THE IMPACTS OF DROUGHT ON CROP AND LIVESTOCK PRODUCTION IN NORTHERN PART OF SOKOTO STATE

by

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CERTIFICATION

This is to certify that this project is an original work undertaken by Hammani Aliyu Dari Gada PGD/GEO/98/99/022 under the able guidance of Dr. G.N.Nsofor and has been prepared in accordance with the regulations governing the preparation and presentation of project in the Department of Geography, Federal University of Technology, Minna - Niger state. Relevant work and other authors used in this project are duly acknowledged and accorded credit.

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DEDICATION

This project is dedicated to my lovely wife and daughter Mrs Aishatu Hammani and Amina H Dari for their contribution towards the successful completion of my course.

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ABSTRACT

This research examines the impact of drought on crops and livestock production in the Northern part of Sokoto State. Drought is a period of dry weather of sufficient duration that may cause devastating effects on both crops, livestock and human lives. The study area has been experiencing a continuous plague of drought. The techniques employed in this research is the analysis of data on rainfall, livestock and crop losses for a period of twenty years from 1980-1999. These data were statistically tested using student's t-test. The result of this statistical test showed that there was significant impact of drought on livestock and crop production in the study area.

The research also established amongst others that:

a. drought in the study area was a recurrent phenomenon and a threat to all the agricultural activities to which all the indigenous responses have evolved.

b. rainfall in the study area cannot be guaranteed with the coming of any rainy season and when it comes, it is usually below normal requirements which may result in crop failure, and death of livestock.

c. farming as well as herding was very much a risky business in the study area.

Issues on the research problem and limitations were also briefly discussed, and lines along which future works may proceed were suggested.

CHAPTER ONE

INTRODUCTION AND BACKGROUND OF THE STUDY

1.1 Introduction

Drought is a periodic reduction in moisture availability below the average conditions. It can also simply be defined as the non-availability of adequate amount of water for man, animals and crops.

Animals and crops production is by far the most important form of human activity in Sokoto State. Even in this modern times, agriculture of any kind provides livelihood for more than half of human race (Adeleke and Gohs, 1978).

Agriculture yields raw materials for industries and factories on which people depend. From the crops the farmer grows, he gets his food to feed his family. The surplus is sold for cash, from which he buys the necessities of his life. However, in recent years agriculture has been affected badly by drought. Drought is one of the man's natural hazards. It has a subtle beginning, insidious progress and devastating effects (Hounum et al 1975).

The problems associated with drought have plagued farmers for many years. It is true once a drought has started, there is partial loss o agricultural production, mass starvation, famine and cessation of economic activities particularly within the developing countries like Nigeria where economies are mainly tied to agriculture. In Nigerian, the northern states are the most affected areas, especially areas lying north of latitude 11°N.

These areas cannot be guaranteed with the approach of any rainy season whether the rains will fall, or if they do, how long they will last. When the precipitation fail to drop, as in the late 1960s, culminating in the early 1970s, 1972-74, and 1984 drought, many farmers within the study area never had chance to plant any crops. The more glaring ones usually have their crops burnt under hot sun. There is also livestock loss during droughts. The land is also under stress from both man and his livestock, and this may cause damage to the environment.

This research may be faced with problems of useful data in the study of drought. However, Yevjevich et al (1978) indicated that it is necessary for this kind of research to aim at the following points:

i. defining areas of drought worthy of support in the light of expected results, such areas must be relevant to the anticipated future conditions of the economy in order to minimise the consequences of available droughts through planned contingency or drought response and control measures;

ii. ensuring that effective attention is given to the research on the water resource aspects of drought by distinguishing related non-water aspects of droughts responses such as agricultural production under drought conditions.

Operating within the context of the possible drought research needs, he identified five basic research areas amongst which is drought impact minimisation control measures. It is at the premises of these areas that the present study is justifiable.

> If drought comes, everybody is concerned. If drought lasts, everybody is trying to do something without succeeding, and if drought is over, everybody forget except those who have been hurt" (Yevjevich et al 1983).

1.2 Study Problem Formulation

Drought struck most part of northern Nigeria lying 11°N north of the equator in 1968. Since then, there has been reoccurrence in the area. The drought was followed by crops failure and livestock *mortality.* It was particularly severe in 1968-73 and 1982-84 drought. During each of these periods, there was less rainfall than required by crops to complete their maturity. This resulted in crop failure; there was not enough grasses, vegetation cover for the animals to feed on, consequent upon which there was increased livestock mortality rate. For example during the 1973 drought food production deficit was as high as 60-70% for some crops (eg. beans and sorghum) in Borno, Sokoto, Yobe and Kano States (Mijindadi and Adegbehin 1991). At the national level agricultural yields ranged between 12 and 40% of the annual averages (Oguntoyinbo and Richards 1977) during the drought. Even in recent years, the farmers, the herders, and all inhabitants of this area, are not sure of the coming of the rainfalls - with start and even duration being unreliable. Therefore both farmers and herders have their invested efforts for a living threatened.

