PRECIPITATION EFFECTIVENESS INDICES AND MILLET YIELD IN TWO LOCAL GOVERNMENT AREAS OF KANO STATE, NIGERIA

BY

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

NOVEMBER, 2012

DECLARATION

I hereby declare that the work in this thesis entitled Precipitation Effectiveness Indices and Millet Yield in Kano State has been written by me in the Department of Geography under the supervision of Professor E. O. Iguisi, Dr. B.A. Sawa and Dr. A. A. Ibrahim. The information derived from the literature has been dully acknowledged in the text and list of references.

This work has not been previously presented in any form for the award of any degree or diploma at Ahmadu Bello University, Zaria or any other institution.

……..	…….	……
Danladi Bello	Signature	Date

CERTIFICATION

This thesis entitled Precipitation Effectiveness Indices and Millet Yield in Kano State, Nigeria is a thesis by Danladi Bello has been read and approved for its contribution to knowledge and literary presentation as meeting the requirement for the award of Master of Science Degree in Geography of the (Ahmadu Bello University, Zaria-Nigeria).

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DEDICATION

This thesis is dedicated to my late father, Mal. Ibrahim Bello, Late Malam Lawan Bello and my mother, Aisha Idris.

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ABSTRACT

This thesis is about precipitation effectiveness indices and millet yield in two local Government Areas of Kano state. This study is aim on the following specific objective: To determine the major precipitation effectiveness parameters that influence millet yield in the two study areas, to determine the relationship between the derived precipitation effectiveness indices and millet yield for the two stations and determine the combined effects to the climatic elements on millet yield to the two stations. For the purpose of this research two sets of data are required. Daily rainfall records (mm) and millet yield data (kg/ha), from 1988-2007. The data were sourced from Kano Agricultural and Rural Development Authority (KNARDA) and Hadejiajama're River Basin Development Authority (HJRBDA). This recommends the practice of using the multiple regression analysis when subjecting the climate crop yield relationship for each climate element separately. The results obtained shows that the coefficients of the four variables are significant in the analysis. The variables are: total rainfall, hydrologic ratio, length of the rainy season, and onset dates of rains. The four variables account for 62.% of the variation in the yield of millet at Kura. While at Dambatta the four variables account for 73.5% of the variation in the yield of millet. The study also recommends. The following measures: application of fertilizer to improve soil fertility and productivity, the use of modern agricultural techniques to boost crop yield and application of insecticides to reduce the effects of pest on crops.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND TO THE STUDY

The term precipitation effectiveness has been interpreted differently not only by specialists in different fields, but also by different workers in the same field (FAO, 2003). The individual farmer considers precipitation effectiveness as that quantity of water which is useful in raising crops planted on his soil, under his management. Water which moves out of the field by run off or by deep percolation beyond the root zone of the crops is ineffective. The other hand, his field receives run off from out side high level surroundings, then it may add to the moisture and it may be useful for crop production consequently farmer with different crops will arrive at different values in assessing precipitation effectiveness.

Precipitation effectiveness is that portion of total precipitation used to satisfy vegetation need; that is the actual available precipitation used in plant development (American Meteorological Society, 2009). Availability is affected by such factors as precipitation intensity, seasons, temperature, ground cover etc (Holiness, 1991).

Precipitation effectiveness is defined as water requirement of a crop, that is the amount of water needed to raise it and this includes water to meet both consumptive and special needs such as land preparation, land submergence, leaching and so on (Forbes and Watson, 1992). Cooper (1990) defines precipitation effectiveness as that portion of total annual or seasonal rainfall which is useful directly and or indirectly for crop production to the site where it falls. Agriculturalists may consider precipitation effectiveness as that portion of the total rainfall which directly satisfies, crop water needs.

Having seen the different interpretations of the concept of precipitation effectiveness, the researcher is in agreement with the concept of precipitation effectiveness that is given by the agriculturalists, because precipitation effectiveness serves as an important factor in determining the ultimate yield of any crop under rainfed agriculture.

Millet (Penisetum Setaria) and Sorghum (Penicumsp) rank third after wheat and rice among the world most important food grains. Wheat, rice and maize are grain commodities in

international commerce. These crops are also extensively researched for the purpose of increasing yield. However, millet has received much less attention, except in the USA and West African countries where it is primarily produced for livestock and direct consumption by the poor people who grow it. More information is needed about the requirement for growing millet (Denddy, 1995).

The International Crop Research Institute for the Semi Arid Tropics (ICRISAT) established by the Consultative Group on International Agricultural Research (CGIAR) and more recently the Internal Sorghum/Millet Research (INSORMIC) funded by United States Agency for International Development (USAID) are two major programmes divided in scope, that are directed towards improving millet production.

Millet is suited to hot and dry agro-ecologies where it is difficult to grow other grain crops. There has been appreciable increase in the land area and output of millet with the establishment of Agricultural Development Projects in Nigeria in general and in particular Kano Agricultural and Rural Development Agency (KNARDA, 2008). This increase could be attributed to advances in agricultural technology such as the introduction of high yielding varieties, application of fertilizers and provision of services such as seminars and workshop to the rural farmers, provision of agricultural facilities and seeds for the farmers. (KNARDA, 1995).

However, despite the advanced techniques used in crop husbandry the yield of millet is still variable. Precipitation effectiveness indices are the major controls of crop yield in the tropical savanna region (Sarker, 2002). Millet is believed to have descended from West African wild grass which was domesticated more than 40, 000 years ago (National Research Council, 1996). It spread from West African to East Africa and then to India. Today millet is a staple food for more than 500 million people. Areas planted with millet are estimated at 15 million hectares annually in Africa and 14 million hectares in Asia. Global production exceeds 10 million tones a year (National Research Council, 1996). The food value of millet is high. Trials in India have shown that millet is nutritionally more superior to maize and rice for human growth. The protein content of millet is higher than maize and has a relatively high vitamin A content (Gallagher, 1984)

1.2 STATEMENT OF THE RESEARCH PROBLEM

Millet is an important staple food crop as well as major raw material for livestock feeds in

the world. In order for the grain supply to sustain livestock industries while still meeting the demand for its direct consumption as food, yield per hectare needs to be improved. Such an improvement could be achieved in part through efficient management of agro-climatological factors.

Several studies have been conducted towards improving the yield of millet in the study area through breeding of high yielding varieties, pest and diseases resistant varieties improved yield and cultural practices of weeding and fertilization. Auwalu (1996) examined seed dressing before planting in which the result shows that farmers have neglected seed dressing before planting. The researcher suggested that seed dressing before plating is important for seed germination and also to prevent seeds from decay. Gazali (1991) studied harvesting and storage techniques of millet in Katagum. The result of the study reveals that farmers are ignorant of the modern techniques of millet storage and recommended that farmers are to employ new modern techniques of storage, so that the millet will not be destroyed. Tanimu (2003) studied people's perception towards accepting high yielding and pest resistant varieties of millet. And the result of the study show that only very few farmers are using insecticide. The author suggested that farmers should apply insecticide on their millet in order to have protection against pests and diseases. KNARDA (1993) conducted a research on short term maturing varieties of millet in Kano state. The result of the study showed that farmers are to accept new short term maturing varieties of millet. KNARDA (1993) suggested that farmers should use new varieties rather than the old varieties. Adebayo (2000) carried out a research on agro-climatic classification of Adamawa state, Nigeria for upland rice production. The study identified four critical climatic parameters influencing upland rice in Adamawa state. The parameters include hydrologic ratio, onset dates of rain, number of dry pentades during the growing season and rainfall amount in June.

Adebayo and Adebayo (1996) carried out similar studies on precipitation effectiveness and upland rice yield in Adamawa state. The findings underscored the importance of precipitation effectiveness indices as critical factors controlling crop yield in the state in particular and in the West African savanna environment in general. Adebayo (1997) studied the application of agro climatology to agricultural planning in Adamawa state, Nigeria. The study has provided to date, the first detailed information on precipitation effectiveness indices in rice production in Adamawa state. It also

provides a base line data and maps for grassroots agricultural planning in the state. Olaniran and Babatolu (1987) conducted a research on effect of climate on sorghum in Nigeria. The study has shown that fluctuations in air temperature conditions during the vegetative and grain filling periods and in rainfall supply condition, during the pre-sowing and vegetative growth periods account for 79.87% of the variability in sorghum yield in the station. Abdulhamid and Giade (2007) carried out a research on the influence of precipitation effectiveness indices on growth and yield of sorghum in Katagum, Bauchi state, Nigeria. The study revealed that precipitation effectiveness parameters are most critical factors affecting the yield of sorghum in the area.

Despite these however, not much attention has been paid to climatic variables as they affect millet yield over time in the study area. It is not the total amount of rainfall that matters, but how effective the rain is in terms of its time of occurrence in the area, spread, intensity, frequency and availability as soil moisture. It is against this background that this research examines the relationship between precipitation effectiveness indices such as onset, cessation, length of the rainy season, rainfall in the growing season of (May, June, July, August and September), hydrologic ratio, seasonality index and millet yield over a period of twenty years (1988-2007).

1.3 RESEARCH QUESTIONS

For the purpose of this research the following research questions are set. These are:

i. **What are the major precipitation effectiveness parameters that influence millet yield in the study area?**
ii. **What is the relationship between the derived indices and millet yield in the study area?**
iii. **What is the combined effect of the climatic elements on millet yield of the study area (Kura and Dambatta)?**
iv. **What are the implications of millet farming to the farmer in the study area?**

1.4 AIM AND OBJECTIVES OF THE STUDY

This study aims at relating precipitation effectiveness indices to millet yield in Kano state. The parameters include onset dates of rains, cessation dates of rains, length of the rainy season, rainfall amount in the growing season (May, June, July, August and September), hydrologic ratio, total rainfall and seasonality index. This aim is predicated on the following specific objectives:

i. **To determine the major precipitation effectiveness parameters that influence millet yield in the state.**

ii. **To determine the relationship between the derived precipitation effectiveness indices and millet yield for the two stations.**

iii. **To determine the combined effects of the climatic elements on millet yield of the two stations.**

iv. **To suggest ways of improving millet farming in the study areas.**

1.5 JUSTIFICATION OF THE STUDY

Previous studies on millet in the study area tend to focus more on variety selection, application of fertilizers, pest and diseases control and storage methods.

Based on literature review, research in the study area covers the whole state and some neighboring areas. However, this is a unique study on two areas that produce millet in the state. In addition, the two areas are the only places where consistent data on rainfall and millet yield can be obtained, because of the presence of the College of Agriculture Dambatta, HadejiaJama'are River Basin Development Authority and Kano Agricultural and Rural Development Authority training school (KNARDA) at Kura.

Therefore, a study of this nature is necessary to fill the gap existing in the knowledge of agro-climatology of millet production in the state. It is conceivable therefore, that given enough information on climatic parameters; it is possible to deduce a simple relationship between crop yield and climatic parameters. Such information will be useful in selecting suitable crop variety for the various sites and determination of farm calendar.

1.6 SCOPE OF THE STUDY

The study covers two local government areas (Kura and Dambatta) of the Forty Four Local Government Areas of Kano. These are the only places where consistent daily rainfall record and millet yield data are kept and can be obtained. The precipitation parameters include onset dates of rains, cessation dates of rains, length of the rainy season, rainfall amount in the growing season (May, June, July, August and September), hydrologic ratio, total rainfall and seasonality index.

Twenty years of daily rainfall and yield data for the period (1988-2007) were sourced from

the teaching and research farm experimental plots of Kano Agricultural and Rural Development Authority and Hadejia Jama'are River Basin Development Authority for this study.

1.7 ORGANIZATION OF THE STUDY

Chapter one is the introduction to the study, which consists of the background of the study, statement of the research problem, research questions, aim and objectives and scope of the study. Chapter two reviews literature on the related previous work. Chapter three is concerned with the study area and the research methodology and agro-climatological analysis. Chapter four presents results and discussion. Chapter five contains the summary of the results, conclusion and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

Precipitation is a very important resource in northern Nigeria as many human activities depend upon its availability. (Buba,1995). It is the factor that limits plant growth in the region. Therefore the amount and the distribution of rainfall are important factors in determining the ultimate productivity of crops under natural conditions. (Bagulia, 2006).

