linear trend line in the time-series graph (fig. 4.1) generally revealed that the study area is gradually becoming wetter due to increase in the annual rainfall amount over recent years. Similarly, the linear trend lines shows that the trend in the onset dates is declining whereas the cessation dates is increasing, this therefore means that the study area is gradually experiencing early onset and late cessation, and consequently increased Length of the rainy season (fig. 4.2, 4.3 and 4.4). The result of the computation of Seasonality Index (S.I.) revealed that the study area has fallen in a zone where most of the rain is in 3 months or less. The linear trend line in the S.I. graph indicates gradual shortening in the spread and steadiness of rainfall in the study area, and this is confirmed by the negative best fit line equation fig. (4.5).

The trend analysis in the yield of crops in fig. (4.6) revealed that the yield of sorghum, maize and soybeans are on the increase, while the yield of millet is gradually decreasing over the years, as indicated by the linear trend line. The descriptive statistics in the yield of crops shows that the variability in the yield across the years is moderate, as indicated by the co-efficient of variability of sorghum, millet, maize and soybeans which is 0.21, 0.29, 0.29 and 0.27 respectively.

The result of correlation analysis between yield of crops and rainfall indices (table 4.5) revealed that significant relationship was found between yield of sorghum and L.R.S. and Annual Total Rainfall Amount at 5% and 1% level of significance respectively, while sorghum yield shows no significant relation with the other rainfall indices. The finding of the study however shows that there is no significant relationship between yield of millet and maize with rainfall indices. The result further indicated that a moderate positive correlation was found between yield of soybeans and L.R.S. at 5% level of significance and a negative correlation between yield of soybeans and onset.

A Multiple Regression Analysis for the prediction of yield of sorghum, millet, maize and soybeans was computed, and the result indicated that a significant regression model was found with the yield of sorghum and soybeans, whereas yield of millet and maize shows no significant regression model. This means rainfall indices play a significant role in predicting the yield of sorghum and soybeans but do not play any significant role in the prediction of yield of millet and maize.

The result of the questionnaire administration shows that most of the farmers (96%) believe that rainfall is variable over years. Similarly, about 58.4% of the respondents also agreed that there is decrease in the yield of crops over the years due to rainfall variability.

5.2 Conclusion

The findings of this study revealed that rainfall in the study area is variable over years in terms of its amount, Onset, Cessation, Length of the Rainy Season and Seasonality Index, and that this variability significantly determine the yield of sorghum and soybeans but do not play any significant role in the determination or prediction of millet and maize yield.

5.3 Recommendations

Based on the findings of this study, the following recommendations are advanced:

1. Agricultural yield data for crops should be properly and reliably documented in order to have more effective future researches on the effect of climate variability on agriculture.
2. There is the need for accurate climatic data of the area especially that of the microclimate as it affects crop production more directly.
3. There is need to ensure that accurate weather forecasting devices are provided and more meteorological stations established in rural areas by Ministries of Agriculture, the Agricultural Development Authorities such as KNARDA and various research institutes, and ensure that the information derived from these stations be made available to farmers. This will help guide them in their agricultural activities for

proper and effective adaptation strategies, this can also go a long way in improving farming activities.

4. Agricultural extension workers need to be empowered through better training in order to function more effectively, this is because of the significant role they play in improving farm productivity. They are trained to link farmers with scientists working on how to improve farm operations. They also help farmers to deal with difficulties that they may have on the field. They may also be relevant in providing weather information based on local and indigenous knowledge, and information about adaptive efforts that are working elsewhere.
5. Farmers should also be enlightened by extension workers on the microclimates of their areas and how it affects crop production. This will allow them understand when and how to plant.
6. The study area does not have access to irrigation infrastructure despite the irrigation projects in the state. Expansion of irrigation facilities will therefore go a long way in reducing or possibly completely eliminating crop failures due to rainfall variability. The project of constructing dam at Yanganau initiated by the Federal Government more than 10 years ago should therefore be completed for full utilization. This will also provide the farmers with the opportunity to produce even during the dry season.

7. The incidence of pest and diseases particularly during dry spells affect to a great extent yield of crops and the entire farming operations. This is further exacerbated by the fact that farmers do not always have access to safe and effective pesticides, robust varieties of plants/seeds and adequate irrigation facilities. The government can do well by assisting the farmers with these necessary inputs at affordable rate.

8. It is recommended that future researches should be to broaden the scope of this study so as to encompass other climatic variables such as temperature, dry spell, wind etc and their interactions with other environmental variables such as nutrient availability, soil type, variety or cultivar of crops, modern agric. techniques used by farmers, etc.