1.3 Objectives

The main objective of this study include the following:

i. To ascertain the impact of drought on livestock production.

ii. To ascertain the impact of drought on crops production.

iii. To examine the various problems caused by drought in study areas.

iv. To recommend measures or suggestions of controlling or minimising the effects of drought in the study area.

1.4 Hypotheses

In the study area livestock losses and crops failures are attributed to weather condition, most especially drought. Both farmers and herders assume that the availability of water in soil required by plants and animals facilitate their survival, and non-availability of water or shortage as required by crops and animals (as in the drought year of 1973) urgur against survival. In other words, crops cannot reach their growth cycle in the absence of enough water, and animals cannot survive long period without water. Therefore based on above assumption, four working hypothesis were tested statistically to verify their validity and significance. These hypotheses included (i) there is no significant drop in crop yields during drought periods (year) (ii) there is no significant increase in livestock mortality rate during drought periods (Appendix 1-12).

1.5 Study Area (Fig. 1.2)

The study area is northern part of Sokoto State (ie. Kwane Gada, Goronyo, Gwadabawa, Illela, Kwane, and Wurno Local Government Areas of Sokoto State). The area is defined by latitudes 12° and 13°45′ North and 4°15′ and 6°00′ East (Fig.1.2) covering a total land area of about 256 sq km. It lies next to the Niger Republic to the north. The most widespread occupations of the inhabitants of this area include grain farming and normadic herding. Both occupations depend upon the annual rainfall for farming and grazing respectively. Fig. 1.5 shows Annual Rainfall (1961-84).

1.6 Rainfall Situation

Sokoto State lies in the rainfall grid of 300 mm up north to 600 mm down south (Fig.1.4) and historically the farmers have adjusted their cropping systems to these changes. However, the year to year rainfall distribution has a great bearing determining the changes in cropping systems and particularly crop yields and production.

Table 1 shows the distribution of rainfall zonewise. Rainfall during 1986, on the overall, was 682 mm compared with 587 mm during 1985. On the average the number of days it rained was almost the same during 1984 and 1986, but the amount of rainfall varied significantly. On the whole, there were more heavy rains during 1985 and still heavier during 1986.

The western and central zone received significantly more rainfall during 1986 than 1985, western zone rather received it on less numbr of days, 36 days in 1986 vis-a-vis 39 days in 1985; and the rainfall was 716 mms in 1986 compared with 607 mms in 1985. In the central zone, the number of rainy days increased from 35 days in 1985 to 47 days in 1986 and the rainfall varied from 578 mms in 1985 to 828 mms in 1986. Infact, on many days there were floods in most parts of the state.

Northern zone received almost the same amount of rainfall during 1986 which was 439 mms. Eastern zone received a little less, ie. 656 mms during 1986 compared with 723 mms during 1985. The rainfall in the state varies significantly from North and North-East to South-West. Likewise, the cropping/grazing pattern in the north of the state is considerably different from the one in the south-western parts of the state.

Table 1: Total Rainfall, Zonewise 1984-1986

Zone	1984	1985	1986
Eastern Rainfall Amount			
(mms)	606	723	656
rain days	42	45	40
Western Rainfall Amount			
(mms)	531	607	716
rain days	34	39	36
Northern Rainfall Amount			
(mms)	294	441	434
rain days	25	33	30
Central Rainfall Amount			
(mms)	568	578	828
rain days	36	35	47
State Aveerage Rainfall Amount			
(mms)	501	587	682
rain days	36	37	38

Source: Sokoto Agricultural and Rural Development Authority (SARDA)

Table 1.2: Climatic Data for Sokoto State

Temperature	J	F	M	A	M	J	J	A	S	O	N	D
Maximum O^c	29.0	29.8	47.5	78.0	42.5	38.5	35.7	32.5	35.2	35.3	32	32
Mean O^c	22	24	40	41	32	30	29	29	30	30	30	29.5
Minimum O^c	12	17.5	22	29	28	27	26	26	26	25	25	24
Rainfal (mm)	-	-	-	1.6	16.2	62.4	91.5	110.5	56.2	3.5	-	-
Rative Humidity												
% 6 a.m	40	41	42	46	52	55	62	63	62	45	41	40
12 noon	18	19	21	22	46	50	50	47	45	42	31	25

Source: Department of Geography Observatory 1990
Usuman Danfodio University, Sokoto

1.7 Climate

Generally the area experiences a tropical climate with two major prevailing winds, the dry continental northeasternly (harmattan) wind which blows into the country from the Sahara desert in dry season and brings harmattan, and the southerwesterly monsoon wind which blows inland from Atlantic Ocean during the rainy season. During the dry season the air is dry, the temperatures is higher with hot days and relatively cool nights. The relative humidity is low, about 40% in some places. Rainfall is practically nil and the sky is generally cloudless. Visibility is often poor owing to the dust haze borne by harmattan. Average temperature are higher during the month of April through March (Table 1.2). The cylic pattern of low or nil rainfall alternating with the years of above average rainfall totals has been established (Fig.1.3).