Precipitation is also considered as critical resources in the study area because its supply is confined to a season which coincides with the northern hemisphere summer (Ofuma and Nnodu 2005). Furthermore, the wet season is characterized by temporal and spatial variations, the magnitude of such variations with regard to the onset, distribution, cessation and length of the season are therefore important in planning for agricultural development and as well as for commercial planning and development. (Nieuwoit,1975).

Since agricultural activities in Northern Nigeria are mostly rain fed, for a successful crop production, there is need to have reliable rainy season in each particular year. (Dhameja, 2005).

The review examines related previous studies on crop climate relationships based on the three methods suggested by Olaniran (1981). These are: the study of fundamental of plants-climate relationship, empirical studies of plant- climate relationships and plant-climate relationship under the controlled environments.

2.2 LITERATURE REVIEW

2.2.1 Crop-Climate Relationship Studies

Rainfall is among the five climatic factors that are of particular importance to millet production: rainfall, air and soil temperature, day length (photoperiod), radiation and wind. There are few studies that have been conducted on crop climate relationship. Among the few ones are Sawa and Abdulhamid (2011) who conducted a study on forecast models for the yield of millet and

sorghum in the Semi Arid Region of Northern Nigeria using Dry spell parameters. The results of the research show that sorghum is more responsive to dry spell occurrence than millet. Occurrence of dry spells at some phonological stages of development of sorghum is beneficiary and increases its yield. About 54.5% and 63.2% of the variation in the yield of millet and sorghum respectively are accounted for by the variation in occurrence of dry spells.

Ijioma (1989) carried out a Micro Analytical study of crop water use in relation to crop production in Nigeria. The study shows that completely different pattern of rainfall distribution occur within the same climatic region and stations located relatively close to one another. It also shows that although all parts of Nigeria experience variation climate, over the past fifteen years, the variation have been more pronounced particularly in the locations in the north of Nigeria. These conditions have greatly affected agricultural production over wide areas. The study also confirms previous conclusions that the characteristics of crop yields are results of a complex of interacting factors of the physical environment. Maman *et al* (2003) investigated pearl millet and Grain sorghum yields response to water supply in Nebraska. The result shows that, the 30 years average growing season rainfall at Mead is 68% greater than that at Sidney. Rainfall was 50% less than the long term seasonal average at Sidney and 25% less than at Mead in 2000. Maksimovic and Buc Sevic *(*2009) also studied the effect of weather variation on crop production in Serbia and Montenegro. The result shows that, corn yield were significantly higher in irrigation than in the variant of dry farming. However, extremely high temperature at the time of flowering pollination and grain filling affected yield performance of corn, not only in dry farming but also in irrigation.

Lobell and Field (2007) studied the Global scale climate–crop yield relationship and impacts of recent warming. The result suggests that recent climate trends attributed to human activity have had a discernible negative impact on global production of several major crops. Abdulhamid *et al* (2011) studied the effect of climate on the growth and yield of sorghum (sorghum bicolor) in Wailo, Gajunwa Local Government Area, Bauchi State. The result shows differences in the effect of each element on sorghum yield at different stages of the growth. Tao *et a*l (2008) conducted a research on climate crop yield relationships at provincial scales in China and the impacts of recent climate trends. The analysis showed that the yields of major crops were significantly related to growing

season climate in the main production regions of China over the last few decades. Furthermore, the growing season temperature especially had a significant warming trend. Ajadi *et al* (2011) examined the impact of climate on urban agriculture: A case study of Illorin city, Nigeria. In this study, the results obtained from the regressions and correlation statistics revealed that climate has little impact on crop productivity within the years under review. In other words, the result implies that, though there are variations in climate parameters within the years, such variation has little impact on the selected crops. Olaniran and Babatunde (1987) studied the effect of climate on the growth of early Maize at Kabba.

2.2.2 The Studies of the Fundamentals of Plant-Climate Relationships

Studies on the fundamentals of plant climate relationship in the field of agro-climatology are not much due to inadequate data records. Some of the few researches that were conducted include Kowal and Kassam (1973) who carried out a study on water balance analysis for Samaru and the result shows that lack of rain for a period of 10 days or more during the early growing season creates water stress condition which affects the performance of sorghum. Downes (1968) investigated the effects of temperature on tillering of grain sorghum Seedling. The researcher found that water supply at Kabba within the first 94 days of sorghum growth is in excess of the water demand of the crop, which led to excessive leaching of the plant nutrients and consequently reduces the final yield of the crop.

Palikhe (2008) studied relationship between pesticide use and climate change for crops in Hrihar Bhawal. The finding of the study shows that, climate and weather can substantially influence the development and distribution of insects. Most of the warming over the last 50 years is likely to have been due to man made activities. Wolfram and Michel (2006) conducted a research on estimating the impact of climate change on crop yields. The test shows that the new estimate is significantly better at predicting yields than other approaches found in the literature. The flexible function form reveals that growth is highly non linear and asymmetric in temperature. Ngujen (2004) examined the global climatic change and rice food security review. Omonona and Akintunde (2009) studied rainfall effects on water use and yield of Cocoa in Nigeria. Raja *et al* (2007) studied the effects of carbon dioxide, temperature and ultraviolet – B radiation and their interactions on Soya beans

(Glycine Max L.) Lobel (2007) investigated changes in diurnal temperature range and national cereals yields. Stone (2001) examined the effects of heat stress on cereals yields and quality crop responses and adaptation to temperature stress. Sadauki and Olarewaju (2012) studied the effect of climate on Yam tuberization in the guinea savanna ecological zone of Nigeria, the case study of Kwara state. The result shows that yam tuberization in the guinea savanna ecological zone of Kwara state is favoured by rainfall that is well spread and with soil temperature at 5cm depth. Soil moisture at all depths shows a positive relationship with tuber formation.

Kassam and Andrew (1975). These therefore suggest, that the time of head initiation of millet crop may be early than ninety four days (94) after sowing assumed to the station every year. In the event or processing data from a time period which is inappropriate for millet flowering at the station. Peacock (1982) noted that moisture stress in sorghum has devastating effect on yield. Availability of water is major climatic factor influencing yield of millet in tropical areas, if rainfall is inadequate or irregular or if the soil does not retain water the yield is adversely affected. (Cocheme,1957).

Crnoparao (1982) reported that ecological conditions such as rainfall, temperature and sunshine affect sorghum yield. Cocheme and Franquin (1957) conducted a research on the relationship between sorghum yield and certain agro-chemical variables at Bombay and Senegal. The result revealed that curvilinear relationship between each of variables that is in semi arid zones, too much water or excessive long wet period can reduce production. Fakorade, (1985) reported that under rain fed agricultural system; the extent of yield variation of sorghum would depend on the dates of planting.

Heinrich (1981) reveal that sorghum genotypes may differ from both the rate and duration of grain and the way in which these are affected by high temperature. This may seem more applicable in explaining the significant positive correlation between air temperature during the grain filling period and grain yield of sorghum at Kabba. There is also a negative and insignificant correlation between total rainfall during the grain filling period and the final sorghum yield at Kabba.

2.2.3 Studies of Plant-Climate Relationships Under the Controlled Environment

Researches on plant climate relationships under control led environment have been carried out differently due to some changes in weather conditions experienced in our environment. Babalola (1972) studied the effect of different soil moisture on plants of cocoa, kola and coffee. The result shows that differences in soil moisture correlate well with height, root and leaf area increment in coffee and cocoa than in kola. Cadidell and Weibel (1971) studied effect of photo period and temperature on the Development of sorghum. They found that in general panicle initiation largely determined temperature photoperiod interaction. Ojeniyi (1981) carried out research on nutrient availability and maize yield under reduced tillage practice. The result shows that area of relatively low rainfall in Nigeria was found to produce lower yield of sorghum.

2.2.4 Empirical Studies of Plant- Climate Relationships

Researches that were conducted on the empirical studies of plant-climate relationships are varied depending on the types of research and nature of the study area. Some of the few researchers are Adejuwon (1962) which correlated annual cocoa production with the total rainfall in western Nigeria. He discovered that, areas that carried out cocoa production have a mean annual rainfall of between 1270mm - 1,524mm.

Olaniran and Babatolu (1987) studied climate and growth of sorghum at Kabba. Nigeria The study shows that fluctuations in air temperature conditions during the vegetative and grain filling period and in rainfall supply conditions during the pre- sowing and vegetative growth periods accounts for 79.8% of the variability in sorghum yield in the station. Oguntoyinbo (1967) analyzed rainfall, compute evapotraspiration and related to cotton yield at Samaru. The study shows that the optimum climate conditions for the growth of rain-fed cotton, it required rainfall of 762mm during the growing season and which is concentrated mainly in the first three months. Adebayo *et al* (2006) investigated the influence of climatic factors on the growth and yield of sugarcane at Numan. The study reveals that, total rainfall relative humidity; minimum temperature and evaporation are critical to sugarcane growth and yield at various stages of development. Abdullahi *et al* (2002) studied the relationship between drought and millet production in the arid zone of Nigeria. The result shows that, the rainfall and trend variable were significant ($P<0.01$) and conformed to a prior expectation of the signs of the coefficients. Mustapha and Mustapha (2007) investigated the growth

and yield of pearl millet (Pennisetum Glaucum) as influenced by Downey mildew and smut diseases in Kabuga area of Kano. The result shows that, there are inherent differences amongst the four varieties tested in flowering and spike length.

Mortimore, (1974), Kowal and Kassam, (1974) they study the influence of climate factors on maize yields in Akure, Ondo state, Nigeria it was observed that rainfall, sunshine, time trend and temperature are jointly responsible for more than 55% of the total variation of maize yields over the period under investigation. Rainfall during the growing season is positively and significantly correlated at 5% level with the maize yields, while the total maximum and minimum temperature, sunshine hours and soil temperature during the growing season have positive but none significant relation with the maize yields at 5% confidence level.

Aliyu (2009) conducted a research on the implication of the recent trends and variability in the duration of the growing seasons for food crop production in northern Nigeria and the author emphasized a downward trend in the duration of the growing season in some locations from 1978 - 2007, with a significant variability in most of the stations north of latitude 9^0N of Nigeria. He did not however, relate the trend of the growing season and monthly rainfall with current trend yields of some major crops growing in these stations. Hurtado *et al* (2001) furthered with a study on spatial distribution of extreme yields of Soybeans and climatic condition in which it grows in pampas area. Ashley (1993) under took a research on drought and crop adoption in Rowland, dry land farming in Africa. Ashley categorized mechanism of drought tolerant crops into three. The drought escape; drought tolerance with tissue water and drought tolerance with low tissue water potential.

Dagaga (1965) investigated a rational approach to the selection of crops for area of marginal rainfall in East Africa. The study established linkages of the growing season with reliable onset of rains. Adejuwon (2004) investigate crop yields responses on climate variability in the Sudano Sahelian ecological zones of Nigeria. The finding is that inter-annual rainfall variability in other parts of West Africa affects the various aspects of plant grow and yields and consequently alters crop productivity.

Apata (2008) investigated the effects of global climate change on Nigerian agriculture. Findings from this study indicted that agricultural impacts of climate change in Nigeria are

uncertain. The total average impact may be positive or negative depending on the climate scenario. But in most scenarios it was shown that climate change will have an overall positive impact on Nigeria's agriculture. Abdulhamid *et al* (2011) these reported that, the result of the correlation between the climatic variables and yield of sorghum at Wailo are presented Table 2. The result shows differences in the effect of each element on sorghum yield at different stages of growth.

For the pre-sowing period rainfall has positive and significant correlation with yield. This shows that rainfall supply during the pre-sowing period is very important for good sorghum yield at Wailo. This provide a quantitative confirmation of the finding of Kowal and Andrew (1973), Kowal and Kassam (1978) at samara and Adebeyo (1994) at Ngurore.

Ben Mohamed et al (2002) reported that, the result of the study show that, the rainfall and the trend variables were significant (P<0.01) and conformed to the prior expectation of the signs of the coefficients. The significance and positive coefficient of the rainfall term means that as rainfall increases, production of millet increases while during drought years (when rainfall decreases), and Millet production declines.