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APPENDICES

APPENDIX I:

QUESTIONNAIRE

Dear Respondent,

I am a post graduate student of the Department of Geography, Bayero University, Kano. I am currently undertaking a research/study titled: "***EFFECTS OF RAINFALL VARIABILITY ON YIELD OF SOME SELECTED EARLY MATURING CROPS IN TSANYAWA LOCAL GOVERNMENT AREA, KANO STATE***." This study is intended purely for academic purpose.

I shall be grateful if you kindly provide information on the questions below to help in the realization of the objectives of the study.

Thank you.

1 Name of the area [ward/village]..

2 Gender : male[ ] female[ ]

3 Age : 30-40[ ] 40-50[ ] 50-60[ ] Above 60[ ]

4 Educational qualification :
No formal education [ ]
Primary education [ ]
Secondary education [ ]
Tertiary education [ ]

5 Occupation :
Student [ ] Trading/Business [ ] Civil servant [ ] Farmer [ ]
Others (please specify) [ ]

6 For how long have you lived here?
<5years [ ] 5-10years [ ] 10-15years [ ] 15-20years [ ] >20years [ ]

7 How many farm plots do you cultivate?..................................

8 What is the total area cultivated?..

9 For how long have you being cultivating crops? <10years[ ] 10-20years[ ] >20years[ ]

10 List the three most important farming practices you employ:

- ....
- ....
- ....

11 List the five major crops you cultivate:
....
....

12 Give reasons why you cultivate these crops:
....
....
....

13 What are the planting and harvesting periods for the crops you cultivate?

S/N	C r o p	Planting Period	Harvesting Period
1 .			
2 .			
3 .			
4 .			
5 .			

14 Do you know what rainfall variability is?
Yes [ ] No [ ] No response [ ]
Rainfall variability involves shifts from the normal pattern of rainfall in terms of amount, frequency, intensity, start and end of rainy season over years.

15 Do you think rainfall is variable over years?
Yes [ ] No [ ] No response [ ]

16 If yes, why do you think so?
....
....
....

17 Have you noticed rainfall variability over years in your area?
Yes [ ] No [ ] No response [ ]

18 Have you noticed any change in the onset of rainfall in your area?
Yes [ ] No [ ] No response [ ]

19 If yes, what is the change?
The rainfall starts early and stops early [ ]
The rainfall starts early and stops late [ ]
The rainfall starts late and stops early [ ]
The rainfall starts late and stops late [ ]

20 Have you noticed change in rainfall amount in your area?
Yes [ ] No [ ] No response [ ]

21 If yes, what is the change in the rainfall amount as compared to the past?
- There is increase in rainfall [ ]
- There is decrease in rainfall [ ]
- The rainfall amount is fluctuating [ ]
- No response [ ]

22 Is the number of rain days per year increasing or decreasing over the past 20years?
Increasing [ ] Decreasing [ ] No response [ ]

23 Are the types of crops grown the same over the past 20years?
Yes [ ] No [ ] No response [ ]

24 If no, what are the changes?

S/N	Crops grown in the past	Crops grown now
1 .		
2 .		
3 .		
4 .		
5 .		

25 Is the yield of the crops increasing or decreasing over the last 20years?
Increasing [ ] Decreasing [ ] No response [ ]

26 Is there any change in the yield of crops due to changes in the rainfall pattern?
Yes [ ] No [ ] No response [ ]

27 If yes, how do changes in the rainfall pattern affect the crop yields?

- There is an increase in the crop yields [ ]
- There is a decrease in the crop yields [ ]
- There is no change in the yield of crops [ ]
- No response [ ]

28 In the last 20years, list the years with the highest and lowest crop yield for each of the major crops you cultivate/grow :

S/N	C r o p	Year with highest yield	Year with lowest yield
1 .			
2 .			
3 .			
4 .			
5 .			

29 How do you respond to possible changes in rainfall characteristics in your area?

APPENDIX II

Regression of sorghum

```
[DataSet1] C:\Users\abdullahibawa\Documents\Untitled1.sav
```

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Cessation, S.I., RAINFALL, L.R.S.[b]	.	Enter

a. Dependent Variable: SORGHUM

b. Tolerance = .000 limits reached.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.839[a]	.703	.612	.22645

a. Predictors: (Constant), Cessation, S.I., RAINFALL, L.R.S.