2.3 SUMMARY OF LITERATURE REVIEW

In general, precipitation is the climatic variable of primary importance in shaping the spatial and temporal variations of Agriculture in the tropics. The seasonal cycles of rainfall directly determine the tempo and rhythm of the growing seasons. A lot of literatures exist on the various studies of establishing weather climate agricultural relationships that was advocated by Olaniran (1981). These are: crop climate relationship, the studies of the fundamentals of plant climate relationship, studies of plant–climate relationship under the control environmental and empirical studies of plant climate relationship.

CHAPTER THREE

STUDY AREA AND METHODOLOGY

3.1 INTRODUCTION

This chapter deals with the study area and methodology employed in the study, the types of data needed, selection of rainfall gauging stations, agro climatological derivation and analysis of data.

3.2 THE STUDY AREA

3.2.1 Locations, Position and Size

Kura:

Location: **Kura lies within latitude $11^0$46'17.47'N of the equator and longitude $8^0$25'48.60'E. of the Greenwhich Meridian.**

Position: **Kura as a Local Government is bounded to the West by Madobi, to the East by Dawakin Kudu and to the South by Bunkure and Garun Malam Local Government Areas.**

Size: **In terms of size Kura has an area of about 206 Square Kilometers. http://enwikipedia.or/wiki/kura.retrievedon24/11/2012.**

Dambatta:

Location: **Dambatta lies within latitude $12^0$25'44.63'N of the equator and longitude $8^0$31'14.90'E of the Greenwich meridian.**

Position: **Dambatta Local Government Area is bounded to the west by Makoda, to the North and East by Jigsaw state and to the South by Mungibir Local Government Area.**

Size: **In terms of the size Dambatta has an area of about 732 square kilometers. http"//enwikipedia.org/wiki/kura.retrievedon23/11/2012.**

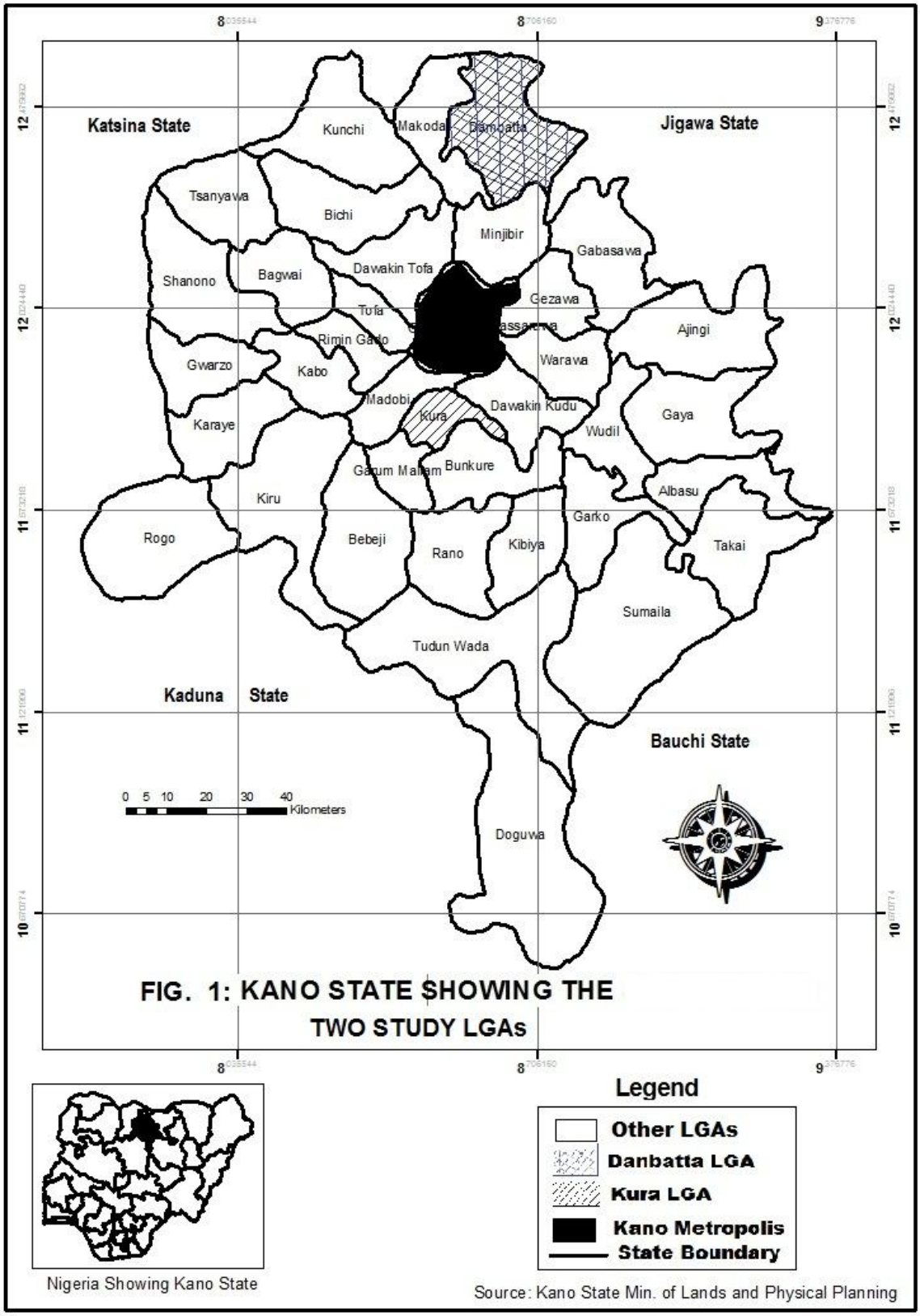
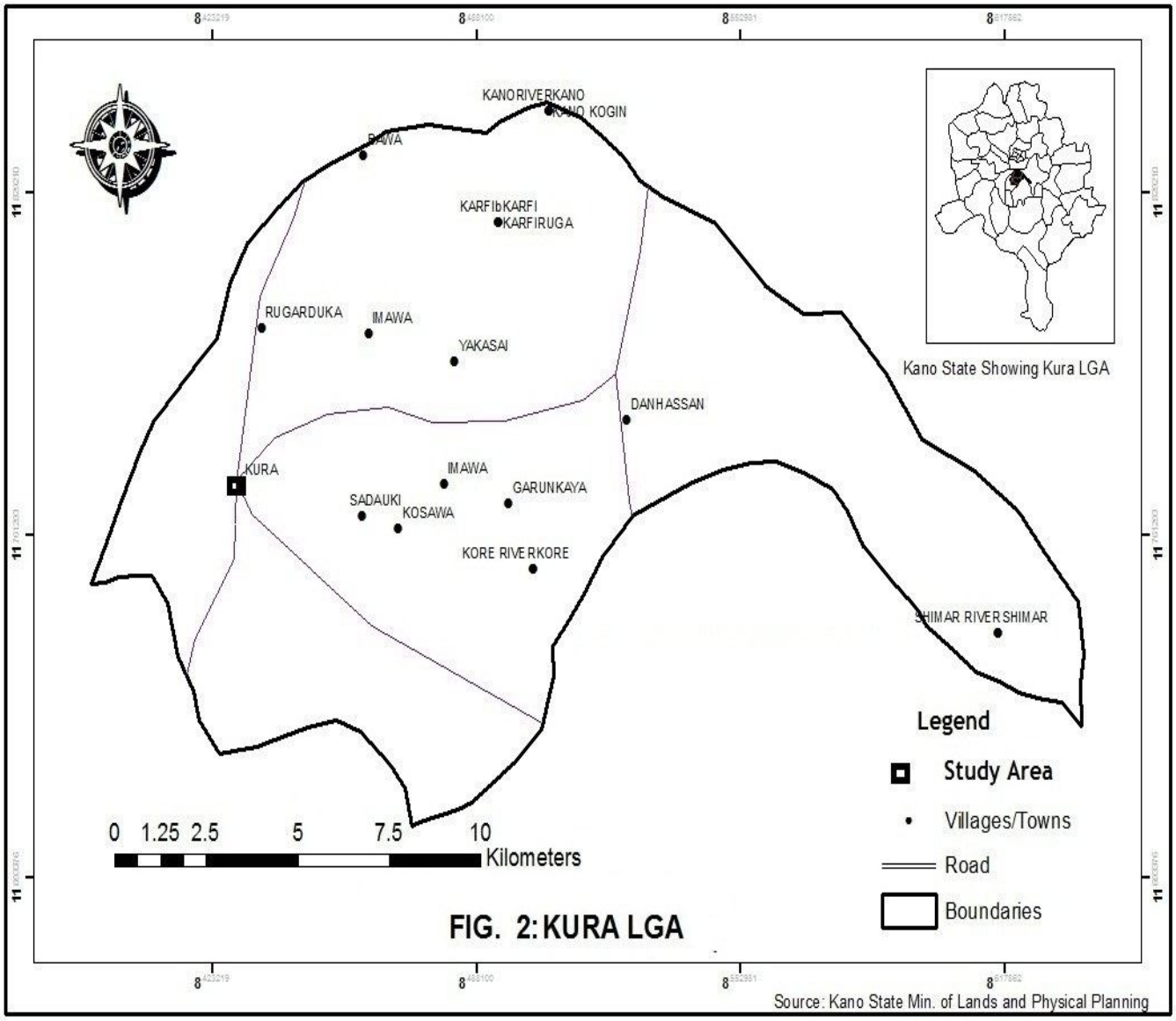
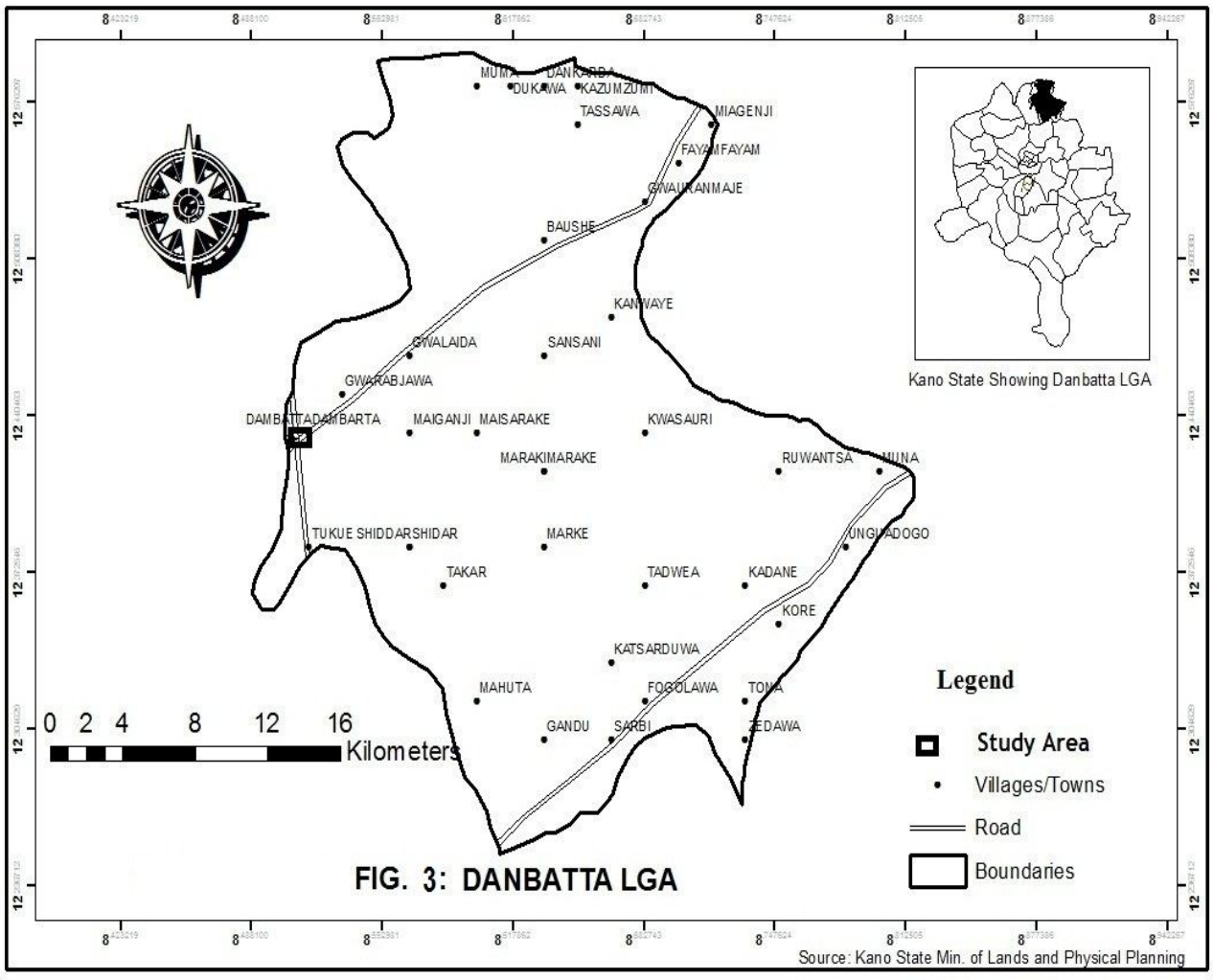


FIG. 1: KANO STATE SHOWING THE TWO STUDY LGAs


KANO RIVER KANO
KANO KOGIN
BAWA
KARFI b KARFI
KARFI RUGA
RUGARDUKA
IMAWA
YAKASAI
DANHASSAN
KURA
IMAWA
GARUNKAYA
SADAUKI
KOSAWA
KORE RIVER KORE
SHIMAR RIVER SHIMAR
Kano State Showing Kura LGA
Legend
Study Area
Villages/Towns
Road
Boundaries
0 1.25 2.5 5 7.5 10
Kilometers
FIG. 2: KURA LGA
Source: Kano State Min. of Lands and Physical Planning


MUMA
DANKARDA
DUKAWA
KAZUMZUMI
TASSAWA
MIAGENJI
FAYAMFAYAM
GWAURANMAJE
BAUSHE
KANWAYE
GWALAIDA
SANSANI
GWARABJAWA
DAMBATTADAMBARTA
MAIGANJI
MAISARAKE
KWASAURI
MARAKIMARAKE
RUWANTSA
MUNA
TUKUE SHIDDARSHIDAR
MARKE
UNGUWADOGO
TAKAR
TADWEA
KADANE
KORE
KATSARDUWA
MAHUTA
FOGOLAWA
TONA
GANDU
SARBI
GEDAWA
0 2 4 8 12 16
Kilometers
Kano State Showing Danbatta LGA
Legend
Study Area
Villages/Towns
Road
Boundaries
FIG. 3: DANBATTA LGA
Source: Kano State Min. of Lands and Physical Planning

3.2.2 Geology, Relief and Drainage

Geology**:**

The study area is characterized by two major geologic structures, with minor intrusions of a third. The larger area of the region to the south and North West is underlain by rocks of the basement complex with intrusions of younger granites in the extreme southern parts. To the North East are unconsolidated sediments of the Chad formation. The two structures are separated by a transitional zone which constitutes the well defined hydrogeologic divide of the region.

According to Olofin (1987), these rocks are of pre-Cambrian origin and consist of metamorphic and igneous types common among these rocks are granites of different descriptions, granitised sandstones (as in Kazaure) migmatites, gneisses, phyllites, and so on. The granites dominate the structure. Hence it is common to refer to the rocks of the basement complex as the older granites. These rocks have being in existence for millions of years. They have been subjected to chemical and other forms of weathering to produce clay rich regolith.

The Jurassic intrusion that affected the Jos plateau occurred in the southern tips of the Kano region which consist of foothills of the Jos plateau. Although younger granites have been subjected to some weathering, their outcrops dominate the area where the intrusion occur, such as in Riruwai, Rishi and Ningi. The younger granites are well jointed and occur in ring complexes. The important economic characteristic of the younger granites is their association with cassiterites, the ore of tin. (Kabuga, 2002).

The Chad formation is composed largely of unconsolidated sediments. In the Kano region these sediments are mainly of tertiary terrestrial origin. On the surface they consist of vast, tertiary accumulation of sand on plains and interfluves, recent alluvial accumulation in channel complexes. In some areas the vertical profile is an alternating bands of sand (aquifer) and clay (impervious) Layers (aquifer) (Adamu, 2003).

Relief**:**

The relief of the study area can be described under three types occupying three distinct zones, as the highland, the high plains and the low Chad plains. The first two types are part of the high plains of Hausa land and the third is a part of the Chad plains. The relief is greatly influenced

by the geology, the highest elevation are associated with igneous structure and the lowest with the Chad formation.

The highlands occupy a relatively small area to the south and south east of the region where they constitute part of the footsteps of the Jos plateau, lying further south. The peaks of the high lands, which are mostly out crops of younger granites, rise more than 1100m above mean sea level. The elevation of their bases ranges between 700m and 800m. The highest peak in the region is about 1230m above sea level (Bello, 2002).

Plains whose elevation range between 450m and 700m occupy about 40% of the surface area of the Kano region and constitute the largest single relief unit. The areas of low relief are usually less than 30m, except in sections where grouped hills occur. In such sections, the hills may arise more than 100m above the plains (Mustapha, 2002).

The lowest relief unit of this region consists of the plains developed essentially on the sedimentary structure known as the Chad formation. The unit also includes the transition plains immediately west of the hydro geological divide, developed on the rocks of the Basement complex, lower than 450m above sea level and over which sands of the Chad formation occur. The relative relief is between 15 and 20m except in sections occupied by sand dunes (Jibril, 2002).

Drainage**:**

The natural drainage of Kura constitutes two major rivers, Kano and Challawa and their numerous tributaries, the former rises from extreme south and latter from south west. They make confluence and drain east wards to Hadejia Nguru wetlands and ultimately to the Lake Chad. And Dambatta is characterized by one river, which is river Tomas and got it sources from Bichi Local Government Area of Kano State and drainage to Dambatta Dam (Udo, 1981).

3.2.3 Climatic Characteristic

Generally, the area lies within the "wet and dry" climate with more dry than wet months (Olofin, 1987), which is categorized under AW in Koppens classification. It has a low mean annual rainfall of about 880mm. In drought years, it could be lower than 450mm as in the case of 1972/73 drought. Recently, between 1997 to 1999 heavy down pours were recorded. In 1998 alone, over 1000mm of rainfall was recorded, (Abdulhamid, 2000). The area is characterized by four months of

wet seasons and eight months of dry season. Therefore water availability is very critical in the area.

Temperature is relatively warm to hot from March to October, and cool from November to February. The mean annual temperature is 26^0C. The hottest months (April / May) have the mean of 31^0C, and the coolest month (December / January) has the mean of 21^0C.

Evapotranspiration (Et) is generally higher than precipitation (table 1). The evaporation data recorded and analyzed by standard class 'A' pan at IAR in 1974 (IAR, l974) was estimated at 2,214mm per annum. Using different data from various sources, Olofin (1980) estimated the potential evaporation in Kano at 2,538mm per annum.

The vapour pressure (eP) is at its maximum point between May and August with the range of 25-28 Hecto Pascal (Hp). The lowest recorded is in March which is 7Hp. The dew point is less than 1^0C I March and rise up to 23°C in August. This factor explains the water condition in the area. The potential evapotranspiration exceeding rainfall changes in vapour pressure records and steady rise in dew point between April to August emphasize the dry condition of the area.

Humidity is largely influenced by the movement of the inter-tropical discontinuity (ITD). Humidity is high under the influence of tropical maritime air mass (™). During the rainy season, it can rise up to 90% and sometimes as low as 20% in harmattarn season between November to March, (for more details see table 1.)

Table 1: Mean Climatic Conditions of Kano

Month	Mean Temp.	Range (^{0}C)	Rainfall (MM)	Et (MM)	VP (Hp)	Sunshine (hours)	RH(%)
January	21.2	17.8"	0.0	133.3	9.2	9.0	28
February	23.7	20.9	0.0	141.1	7.6	9.0	25
March	27.7	18.5	0.0	182.5	6.8	8.6	23
April	30.5	16.4	8.9	195.5	18.6	8.4	36
May	30.4	13.6	70.2	187.9	28.2	8.8	51
June	28.1	13.0	132.7	156.3	23.4	8.7	65
My	25.7	10.7	210.9	126.4	26.1	7.5	78
August	24.9	9.0	314.0	112.7	28.1	6.0	88
September	25.9	10.9	132.8	126.5	22.5	7.9	79
October	26.8	16.5	12.8	144.0	24.8	9.5	58
November	24.6	19.7	0.8	139.9	16.7	9.8	37
December	21.7	18.7	0.0	127.4	14.4	9.2	32
Mean	25.9	15.5			18.9	8.5	49.6
Total			882.3	1,773.5		110.9	

Source: Olofin *et al* (2008*).*

3.2.4 Soils, Vegetation and Land Uses

Soils:

The factors of soil formation in the region are not different from the factors else where. However, the role of parent material is very great in the region. Parent rock appears to pull a greater influence than climate. Thus, the variety of soils occurring in the basement complex area is different from the variety occurring in the Chad formation zone. Another factor of great significance is topography. Climate has only a generalized influence; parent rock creates maculate spatial differences.

The soils are generally matured on the plain but seriously altered due to human settlements. The influence of topography, wind drift (materials from the desert) and climate are what shaped the aggregate of the soil. The matured soils are said to be latosols of ferruginous type (Olofin, 1987). The soil is however well drained, brown to reddish in colour. Along the floodable area of river channels, hydromorphic soils are found. These are dark in colour and have high clay content. Intensive use of soils and addition of manure and chemicals fertilizers have altered their character, profile, texture, structure and chemicals characteristics (Abdulhamid, 1987) the soils are good for agriculture especially fadama cultivation that is practiced in the area due to their clay loamy nature.

Vegetation:

The "natural" vegetation of Kano region is the savanna type. Most of the region is contained within the Sudan savanna variety. The exceptions include the southernmost area which is characterized by the northern Guinea savanna and the northernmost section (Dambatta and Gaya) which is characterized by the Sahel thorn shrub.

The study area lies within the Sudan savannah zone and form part of the human settlement in which vegetation is seriously depleted through construction process. It comprises both tall and short grasses with scattered trees most of which are semi - natural, planted for shade and their economic values. The natural vegetation has been cleared especially for cultivation purposes. Very few natural vegetation species are often found and these do not exceed 20 meters in height consisting of trees like Accia Aibida, Tamarindus indica, Butyospemum parki, clappertonia and handful of

others. Grasses are hardly found, except in scanty patches. These hardly reach 1 metre high at maturity, and tend to dry up in the dry season; cultural vegetation has replaced the natural vegetation in the area where exotic species predominate (Bichi, 2009).

Land use of the study areas:

The major and most important land use in the study areas is agriculture, which can either be rainfall agriculture or irrigation agriculture. The farming systems in the study area are mainly subsistence and commercial.

The main crops that are grown in the study areas are seasonal crops. The rainy season crops (rain-fed) include: Sorghum, millet, groundnut, rice etc, while the dry season crops (Irrigation agriculture) are mainly crops like wheat, rice, maize, tomatoes and onion etc. Other land use activities include residential houses, markets, and schools, government offices for administration, motor parks, communication network, roads and forest reserved.

Although the study areas are yet to be developed for industrial land use, but small scale industries many be found, for example: rice processing mills and other small scales.

3.2.5 People and Economic Activities

People:

The majority of the people of the study areas are Hausa/Fulani, but Hausa language is the common language spoken by all. Hausa is spoken in many parts of West Africa and Sudan. According to some authorities in African history, the Hausa people are believed to originate from Ethiopia. Hausa language is broadcast in BBC, VOA, Deutsche Welle, Radio Beijing, Radio Iran, Radio Egypt, Voice of African (Libya).

Nonetheless, the study areas are cosmopolitan settlement comprising significant number of other Nigerian ethnic groups such as Yoruba, Igbos, Tangale, Kanuris, Biu, Calabars, TV and many others. More than 90% of the people of the study areas are Muslim Sunni and Sufi order. Christians of several denominations make the non Muslim community with a significant number. The followers' traditional religions are found in the remote villages of the study areas.

Economic Activities

The study areas as centres of commerce are consistent Slogan or epithet of the state. This is true because they are the most enterprising since pre-colonial times. Agriculture is the mainspring of the economy providing jobs for farmers and animal raisers who constitute the greatest of the population of the study areas. There are also small scale industries, such as rice milling processing, petty-petty traders and other Agro-allied.