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	1.580	4	.395	7.702	.002[b]
	Residual	.667	13	.051		
	Total	2.246	17			

a. Dependent Variable: SORGHUM

b. Predictors: (Constant), Cessation, S.I., RAINFALL, L.R.S.

Excluded Variables[a]

Model		Beta In	T	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	Onset	.[b]	.	.	.	.000

a. Dependent Variable: SORGHUM

b. Predictors in the Model: (Constant), Cessation, S.I., RAINFALL, L.R.S.

```
REGRESSION
/DESCRIPTIVES MEAN STDDEV CORR SIG N
/MISSING LISTWISE
/STATISTICS COEFF OUTS R ANOVA
/CRITERIA=PIN(.05) POUT(.10)
/NOORIGIN
/DEPENDENT millet
/METHOD=ENTER LRS SI Rainfall Onset Cessation.
```

Regression of Millet

[DataSet1] C:\Users\abdullahibawa\Documents\Untitled1.sav

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Cessation, S.I., RAINFALL, L.R.S.[b]	.	Enter

a. Dependent Variable: MILLET

b. Tolerance = .000 limits reached.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.349[a]	.122	-.148	.39625

a. Predictors: (Constant), Cessation, S.I., RAINFALL, L.R.S.

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	.283	4	.071	.450	.770[b]
	Residual	2.041	13	.157		
	Total	2.324	17			

a. Dependent Variable: MILLET

b. Predictors: (Constant), Cessation, S.I., RAINFALL, L.R.S.

Excluded Variables[a]

Model		Beta In	T	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	Onset	.[b]	.	.	.	.000

a. Dependent Variable: MILLET

b. Predictors in the Model: (Constant), Cessation, S.I., RAINFALL, L.R.S.

```
REGRESSION
/DESCRIPTIVES MEAN STDDEV CORR SIG N
/MISSING LISTWISE
/STATISTICS COEFF OUTS R ANOVA
/CRITERIA=PIN(.05) POUT(.10)
/NOORIGIN
/DEPENDENT maize
/METHOD=ENTER LRS SI Rainfall Onset Cessation.
```

Regression of Maize

```
[DataSet1] C:\Users\abdullahibawa\Documents\Untitled1.sav
```

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Cessation, S.I., RAINFALL, L.R.S.[b]	.	Enter

a. Dependent Variable: MAIZE

b. Tolerance = .000 limits reached.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.527[a]	.278	.056	.61152

a. Predictors: (Constant), Cessation, S.I., RAINFALL, L.R.S.

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	1.871	4	.468	1.251	.338[b]
	Residual	4.861	13	.374		
	Total	6.732	17			

a. Dependent Variable: MAIZE

b. Predictors: (Constant), Cessation, S.I., RAINFALL, L.R.S.

Excluded Variables[a]

Model		Beta In	T	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	Onset	.[b]	.	.	.	.000

a. Dependent Variable: MAIZE

b. Predictors in the Model: (Constant), Cessation, S.I., RAINFALL, L.R.S.

```
REGRESSION
/DESCRIPTIVES MEAN STDDEV CORR SIG N
/MISSING LISTWISE
/STATISTICS COEFF OUTS R ANOVA
/CRITERIA=PIN(.05) POUT(.10)
/NOORIGIN
/DEPENDENT soya
/METHOD=ENTER LRS SI Rainfall Onset Cessation.
```

Regression of soybeans

```
[DataSet1] C:\Users\abdullahibawa\Documents\Untitled1.sav
```

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Cessation, Onset, RAINFALL, S.I.[b]	.	Enter

a. Dependent Variable: SOYA B.

b. Tolerance = .000 limits reached.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.905[a]	.820	.699	.26890

a. Predictors: (Constant), Cessation, Onset, RAINFALL, S.I.

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	1.970	4	.493	6.811	.020[b]
	Residual	.434	6	.072		
	Total	2.404	10			

a. Dependent Variable: SOYA B.

b. Predictors: (Constant), Cessation, Onset, RAINFALL, S.I.