The study areas have abundant land and water resources as well as some solid minerals. The modern business is also fairly represented in the study areas and fair representation of financial institutions (Barau, 2007).

3.2.6 Environmental Problems and Land Forms

Environmental scientists interchangeably regard hazards and disasters pertaining to biophysical environment to mean environmental problems (Maigari, 2002). Environmental problems are broadly classified into four major groups, based on geophysical constituent, namely Geological, ecological, atmospheric and structural.

The geological problems include diverse geological phenomena such as earthquakes, volcanic eruptions, flood, land slides, tsunamis, soil scrip, and glacier burst among others (Nagle, 2000). Some of the geological problems that are found in the study area are; floods, landslide, subsidence and soil scrip.

Ecological problems result from the interplay of geological problems and or the human use of environmental resource. The most predominant ecological problems that we found in the area include; Soil degradation, deforestation, wild life extinct and water resources degradation. (Dhameja, 2005).

The atmospheric problems however, which are also found in the area consists of drought, atmospheric pollution, lightening, thunder storms, wind and dust storms. The structural problems that are characterized in the area on the other hand comprises man induced and man assisted problems such as noise pollution, traffic congestion, improper waste disposal and dam failure among others.

Land forms

Six major land form types, each associated with a particular relief unit are identified in the

study area as discussed below:

This land form type consists of the Rishi Hills which form a very rugged topography with the highlands. The hills are massive bare and of different shapes and dimensions A slightly elongated type, about 500m in length and 300-400m in width. The mean height of the hills is about 300m and they occur on more than 60% of the area occupied by this landform type (Hassan. 2000),

Hill occur in large and sometimes extensive groups in parts of the highlands and high plains, but are separated extensive gently sloping units unlike is the case in the dissected hilly land. The hills are also not as massive, nor as high, as those found in the dissected hilly land. Prominent among the grouped hills are: the Dadi plains, the Garanga plains and the Dakwat plains, (Yakoubou, 2000).

Plains without dominant grouped hills occupy the remaining high plains relief unit. These plains are believed to be initial pediplains which are now covered in many areas by a layer of wind drift materials some times to 2.5 meters thick. A typical drift plain consist of an upland plain river terraces and wide alluvial beds, all sloping, at angles less than 2 degrees, plus inter unit scarps steeper than 60 degrees. (Yakudima, 2005).

Great sand sheets occupy the northern and north central parts of the low Chad plains. They are characterized by very gentle slopes (0- 2 degrees), low relief (usually less than 1 5m) and disappearing stream channels. Occasional sand dunes and swampy depressions break other wise monotonous flattish landscape. The Gumel and the Hadejia sand plains are two main examples (Kabir, 2004).

Grouped dunes, which are up to 30 meters high, occur south of sandy plains and are traceable to latitude 11^0N where they are believed to mark the southern margin of an extensive desert in the past. The longitudinal dunes each several kilometers in length, occur in multiple rows and are aligned NNE SSW, the main example in the region are now stabilized and constitute part of the fossil land forms in this part of the country (Olofin, 1987).

Many river systems create alluvial channel complexes consisting both old (inactive) and current (active) flutes. The old flats are muddy, abandoned flood plains originating from the migration of rivers over very extensive storm channels. Since the escalation of dam construction in the region, a large portion of the naturally active channels has been rendered inactive downstream of

dams. Where the downstream discharges are appropriate, some reaches of the channels have been metamorphosed into narrow channels. A good example is the Kano river channels from near the outlet of the Tiga Dam to its confluence with Challawa River (Barau, 2007)

3.2.7 Implication of Precipitation on Biophysical and Human Characteristics for Millet Yield in the Local Government Areas under Study

Precipitation effectiveness is used in crops growth and perhaps, the most important factor that influences almost all the stages of millet growth and yield. Therefore the higher the rainfall the higher the growth of plants (grasses) and millet will increase. And the moment these grasses start to grow they will affect the development of the millet in the study areas.

As regards to these problems, something need, to be done in order to overcome the situation, it can be tackled by employing more labourers and buying more chemicals for spray, for the purpose of reducing the growth of grasses in the study areas.

3.3 DATA COLLECTIONS

3.3.1 Types of Data Required

For the purpose of this study two sets of data are required. Daily rainfall records (mm) and millet yield data in (Kilograms per hectare), from 1988-2007.

3.3.2 Sources and Methods of Data Collection

Daily rainfall records (mm) and millet yield (kilograms per hectare) for the study were collected from Kano Agricultural and Rural Development Authority (KNARDA) and Hadejia Jama'are River Basin Development Authority (HJRBDA).

3.4 DATA ANALYSIS

3.4.1 Selection of Rainfall Gauging Stations

The stations were selected based on the following criteria

1. **Long data record for more than minimum length considered for climatological analysis (Critchfield, 2003).**
2. **They are synoptic stations**
3. **They are spread across the study area.**

Table 3.1: Selected rainfall gauging stations in Kano State

s/n	Station Name	Year established	Station No.	Latitude	Longitude	Elevation	Rainfall record	Crop yield
1	**Kura**	**1981**	**9005.32**	**$11^0$46'17.47^{0}N**	**$11^0$46`17.4^{0}N**	**155**	**1988-2007**	**1988-2007**
2	**Dambatta**	**1976**	**9004.51**	**$12^0$25`44.6^{0}N**	**$8^0$31`14.90^{0}E**	**1468**	**1988-2007**	**1988-2007**

Table 3.2: Annual Rainfall (mm) and millet yield data (kg/ha) Kura Local Government Area from 1988 to 2007

S/N	Year/Month	MAY	JUNE	JULY	AUG.	SEP.	Total rainfall (mm)	Millet Yield (Kg/h)
1	**1988**	**204.3**	**226**	**240**	**261**	**190**	**1244**	**287.70**
2	**1989**	**150.6**	**220**	**232**	**253**	**200**	**1258**	**296.87**
3	**1990**	**77.5**	**208**	**224**	**248**	**199**	**1202**	**243.91**
4	**1991**	**43.4**	**234**	**250**	**285**	**207**	**1315**	**322.52**
5	**1992**	**60.7**	**224**	**246**	**273**	**201**	**1227**	**282.39**
6	**1993**	**4.3**	**201**	**252**	**295**	**188**	**1125**	**150.45**
7	**1994**	**111.3**	**210**	**234**	**249**	**203**	**1187**	**203.59**
8	**1995**	**58.2**	**230**	**245**	**280**	**200**	**1341**	**366.13**
9	**1996**	**17.1**	**200**	**238**	**261**	**194**	**1114**	**181.23**
10	**1997**	**68.6**	**218**	**226**	**279**	**178**	**1341**	**23S.23**
11	**1998**	**105.6**	**230**	**220**	**264**	**183**	**1206**	**25S.38**
12	**1999**	**3.1**	**221**	**238**	**259**	**196**	**1220**	**280.19**
13	**2000**	**41.7**	**215**	**246**	**282**	**200**	**1157**	**175.92**
14	**2001**	**39.9**	**210**	**240**	**275**	**194**	**1206**	**227.23**
15	**2002**	**41.9**	**200**	**230**	**266**	**201**	**1220**	**193.15**
16	**2003**	**6.9**	**216**	**221**	**244**	**200**	**1250**	**237.13**

17	**2004**	**68.7**	**212**	**258**	**285**	**190**	**1100**	**183.25**
18	**2005**	**32.0**	**234**	**264**	**276**	**199**	**1337**	**315.37**
19	**2006**	**93.5**	**209**	**249**	**297**	**200**	**1154**	**311.34**
20	**2007**	**19.5**	**226**	**260**	**281**	**204**	**1118**	**182.88**

Source: KNARDA (2011)

Table 3.3: Annual Rainfall (mm) and millet yield data for Dambatta Local Government Area from 1988 to 2007

S/N	Year/Month	MAY	JUNE	JULY	AUG.	SEP.	Total Rainfall (mm)	Millet Yield (Kg/h)
1	**1988**	**1.6**	**149.2**	**213.6**	**428.5**	**154.1**	**987.9**	**203.74**
2	**1989**	**10.4**	**36.0**	**142.4**	**382.1**	**84.0**	**700.2**	**220.27**
3	**1990**	**40.1**	**59.8**	**228.1**	**151.5**	**89.2**	**568.7**	**210.14**
4	**1991**	**88.4**	**148.6**	**287.3**	**401.1**	**26.9**	**1017.0**	**218.82**
5	**1992**	**122.1**	**45.1**	**177.6**	**324.8**	**205.5**	**912.5**	**219.78**
6	**1993**	**68.2**	**185.9**	**157.9**	**425.8**	**83.7**	**791.6**	**221.06**
7	**1994**	**5.9**	**101.6**	**149.4**	**325.2**	**156.5**	**698.2**	**247.60**
8	**1995**	**24.4**	**155.0**	**189.4**	**145.0**	**173.5**	**1064.0**	**229.45**
9	**1996**	**37.2**	**101.6**	**253.8**	**388.9**	**235.5**	**1226.7**	**221.90**
10	**1997**	**100.6**	**161.9**	**217.9**	**451.9**	**222.5**	**1100**	**212.05**
11	**1998**	**69.6**	**173.0**	**573.0**	**501.8**	**444.1**	**1384.7**	**219.63**
12	**1999**	**44.5**	**88.8**	**527.5**	**465.9**	**240.3**	**1024.0**	**198.02**
13	**2000**	**98.3**	**135.7**	**354.2**	**332.4**	**69.4**	**1186.4**	**223.24**
14	**2001**	**185.8**	**228.1**	**604.7**	**521.1**	**205.6**	**1035.7**	**217.44**
15	**2002**	**1.0**	**124.4**	**276.9**	**376.6**	**199.9**	**1319.2**	**220.08**
16	**2003**	**66.8**	**247.2**	**394.2**	**465.4**	**232.6**	**1243.6**	**224.85**
17	**2004**	**150.5**	**189.9**	**396.1**	**277.7**	**229.4**	**1336.6**	**214.22**
18	**2005**	**119.7**	**188.1**	**383.6**	**442.9**	**200.4**	**1309**	**214.47**
19	**2006**	**149.7**	**114.9**	**374.1**	**334.4**	**336.0**	**1007.5**	**231.12**
20	**2007**	**91.0**	**329.3**	**188.5**	**410.0**	**37.5**	**1035.9**	**226.50**

Source: KNARDA (2011)

3.4.2 Agro-Climatologically Data Analysis

The monthly rainfall data were used in calculating the mean monthly and annual rainfall for the stations. From the Rainfall data collected precipitation effectiveness indices were computed accordance with the following methods:

(a) Onset (start), cessation (end) and length of the rainy season (LRS)

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

$$\text{The number of days in the month} \times \frac{(51 - \text{Accumulated rainfall of the previous months})}{\text{Total rainfall for the month}}$$

Cessation (end) means 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 the way as the onset except that the computation is done backward from December following Walter's (1967) method, it is:

$$\text{The number of days in the first month from December with the cumulative monthly rainfall} = \frac{51 - \text{rainfall total of the previous month}}{\text{Total rainfall of the first month with cumulative rainfall greater than 51mm.}}$$

(b) Length of the Rainy Season (LRS)

The length of the Rainy Season (LRS) is the difference between the cessation date of rains and the onset date. The LRS can be computed or obtained by subtracting the onset date from the cessation date (Adefolalu, 1993).

(c) Rainfall amount in May, June, July, August and September

The records of daily rainfall values were added monthly to give the monthly rainfall totals for the months of May to September (Adebayo, 2000).

(d) Hydrologic Ratio (HR)

Adefolalu (1988) stated that, Hydrologic Ratio (HR) may be defined as the ratio of mean annual rainfall to the potential evapotranspiration PE (P/PE). It is also described as the best

methods of estimating water availability as soil moisture. According to Duckham (1996), these indices help in making decision in agricultural field, because they provide a guide on the best choice of the area/plot where a particular type of crop will not only thrive well but will equally have high yield or reach optimum growth level.