Excluded Variables[a]

Model		Beta In	T	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	L.R.S.	.[b]	.	.	.	.000

a. Dependent Variable: SOYA B.

b. Predictors in the Model: (Constant), Cessation, Onset, RAINFALL, S.I.

```
GET
FILE='C:\Users\abdullahibawa\Documents\Untitled1.sav'.
DATASET NAME DataSet1 WINDOW=FRONT.
```

APPENDIX III
JULIAN DATE CALENDAR PERPETUAL

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Day
1	001	032	060	091	121	152	182	213	244	274	305	335	1
2	002	033	061	092	122	153	183	214	245	275	306	336	2
3	003	034	062	093	123	154	184	215	246	276	307	337	3
4	004	035	063	094	124	155	185	216	247	277	308	338	4
5	005	036	064	095	125	156	186	217	248	278	309	339	5
6	006	037	065	096	126	157	187	218	249	279	310	340	6
7	007	038	066	097	127	158	188	219	250	280	311	341	7
8	008	039	067	098	128	159	189	220	251	281	312	342	8
9	009	040	068	099	129	160	190	221	252	282	313	343	9
10	010	041	069	100	130	161	191	222	253	283	314	344	10
11	011	042	070	101	131	162	192	223	254	284	315	345	11
12	012	043	071	102	132	163	193	224	255	285	316	346	12
13	013	044	072	103	133	164	194	225	256	286	317	347	13
14	014	045	073	104	134	165	195	226	257	287	318	348	14
15	015	046	074	105	135	166	196	227	258	288	319	349	15
16	016	047	075	106	136	167	197	228	259	289	320	350	16
17	017	048	076	107	137	168	198	229	260	290	321	351	17
18	018	049	077	108	138	169	199	230	261	291	322	352	18
19	019	050	078	109	139	170	200	231	262	292	323	353	19
20	020	051	079	110	140	171	201	232	263	293	324	354	20
21	021	052	080	111	141	172	202	233	264	294	325	355	21
22	022	053	081	112	142	173	203	234	265	295	326	356	22
23	023	054	082	113	143	174	204	235	266	296	327	357	23
24	024	055	083	114	144	175	205	236	267	297	328	358	24
25	025	056	084	115	145	176	206	237	268	298	329	359	25
26	026	057	085	116	146	177	207	238	269	299	330	360	26
27	027	058	086	117	147	178	208	239	270	300	331	361	27
28	028	059	087	118	148	179	209	240	271	301	332	362	28
29	029		088	119	149	180	210	241	272	302	333	363	29
30	030		089	120	150	181	211	242	273	303	334	364	30
31	031		090		151		212	243		304		365	31

FOR USE IN 1995, 1997, 1998, 1999, 2001, 2002, 2003, 2005, 2006, 2007, 2009, 2010, 2011, 2013 and 2014.

JULIAN DATE CALENDAR
FOR LEAP YEARS ONLY

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Day
1	001	032	061	092	122	153	183	214	245	275	306	336	1
2	002	033	062	093	123	154	184	215	246	276	307	337	2
3	003	034	063	094	124	155	185	216	247	277	308	338	3
4	004	035	064	095	125	156	186	217	248	278	309	339	4
5	005	036	065	096	126	157	187	218	249	279	310	340	5
6	006	037	066	097	127	158	188	219	250	280	311	341	6
7	007	038	067	098	128	159	189	220	251	281	312	342	7
8	008	039	068	099	129	160	190	221	252	282	313	343	8
9	009	040	069	100	130	161	191	222	253	283	314	344	9
10	010	041	070	101	131	162	192	223	254	284	315	345	10
11	011	042	071	102	132	163	193	224	255	285	316	346	11
12	012	043	072	103	133	164	194	225	256	286	317	347	12
13	013	044	073	104	134	165	195	226	257	287	318	348	13
14	014	045	074	105	135	166	196	227	258	288	319	349	14
15	015	046	075	106	136	167	197	228	259	289	320	350	15
16	016	047	076	107	137	168	198	229	260	290	321	351	16
17	017	048	077	108	138	169	199	230	261	291	322	352	17
18	018	049	078	109	139	170	200	231	262	292	323	353	18
19	019	050	079	110	140	171	201	232	263	293	324	354	19
20	020	051	080	111	141	172	202	233	264	294	325	355	20
21	021	052	081	112	142	173	203	234	265	295	326	356	21
22	022	053	082	113	143	174	204	235	266	296	327	357	22
23	023	054	083	114	144	175	205	236	267	297	328	358	23
24	024	055	084	115	145	176	206	237	268	298	329	359	24
25	025	056	085	116	146	177	207	238	269	299	330	360	25
26	026	057	086	117	147	178	208	239	270	300	331	361	26
27	027	058	087	118	148	179	209	240	271	301	332	362	27
28	028	059	088	119	149	180	210	241	272	302	333	363	28
29	029	060	089	120	150	181	211	242	273	303	334	364	29
30	030		090	121	151	182	212	243	274	304	335	365	30
31	031		091		152		213	244		305		366	31

FOR USE IN 1996, 2000, 2004, 2008 AND 2012.