Hydrological Ratio (HR) is expressed as follows:

$$HR = P/PE$$

Where HR = Hydrologic ratio

P = Precipitation

PE = Potential evapotranspiration

(e) Seasonality Index (SI) **Seasonality index of rainfall is the sum of absolute deviations of means monthly rainfall from the overall monthly mean divided by the mean annual rainfall. It measures the spread and steadiness of rainfall during the wet season.**

According to the method of Waish and Mawler (1981), the seasonality index is computed as follows:

$$SI = {}^{I}/_{R} \sum / Xn - {}^{R}/_{12} /$$

Where SI = Seasonality index

R = Mean annual rainfall

$\overline{X}n$ **= mean rainfall of the month n**

The values of SI that are obtained here were compared to the values from table 3.4 as given by Walsh and Lawler (1981) for the interpretation of the results and possible classification of the study area into different rainfall regimes.

Table 3.4: Classification of Seasonality Index of Rainfall

S/No	SI Class	Rainfall regime
1	**≤ 0.19**	**Very equitable**
2	**0.20 – 039**	**Equitable but with a definite wet season**
3	**0.40 – 0.59**	**Rather seasonal with a shorter drier season**
4	**0.60 – 0.76**	**Seasonal**
5	**0.80 – 0.99**	**Markedly seasonal with a long drier season**
6	**1.00 – 1.99**	**Most rain in three months of less**
7	**>1.99**	**Extreme, almost all rain in 1-2 months**

Source: Adapted from Waish and Lawler (1981)

3.4.3 (1) Data Transformation

Precipitation effectiveness indices is measured in various units millimeters (mm) days, etc and crop yield in kilograms per hectare. For the purpose of this study all the data will be harmonized through the method is called pooled.

3.5 STATISTICAL ANALYSIS

According to Jackson (1972), Olaniran and Babatolu (1987) and Adebayo (1994) crop yield area affected by a wide range factors and separation of the influence of one from the others, is extremely difficult or impossible. This recommends practice of using the multiple regression techniques when subjecting climate crop yield relationship for each climate element separately. (Sulivan and Ross, 1979).

Accordingly bivariate correlation analysis is used to establish the relationship between precipitation effectiveness indices that are critical to millet yield and crop yield (kg/ha). Multiple regression analysis was employed. The yields are expressed as dependent variable (Y) while the precipitation parameters are the independent variables (x).

The general form of multiple regression equation is presented below:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + \text{-----} b_nX_n$$

Where y = millet yields kg/ha

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter presents and discusses, onset dates, cessation dates, length of the rainy season, hydrological ratio, seasonality index and their relationship with millet yield in Kura and Dambatta. Related literature on the precipitation has been reviewed in chapter two. Here attempts are made to discuss results, from the analysis carried out in precipitation effectiveness indices and millet in Kura and Dambatta. The order of presentation of the results is guided by earlier stated objectives. This involves a careful examination of the contribution of all the variables.

4.2 THE DERIVED PRECIPITATION EFFECTIVENESS INDICES

The derived agro-climatic parameters (onset, cessation length of the rainy season, hydrologic ratio and seasonally index) are presented in Tables 4.1 and 4.2 for Kura Local Government Area and Dambatta Local Government Area, respectively.

Table 4.1: **Millet yield data (kg/ha), Rainfall (mm) and computed precipitation effectiveness indices for Kura Local Government Area (1988-2007)**

Year	Yield	Rainfall (mm)	Onset (May)	Julian Date	Cessation	Julian Date	(L.R.S)	HR	June	July	Aug.	Sep.	S.I
1988	287.70	1244		129	23rd Sept.	266	137	0.45	226	240	261	190	1.17
1989	296.87	1258	9th May	130	22nd Sept.	265	135	0.44	220	232	253	200	1.14
1990	243.91	1202	10th May	134	18th Sept.	261	127	0.32	208	224	248	199	1.12
1991	322.52	1315	14th May	12S	25th Sept.	268	140	0.59	234	250	285	207	1.12
1992	282.39	1227	6th May	131	21st Sept	264	133	0.44	224	246	273	201	1.01
1993	150.45	1125	11th May	137	18th 5601.	261	124	0.29	201	252	295	188	1.06
1994	203.59	1187	17th May	132	18th Sept.	261	129	0.38	210	234	249	203	1.19
1995	366.13	1341	12th May	129	24th Sept.	267	138	0.59	230	245	280	200	1.16
1996	181.23	1114	9th May	132	9th Sept.	252	120	0.28	200	238	261	194	1.01
1997	23S.23	1341	12th May	130	16th Sept.	259	129	0.3S	218	226	279	178	1.15
1998	25S.38	1206	10th May	131	16th Sept.	259	128	0.41	230	220	264	183	1.13
1999	280.19	1220	11th May	133	13th Sept.	256	123	0.43	221	238	259	196	1.13
2000	175.92	1157	13th May	143	22nd Sept.	265	122	0.28	215	246	282	200	1.18
2001	227.23	1206	23rd May	134	19th Sept.	262	128	0.36	210	240	275	194	1.14
2002	193.15	1220	14th May	135	8th Sept.	251	126	0.32	200	230	266	201	1.12
2003	237.13	1250	15th May	131	7th Sept.	250	129	0.50	216	221	244	200	1.16
2004	183.25	1100	11th May	136	23rd Sept.	266	130	0.29	212	258	285	190	1.15
2005	315.37	1337	16th May	129	18th Sept.	261	132	0.61	234	264	276	199	1.12
2006	311.34	1154	9th May	136	21st Sept.	264	125	0.36	209	249	297	200	1.19
2007	182.88	1118	16th May 13th May	133	17th Sept.	260	127	0.44	226	260	281	204	117

TABLE 4.2: **Millet yield data (kg/ha), Rainfall (mm) and computed precipitation effectiveness indices for Dambatta Local Government Area (1988-2007).**

Year	Yield	Rainfall (mm)	Onset	Julian dates	Cessation	Julian dates	HR	LRS	June	July	Aug.	Sept.	S.I
1988	203.74	1100.00	27th May	147	15th Sept.	258	0.38	111	149.2	213.6	428.5	154.1	1.1
1989	220.27	1671.00	17th May	137	23rd Sept	266	0.42	129	36.0	142.4	382.1	84.0	1.17
1990	210.14	1480.00	30th May	150	14th Sept.	287	0.41	137	59.8	228.1	151.5	89.2	1.18
1991	218.82	1632.00	19th May	139	10th Sept.	253	0.42	114	148.6	287.3	401.1	26.9	1.11
1992	219.78	1661.00	20th May	140	23rd Sept	266	0.46	126	45.1	177.6	324.8	205.5	1.14
1993	221.06	1724.00	19th May	139	25th Sept.	268	0.42	129	185.9	157.9	425.8	83.7	1.06
1994	247.60	1971.00	15th May	135	2nd Sept.	275	0.47	140	101.6	149.4	325.2	156.5	1.11
1995	229.45	1910.00	12th May	132	18th Sept.	261	0.46	129	155.0	189.4	145.0	173.5	1.09
1996	221.90	1869.00	18th May	138	21st Sept.	264	0.47	126	101.6	253.8	388.9	235.5	1.19
1997	212.05	1369.00	29th May	149	8th Sept.	251	0.40	102	161.9	217.9	451.9	222.5	1.16
1998	219.63	1569.00	29th May	149	29th Sept.	272	0.43	123	173.0	573.0	501.8	444.1	1.15
1999	198.02	978.00	22nd May	142	1st Sept.	244	0.38	102	88.8	527.5	465.9	240.3	1.13
2000	223.24	1704.00	16th May	136	28th Sept.	271	0.44	135	135.7	354.2	332.4	69.4	1.24
2001	217.44	1417.00	23rd May	143	21st Sept	264	0.41	121	228.1	604.7	521.1	205.6	1.17
2002	220.08	1249.00	18th May	138	19th Sept.	262	0.41	124	124.4	276.9	376.6	199.9	1.12
2003	224.85	1806.00	14th May	134	26th Sept.	269	0.45	135	247.2	394.2	465.4	232.6	1.01
2004	214.22	1340.00	26th May	146	2nd Sept.	275	0.40	129	189.9	396.1	277.7	229.4	1.16
2005	214.47	1508.00	24th May	144	25th Sept.	268	0.42	124	188.1	383.6	442.9	200.4	1.13
2006	231.12	1921.00	10th May	130	24th Sept.	267	0.46	137	114.9	374.1	334.4	336.0	1.19
2007	226.50	1074.00	13th May	133	25th Sept.	268	0.41	135	329.3	188.5	410.0	37.5	1.04

4.2. The rains commence between 7th and 22nd May at Kura and 9th to 29th at Dambatta. This shows that areas within Kura will receive rainfall earlier than Dambatta. Similarly it is observed from the table that, at Kura planting of crops commences as early as between 7th and 22nd May compared to Dambatta where planting of crops commences between 9th and 29th May. In order to maximize crop yield in the Local Government Areas, farmers should maintain this timing.

4.2.2 Cessation Dates of the Rainy Season

The cessation dates of the rainy season in both areas are shown in tables 4.1 and 4.2 respectively. The cessation dates follow the same pattern with those of the onset dates. End of the rainy season begins around 24th September in Kura and 13th October in Dambatta. This means that Kura has early cessation while Dambatta experiences late cessation.

4.2.3 Length of the Rainy Season

The length of the rainy season for Kura and Dambatta presented in Tables 4.1 and 4.2 respectively. The length of the rain is almost the same with that of onset dates and cessation dates. In Kura Local Government Area the length of rainy season is as high between 120 - 140 days (Table 4.1) while Dambatta is as low as 102- 120 days (Table 4.2). This shows that Kura experiences longer length of rainy season, while Dambatta experiences shorter length of the rainy season.

The length of the rainy season is agriculturally is of great significance to farmers, because it guides the farmers on the type of crops that can be grown and the number of days needed by the crop to grow to the point of harvests.

4.2.4 Hydrologic Ratio

The hydrologic ratio (degree of dryness) in the study area is shown in Tables 4.1 and 4.2 for Kura and Dambatta respectively. The index is a ratio of rainfall to potential evapotranspiration, and this implies that the higher the potential evapotranspiration, the lower the ratio. Areas with low ratio are drier than the area with high ratio vice verse. From Tables 4.1 and 4.2 the hydrologic ratio ranges from 0.59 to 0.28 in Kura and 0.47 to 0.38 at Dambatta. This shows that Kura is wetter than Dambatta.

4.2.5 Seasonality Index

So far the study area they are shown in Tables 4.1 and 4.2 seasonality index values from Tables 4.1 and 4.2 were compared to the values from Walsh and Lawler's (1981) classification Tables 3.4 page 38. It was seen that the study area (Kura and Dambatta) fall within the seasonality index class of 1.00-1.99. This means that they fall within the Sudan Savanna zone with three month or less of rains.

4.3 RELATIONSHIP BETWEEN DERIVED INDICES AND MILLET YIELD

The result of the correlation between the derived precipitation effectiveness and millet yield at Kura is presented in table 4.3.

Table 4.3: Relationship between derived indices and Millet yield Kura LGA

Variables	Correlation coefficient
Rainfall	0.730**
Onset	0-.643**
LRS	0.734**
HR	0.787**
Cessation	0.414
June	0.685**
July	0.025
August	0-.007
September	0.252
S.I	00.0.51

Total rainfall was found to be significantly and positively correlated with millet yield at the 0.01 probability level (r = 0.730). The result shows that rainfall supply during the growing season is very important for millet yield at Kura.

This provides a quantitative confirmation of the finding of Kowal and Andrews (1973) at Samaru. It also supports earlier claims by Adebayo (1994) at Ngurore and Abdulhamed (2006) at Wailo that the antecedent moisture status of soil at planting is more important for sustained growth and has affects the final yield.

Onset dates of rains also have high correlation with millet yield. (r = 0.643) the result indicates that onset of rainfall is a very important factor in determining the yield of millet. Late onset of rainfall reduces yield of millet. Delayed onset of rain in rain fed agriculture lead to crop failure or poor yield. This result confirms the finding of Adebayo (1997) in Adamawa state for rice yield.

Length of rainy season also has a significant correlation with millet yield (r = 0.734). The result shows the implication of length of rainy season in the area. Where the length is longer it tends to influence high yield of crops and the reverse is the case in the area. This may also be as a result of both early or late onset and early or late cessation of rainfall. In this case it is as a result of early onset of rainfall in the area because onset date of rainfall in the area ranges between 7th May to 22nd May and cessation date ranges from 24th September to 13th October.

Hydrologic ratio also has a significant correlation at 0.01 levels (r =0.787) with millet yield at Kura. The result indicates that the ratio of mean annual rainfall to the potential evaporation in the area is low because this area has long dry season and crop yield is expected to be poor, supplementary irrigation may be required to reach optimum yield potential.

There is a significant correlation between millet yield and rainfall in June at 0.01 level (r =.685). This indicates that the higher amount of rainfall in June the higher the yield of millet. This is expected because the period coincides with the vegetative growth phase of millet. Study shows that rainfall distribution and the occurrence of moisture stress condition are critical to the yield formation of millet (Olaniran, 1981).

4.3.1 Combined Effects of the Climatic Elements on millet yield at Kura

The combined effects of the different precipitation effectiveness indices on the yield of millet at Kura were analyzed using the multiple regression technique. Only the five climatic variables which correlate significantly with yield at 99% probability level were included in the analysis. These are total rainfall, rainfall in June, and hydrologic ratio, length of rainfall and onset of dates of rainfall. Table 4.4 shows the summary of the regression result.

Table 4.4: Coefficient of Multiple Regressions of Significant Indices to Millet Yield

Variable	co-efficient	T-ratio	
HR	**.787**	**1.75***	**F =29.35**
Rainfall total	**2.92**	**1.261***	**R^2 = 60.2**
Onset	**.11.7**	**-5.20*****	
LRS	**3.33**	**1.60***	
June	**.0.80**	**2.90****	

Four of the five variables account for 62.0% of the variation in the yield of millet at Kura.

4.3.2 Relationship between Derived Precipitation Effectiveness Indices and Yield of Millet at Dambatta

The results of the correlation between millet yield and derived precipitation effectiveness indices at Dambatta is presented in Table 4.5.

Table 4.5: Millet yield correlation for Dambatta

Variables	Correlation coefficient
Rainfall total	**0.713****
Onset	**0-.688**
Cessation	**0.397**
HR	**0.798****
LRS	**0.718****
S.I	**0-.372**
June	**0.705****
July	**0-.047**
August	**0.084**
September	**0-.254**

Onset o **nfall sufficien** **nigh negative correlation with millet yield at Dambatta (r =-.688). This indicates that late onset of rains in the area could drastically reduce the final yield. Late onset of rainfall usually affects farmers adversely because rainfall received during the pre-sowing period is a measure of the some extent of the soil moisture available at germination (Semb and Ganberg,: 1969 Andrews 1973). Adebayo and Abdulhamed (1994) have shown is most essential for a better root system and growth at planting. That is why farmers have identified the onset dates as the single most desirable piece of forecast information, because rainfall will become fairly continuous and sufficient to ensure adequate soil moisture for and after planting. Delayed onset of rains is very critical in rainfed agriculture as it may lead to crop failure or poor yield.**

Length of rainy season has a significant correlation with yield (r =.718). The result shows that rainfall distribution and moisture stress are critical to yield formation. Short length of rainy or high concentration of rainfall in one phonological stage than the others, result in the occurrence of short term, high evaporative demand on the crop. The ability of millet to cope with moisture stress will depend on the stored moisture of the soil. Water balance analysis carried out by Kowal and Kassam (1973) has shown that lack of rain for a period of 5 days or more during the early growing

season creates water stress condition which may affect the performance of the millet crop. This is also in line with Adebayo's (1997) findings in Adamawa that length of rainy seasons has a significant correlation with yield of crops.

Rainfall in June has a positive and significant correlation with yield at Dambatta (r = 0.713). This also signifies the importance of rainfall during the pre-sowing and vegetative which refers to the period when the antecedent moisture status of the soil is good for planting and germination or sustained growth of seedling which may have effects on the final yield. It has been shown that rainfall supply during the period is more important for millet yield, than flowering and grain filling stage. The occurrence of moisture stress condition at that period are critical for yield formation, therefore the positive correlation is not surprising at that period in Dambatta because it has coincided with vegetative growth phase of millet in the area. According to Downes (1972) yield is relatively sensitive to water deficit during the stage.**

Hydrologic ratio also has high positive and significant correlation with millet yield at Dambatta (r =798) this shows the degree of wetness or dryness of a place which symbolizes soil moisture deficiency or surplus. This result is an indication of the adequacy of rainfall in the study area.

4.3.3 Combined Effects of climatic variables on millet yield at Dambatta

The combined effect of the different precipitation effectiveness indices on the yield of millet at Dambatta was also investigated using the multiple regression technique. Only the indices which are significantly correlated with millet yield at 95% or more probability level were included in the multiple regression analysis from table 4.6.

Table 4.6: Summary of the regression analysis at Dambatta

Variables	co-efficient	T-ratio	
HR	**.798**	**5.623**	**F = 23.60**
Rainfall total	**.086**	**2.96****	**R^2 =**
73.5%			
Onset	**-321**	**-1.922***	
LRS	**363**	**2.212****	

*** Significant at 0.05%**

**** Significant at 0.01%**

The coefficients of four of the variables are significant in the analysis, accounting for 73.5% of the variation in the yield of millet at Dambatta.

CHAPTER FIVE

SUMMARY OF THE STUDY, CONCLUSION AND RECOMMENDATIONS.

5.1 INTRODUCTION

This section deals with the summary of the study (overview of the study), conclusions and recommendations.

5.2 SUMMARY OF THE STUDY (OVERVIEW OF THE STUDY)

Precipitation is a very important resource in north Nigeria, as many human activities depend upon its availability. It is the factor that controls plant growth in region. Therefore, the amount and distribution of rainfall are important factors in determining the ultimate productivity of crops under natural conditions.

The review examines previous studies on crops climate relationship based on the three methods according to (Olaniran, 1981). The first is the studies of fundamentals of plant-climate relationship, namely the radiation and moisture balance for various climatic environments. The second method is the studies of plant-climate relationships under the controlled environmental. For examples, Babatola (1972) varied the soil moisture regime inside a green house with relative humidity averaging 80 percent and air temperature of 26^0c to study the effect of different soil moisture on plants of cocoa.

The third methods of determining climate agriculture relationships is by studying a number of places within a given area, for a long period as consistent records of both agriculture and climate allows and deducing agroclimatological relationships from analysis of the data.

The two sets of data are used for the purpose of this study. Daily rainfall records (mm) and millet yield data (kilograms per hectare), sourced from Kano Agricultural and Rural Development Authority (KARDA) and HadejiaJama'are River Basin Development Authority (HJRBDA) from 1988-2007. And this shows that the nature and extent of relationships between millet yield and climatic variable or elements at each of the study area were analyzed using multiple correlation and regression techniques.

From the analysis it was observed that, the combined effect of the different precipitation effectiveness indices on the yield of millet at Kura was analyzed using the multiple regression technique (Table 4.4). Only the five climatic variables which correlate significantly with yield at

95% and above probability level were included in the analysis from (Table 4.3). These are total rainfall, rainfall in June, hydrologic ratio and length of rainfall and onsets dates of rainfall. The coefficients of the four variables are significant in the analysis. Four of the five variables account for 62.0% and of the variation in the yield of millet at Kura.

Similarly the combined effect of the different precipitation effectiveness indices on the yield of millet at Dambatta was also investigated using the multiple regression technique (Table 4.6). Only the indices which are significantly correlated with yield at 95% or more probability level were included in the multiple regression analysis from (Table 4.6). The coefficients of the four variables are significant in the analysis. The four variables account for 73.5% of the variation in the yield of millet at Danbatta. The four variables are onset dates of rains, Hydrology ratio, length of the rainy section and rainfall in June.

5.3 CONCLUSION

This research examines precipitation effectiveness indices and millet yield in two Local Government Areas of Kano state. The study has provided detailed information on the uses of precipitation effectiveness indices which are the major climatic elements controlling millet production in the study areas. These climatic elements are: hydrologic ratio, total rainfall, onset dates of rains, cessation dates of rains, length of the rainy season and rainfall amount in the growing season (May, June, July, August and September). The study however, has not exhausted all the Agro-climatic parameters that influence crop yield.

5.4 RECOMMENDATIONS

Based on the findings of this research, the following recommendations are proposed:

1. **The planting period of millet must be as soon as antecedent moisture status of the soil is good for effective germination.**
2. **From the study, it is suggested that medium maturing varieties of millet should be introduce to minimize the effect of late onset of rains in the areas and also information on climatic data should be collected all over the state to provide information for long term planning of agricultural development in the study areas and in the state.**
3. **It is also suggested that the planting time of millet should be taking into consideration to avoid delayed as a result of seasonality of rainfall in the study areas.**

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APPENDIX A_1

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 LEAP YEAR USE REVERSE SIDE

JULIAN DATE CALENDAR A_2

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	330	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

USE IN 2004, 2008, 2012, 2016, 2020,2024, ETC.

```
CORRELATIONS
  /VARIABLES=Yeild RainfallaTotal
  /PRINT=TWOTAIL NOSIG
  /STATISTICS DESCRIPTIVES
  /MISSING=PAIRWISE.
```

Correlations

[DataSet0]

Descriptive Statistics

	Mean	Std. Deviation	N
Yeild	2.4689E2	59.63508	20
RainfallaTotal	1.2186E3	80.89005	20

Correlations

		Yeild	RainfallaTotal
Yeild	Pearson Correlation	1	.730**
	Sig. (2-tailed)		.000
	N	20	20
RainfallaTotal	Pearson Correlation	.730**	1
	Sig. (2-tailed)	.000	
	N	20	20

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

```
CORRELATIONS
  /VARIABLES=Yeild Onset
  /PRINT=TWOTAIL NOSIG
  /STATISTICS DESCRIPTIVES
  /MISSING=PAIRWISE.
```

Correlations

[DataSet0]

Descriptive Statistics

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Onset	1.3265E2	3.57292	20

Correlations

		Yeild	Onset
Yeild	Pearson Correlation	1	-.643**
	Sig. (2-tailed)		.002
	N	20	20
Onset	Pearson Correlation	-.643**	1
	Sig. (2-tailed)	.002	
	N	20	20

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

```
CORRELATIONS
  /VARIABLES=Yeild Cessation
  /PRINT=TWOTAIL NOSIG
  /STATISTICS DESCRIPTIVES
  /MISSING=PAIRWISE.
```

Correlations

```
[DataSet0]
```

Descriptive Statistics

	Mean	Std. Deviation	N
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Cessation	2.6190E2	3.87842	20

Correlations

		Yeild	Cessation
Yeild	Pearson Correlation	1	.414
	Sig. (2-tailed)		.070
	N	20	20
Cessation	Pearson Correlation	.414	1
	Sig. (2-tailed)	.070	
	N	20	20

Positive

```
CORRELATIONS
```

```
/VARIABLES=Yeild LRS
/PRINT=TWOTAIL NOSIG
/STATISTICS DESCRIPTIVES
/MISSING=PAIRWISE.
```

Correlations

[DataSet0]

Descriptive Statistics

	Mean	Std. Deviation	N
Yeild	2.4689E2	59.63508	20
LRS	1.2925E2	5.32002	20

Correlations

		Yeild	LRS
Yeild	Pearson Correlation	1	.734**
	Sig. (2-tailed)		.000
	N	20	20
LRS	Pearson Correlation	.734**	1
	Sig. (2-tailed)	.000	
	N	20	20

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

```
CORRELATIONS
  /VARIABLES=Yeild HR
  /PRINT=TWOTAIL NOSIG
  /STATISTICS DESCRIPTIVES
  /MISSING=PAIRWISE.
```

Correlations

[DataSet0]

Descriptive Statistics

	Mean	Std. Deviation	N
Yeild	2.4689E2	59.63508	20
HR	.4080	.10340	20

Correlations

		Yeild	HR
Yeild	Pearson Correlation	1	.787**
	Sig. (2-tailed)	.	.000
	N	20	20
HR	Pearson Correlation	.787**	1
	Sig. (2-tailed)	.000	.
	N	20	20

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

```
CORRELATIONS
  /VARIABLES=Yeild June
  /PRINT=TWOTAIL NOSIG
  /STATISTICS DESCRIPTIVES
  /MISSING=PAIRWISE.
```

Correlations

```
[DataSet0]
```

Descriptive Statistics

	Mean	Std. Deviation	N
Yeild	2.4689E2	59.63508	20
June	2.1720E2	10.90437	20

Correlations

		Yeild	June
Yeild	Pearson Correlation	1	.685**
	Sig. (2-tailed)	.	.001
	N	20	20
June	Pearson Correlation	.685**	1
	Sig. (2-tailed)	.001	.
	N	20	20

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

```
CORRELATIONS
  /VARIABLES=Yeild July
  /PRINT=TWOTAIL NOSIG
  /STATISTICS DESCRIPTIVES
  /MISSING=PAIRWISE.
```

Correlations

[DataSet0]

Descriptive Statistics

	Mean	Std. Deviation	N
Yeild	2.4689E2	59.63508	20
July	2.4065E2	12.84431	20

Correlations

		Yeild	July
Yeild	Pearson Correlation	1	.025
	Sig. (2-tailed)		.916
	N	20	20
July	Pearson Correlation	.025	1
	Sig. (2-tailed)	.916	
	N	20	20

```
CORRELATIONS
  /VARIABLES=Yeild August
  /PRINT=TWOTAIL NOSIG
  /STATISTICS DESCRIPTIVES
  /MISSING=PAIRWISE.
```

Correlations

[DataSet0]

Descriptive Statistics

	Mean	Std. Deviation	N
Yeild	2.4689E2	59.63508	20
August	2.7065E2	15.45205	20

Correlations

		Yeild	August
Yeild	Pearson Correlation	1	-.007
	Sig. (2-tailed)		.975
	N	20	20

Correlations

		Yeild	August
August	Pearson Correlation	-.007	1
	Sig. (2-tailed)	.975	
	N	20	20

```
CORRELATIONS
  /VARIABLES=Yeild September
  /PRINT=TWOTAIL NOSIG
  /STATISTICS DESCRIPTIVES
  /MISSING=PAIRWISE.
```

Correlations

```
[DataSet0]
```

Descriptive Statistics

	Mean	Std. Deviation	N
Yeild	2.4689E2	59.63508	20
September	1.9635E2	7.31455	20

Correlations

		Yeild	September
Yeild	Pearson Correlation	1	.220
	Sig. (2-tailed)		.352
	N	20	20
September	Pearson Correlation	.220	1
	Sig. (2-tailed)	.352	
	N	20	20

```
CORRELATIONS
  /VARIABLES=Yeild SI
  /PRINT=TWOTAIL NOSIG
  /STATISTICS DESCRIPTIVES
  /MISSING=PAIRWISE.
```

Correlations

[DataSet0]

Descriptive Statistics

	Mean	Std. Deviation	N
Yeild	2.4689E2	59.63508	20
SI	1.1355	.04334	20

Correlations

		Yeild	SI
Yeild	Pearson Correlation	1	.051
	Sig. (2-tailed)		.830
	N	20	20
SI	Pearson Correlation	.051	1
	Sig. (2-tailed)	.830	
	N	20	20

```
SAVE OUTFILE='C:\Users\slim\Documents\danladi kano\Kaura.sav'
  /COMPRESSED.
REGRESSION
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT Yeild
  /METHOD=STEPWISE RainfallaTotal Onset LRS HR June.
```

Regression

[DataSet0] C:\Users\slim\Documents\danladi kano\Kaura.sav

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	HR	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: Yeild

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.787[a]	.620	.599	37.77841

a. Predictors: (Constant), HR

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	41880.757	1	41880.757	29.345	.000[a]
	Residual	25689.754	18	1427.209		
	Total	67570.510	19			

a. Predictors: (Constant), HR

b. Dependent Variable: Yeild

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	61.629	35.228		1.749	.097
	HR	454.078	83.824	.787	5.417	.000

a. Dependent Variable: Yeild

Excluded Variables

```
NEW FILE.
DATASET NAME DataSet1 WINDOW=FRONT.
DATASET ACTIVATE DataSet1.
DATASET CLOSE DataSet0.
CORRELATIONS
  /VARIABLES=Yeild RainfallTotal
  /PRINT=TWOTAIL NOSIG
  /STATISTICS DESCRIPTIVES
  /MISSING=PAIRWISE.
```

Correlations

[DataSet1]

Descriptive Statistics

	Mean	Std. Deviation	N
Yeild	2.1972E2	10.34731	20
RainfallTotal	1.5576E3	302.19570	20

Correlations

		Yeild	RainfallTotal
Yeild	Pearson Correlation	1	.713**
	Sig. (2-tailed)		.000
	N	20	20
RainfallTotal	Pearson Correlation	.713**	1
	Sig. (2-tailed)	.000	
	N	20	20

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

```
CORRELATIONS
  /VARIABLES=Yeild Onset
  /PRINT=TWOTAIL NOSIG
  /STATISTICS DESCRIPTIVES
  /MISSING=PAIRWISE.
```

Correlations

[DataSet1]

Descriptive Statistics

	Mean	Std. Deviation	N
Yeild	2.1972E2	10.34731	20
Onset	1.4005E2	6.00417	20

Correlations

		Yeild	Onset
Yeild	Pearson Correlation	1	-.688**
	Sig. (2-tailed)		.001
	N	20	20
Onset	Pearson Correlation	-.688**	1
	Sig. (2-tailed)	.001	
	N	20	20

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

```
CORRELATIONS
  /VARIABLES=Yeild Cessation
  /PRINT=TWOTAIL NOSIG
  /STATISTICS DESCRIPTIVES
  /MISSING=PAIRWISE.
```

Correlations

[DataSet1]

Descriptive Statistics

	Mean	Std. Deviation	N
Yeild	2.1972E2	10.34731	20
Cessation	2.6545E2	9.37789	20

Correlations

		Yeild	Cessation
Yeild	Pearson Correlation	1	.397
	Sig. (2-tailed)		.083
	N	20	20
Cessation	Pearson Correlation	.397	1
	Sig. (2-tailed)	.083	
	N	20	20

```
CORRELATIONS
  /VARIABLES=Yeild HR
  /PRINT=TWOTAIL NOSIG
  /STATISTICS DESCRIPTIVES
  /MISSING=PAIRWISE.
```

Correlations

```
[DataSet1]
```

Descriptive Statistics

	Mean	Std. Deviation	N
Yeild	2.1972E2	10.34731	20
HR	.4260	.02798	20

Correlations

		Yeild	HR
Yeild	Pearson Correlation	1	.798**
	Sig. (2-tailed)		.000
	N	20	20
HR	Pearson Correlation	.798**	1
	Sig. (2-tailed)	.000	
	N	20	20

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

```
CORRELATIONS
  /VARIABLES=Yeild LRS
  /PRINT=TWOTAIL NOSIG
  /STATISTICS DESCRIPTIVES
  /MISSING=PAIRWISE.
```

Correlations

```
[DataSet1]
```

Descriptive Statistics

	Mean	Std. Deviation	N
Yeild	2.1972E2	10.34731	20
LRS	1.2540E2	10.93714	20

Correlations

		Yeild	LRS
Yeild	Pearson Correlation	1	.718**
	Sig. (2-tailed)		.000
	N	20	20
LRS	Pearson Correlation	.718**	1
	Sig. (2-tailed)	.000	
	N	20	20

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

```
CORRELATIONS
  /VARIABLES=Yeild June
  /PRINT=TWOTAIL NOSIG
  /STATISTICS DESCRIPTIVES
  /MISSING=PAIRWISE.
```

Correlations

```
[DataSet1]
```

Descriptive Statistics

	Mean	Std. Deviation	N
Yeild	2.1972E2	10.34731	20
June	2.1520E2	10.93329	20

Correlations

		Yeild	June
Yeild	Pearson Correlation	1	.705**
	Sig. (2-tailed)		.001
	N	20	20
June	Pearson Correlation	.705**	1
	Sig. (2-tailed)	.001	
	N	20	20

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

```
CORRELATIONS
  /VARIABLES=Yeild July
  /PRINT=TWOTAIL NOSIG
  /STATISTICS DESCRIPTIVES
  /MISSING=PAIRWISE.
```

Correlations

[DataSet1]

Descriptive Statistics

	Mean	Std. Deviation	N
Yeild	2.1972E2	10.34731	20
July	2.5435E2	12.02749	20

Correlations

		Yeild	July
Yeild	Pearson Correlation	1	-.047
	Sig. (2-tailed)		.845
	N	20	20
July	Pearson Correlation	-.047	1
	Sig. (2-tailed)	.845	
	N	20	20

```
CORRELATIONS
  /VARIABLES=Yeild August
  /PRINT=TWOTAIL NOSIG
  /STATISTICS DESCRIPTIVES
  /MISSING=PAIRWISE.
```

Correlations

[DataSet1]

Descriptive Statistics

	Mean	Std. Deviation	N
Yeild	2.1972E2	10.34731	20
August	2.8290E2	11.39668	20

Correlations

		Yeild	August
Yeild	Pearson Correlation	1	.084
	Sig. (2-tailed)		.724
	N	20	20
August	Pearson Correlation	.084	1
	Sig. (2-tailed)	.724	
	N	20	20

```
CORRELATIONS
  /VARIABLES=Yeild September
  /PRINT=TWOTAIL NOSIG
  /STATISTICS DESCRIPTIVES
  /MISSING=PAIRWISE.
```

Correlations

```
[DataSet1]
```

Descriptive Statistics

	Mean	Std. Deviation	N
Yeild	2.1972E2	10.34731	20
September	1.9830E2	5.75920	20

Correlations

		Yeild	September
Yeild	Pearson Correlation	1	-.254
	Sig. (2-tailed)		.280
	N	20	20
September	Pearson Correlation	-.254	1
	Sig. (2-tailed)	.280	
	N	20	20

```
CORRELATIONS
  /VARIABLES=Yeild SI
  /PRINT=TWOTAIL NOSIG
  /STATISTICS DESCRIPTIVES
  /MISSING=PAIRWISE.
```

Correlations

[DataSet1]

Descriptive Statistics

	Mean	Std. Deviation	N
Yeild	2.1972E2	10.34731	20
SI	1.1270	.06258	20

Correlations

		Yeild	SI
Yeild	Pearson Correlation	1	-.372
	Sig. (2-tailed)		.106
	N	20	20
SI	Pearson Correlation	-.372	1
	Sig. (2-tailed)	.106	
	N	20	20

```
SAVE OUTFILE='C:\Users\slim\Documents\danladi kano\Dambatta.sav'
  /COMPRESSED.
REGRESSION
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT Yeild
  /METHOD=STEPWISE RainfallTotal Onset HR LRS June.
```

Regression

[DataSet1] C:\Users\slim\Documents\danladi kano\Dambatta.sav

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	HR	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	June	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: Yeild

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.798[a]	.637	.617	,6.40300
2	.857[b]	.735	.704	5.62933

a. Predictors: (Constant), HR

b. Predictors: (Constant), HR, June

ANOVA[c]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1296.301	1	1296.301	31.618	.000[a]
	Residual	737.970	18	40.998		
	Total	2034.271	19			
2	Regression	1495.553	2	747.777	23.597	.000[b]
	Residual	538.718	17	31.689		
	Total	2034.271	19			

a. Predictors: (Constant), HR

b. Predictors: (Constant), HR, June

c. Dependent Variable: Yeild

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	93.983	22.407		4.194	.001

a. Dependent Variable: Yeild

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	HR	295.156	52.491	.798	5.623	.000
2	(Constant)	50.328	26.290		1.914	.073
	HR	217.271	55.627	.588	3.906	.001
	June	.357	.142	.377	2.508	.023

a. Dependent Variable: Yeild

Excluded Variables[c]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	RainfallTotal	.086[a]	.296	.771	.071	.249
	Onset	-.321[a]	-1.922	.072	-.422	.628
	LRS	.363[a]	2.215	.041	.473	.616
	June	.377[a]	2.508	.023	.520	.688
2	RainfallTotal	.077[b]	.298	.769	.074	.249
	Onset	-.175[b]	-.984	.340	-.239	.492
	LRS	.222[b]	1.242	.232	.297	.472

a. Predictors in the Model: (Constant), HR

b. Predictors in the Model: (Constant), HR, June

c. Dependent Variable: Yeild