1.8 Soils

The soils of the area are mostly composed of unconsolidated sands. They are usually developed from desert sand-rift called regosols. In some areas like Illela, Gada and Saon Birni, these desert deposits had been subjected to greater pedogenesis giving rise to the brown and reddish brown soils. These types of soils usually have a clay-enriched B-horizon with fairly high content of weatherable minerals which has higher water and nutrient holding capacities with adequate water either from rainfall or by irrigation. Such types of soils are very productive. However the degree of leaching is very high, due to the effect of drought conditions which totally render the area very permeable and susceptible to both water and wind erosion, and hence the soil become dry and sandy with sand fractions exceeding seventy per cent (70%) and low ability to hold both water and nutrient.

1.9 Vegetation

The vegetation of the aea is mixed combrataceous woodlord Sudan-Savanna dominated by hyparrhernia, subplumosa and H. cynanesceus species with shrubs, little and short grasses, and scattered short savanna trees (Chevalier 1980). The vegetation has been modified by intense cultivation, firewood cutting, bush burning, and animal grazing which denies the natural defense mechanisms against environmental hazards such as drought, desertification, and soil erosion among others.

Fig. 1.1

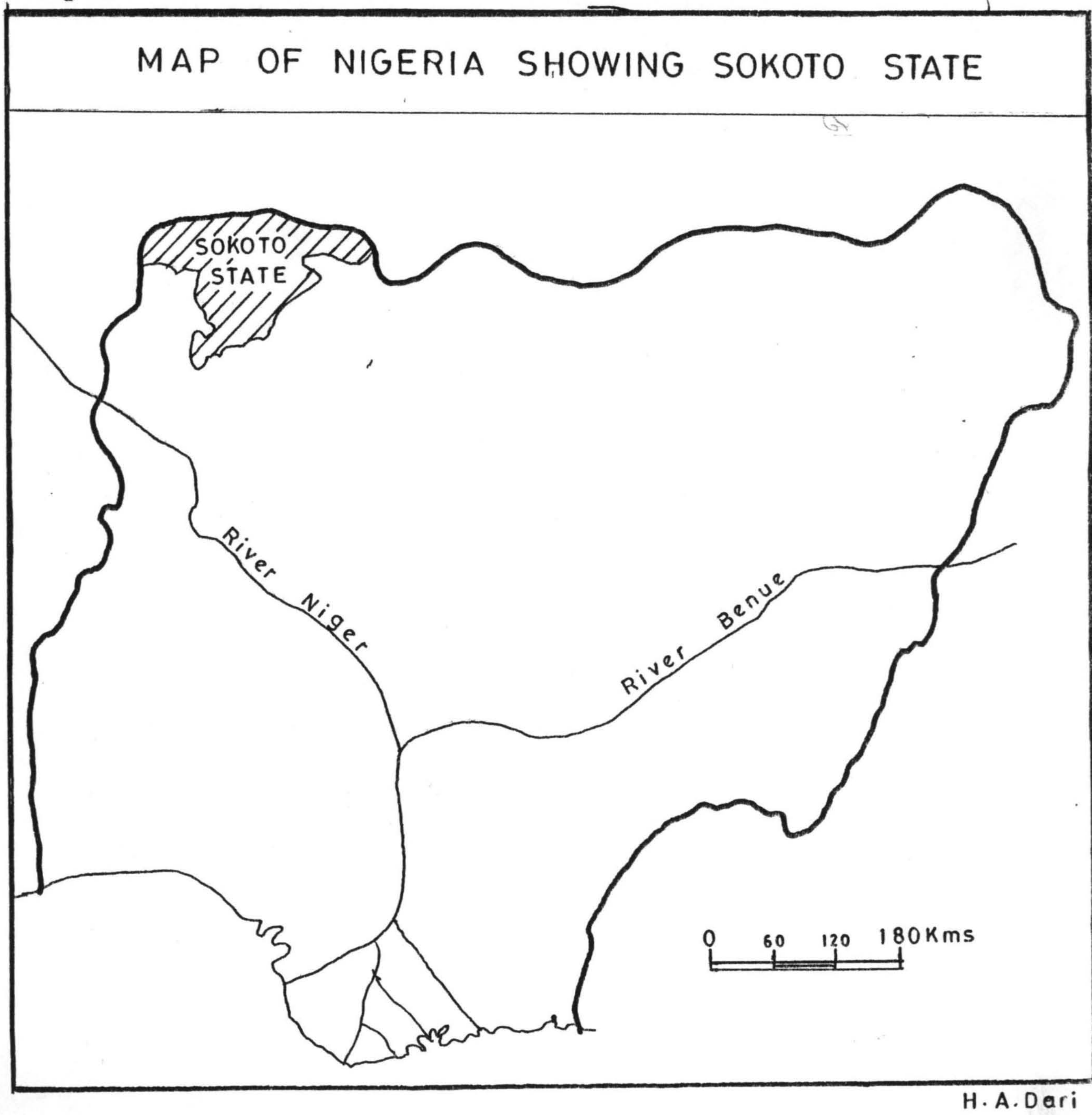


FIG. 1.1

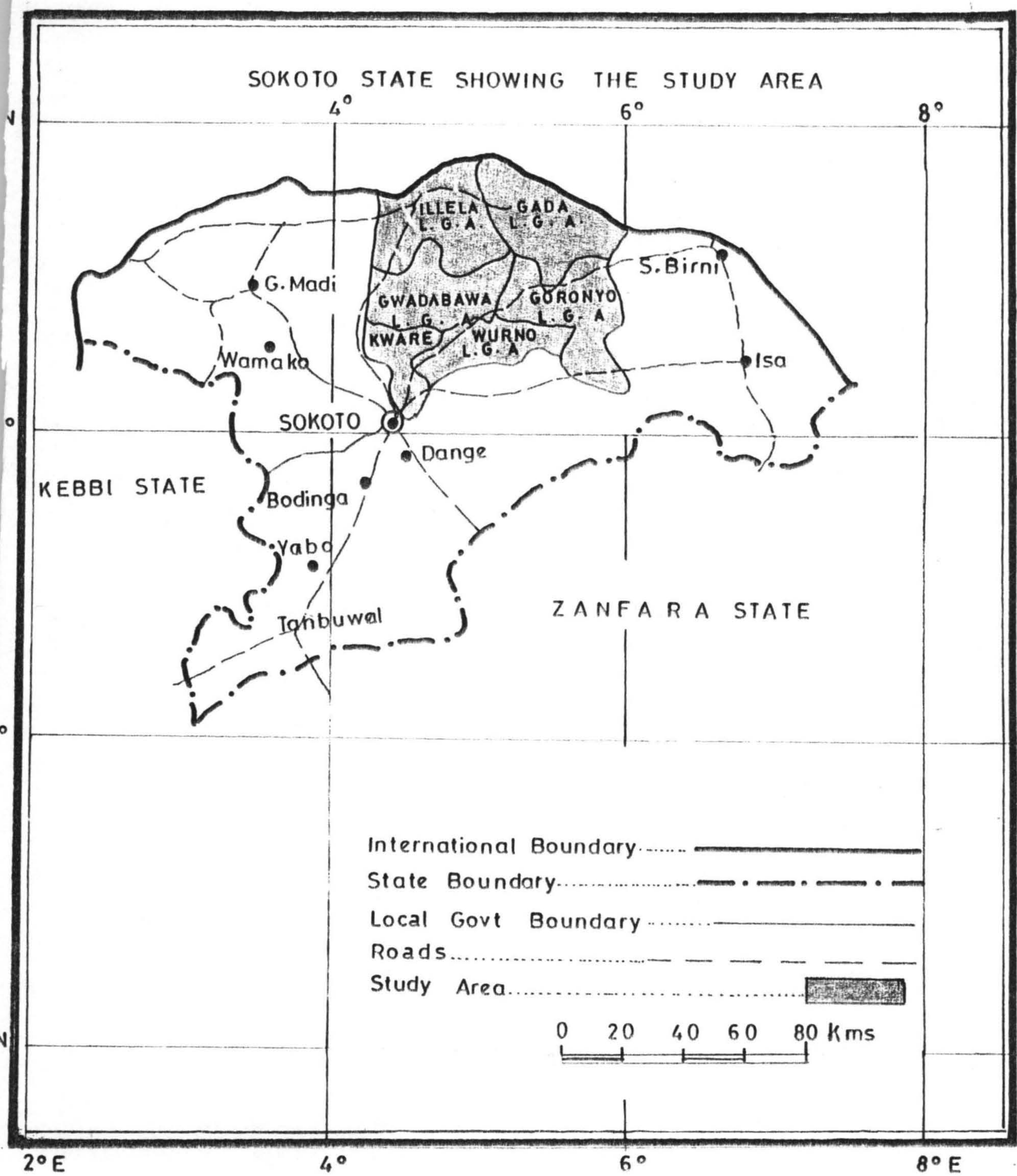
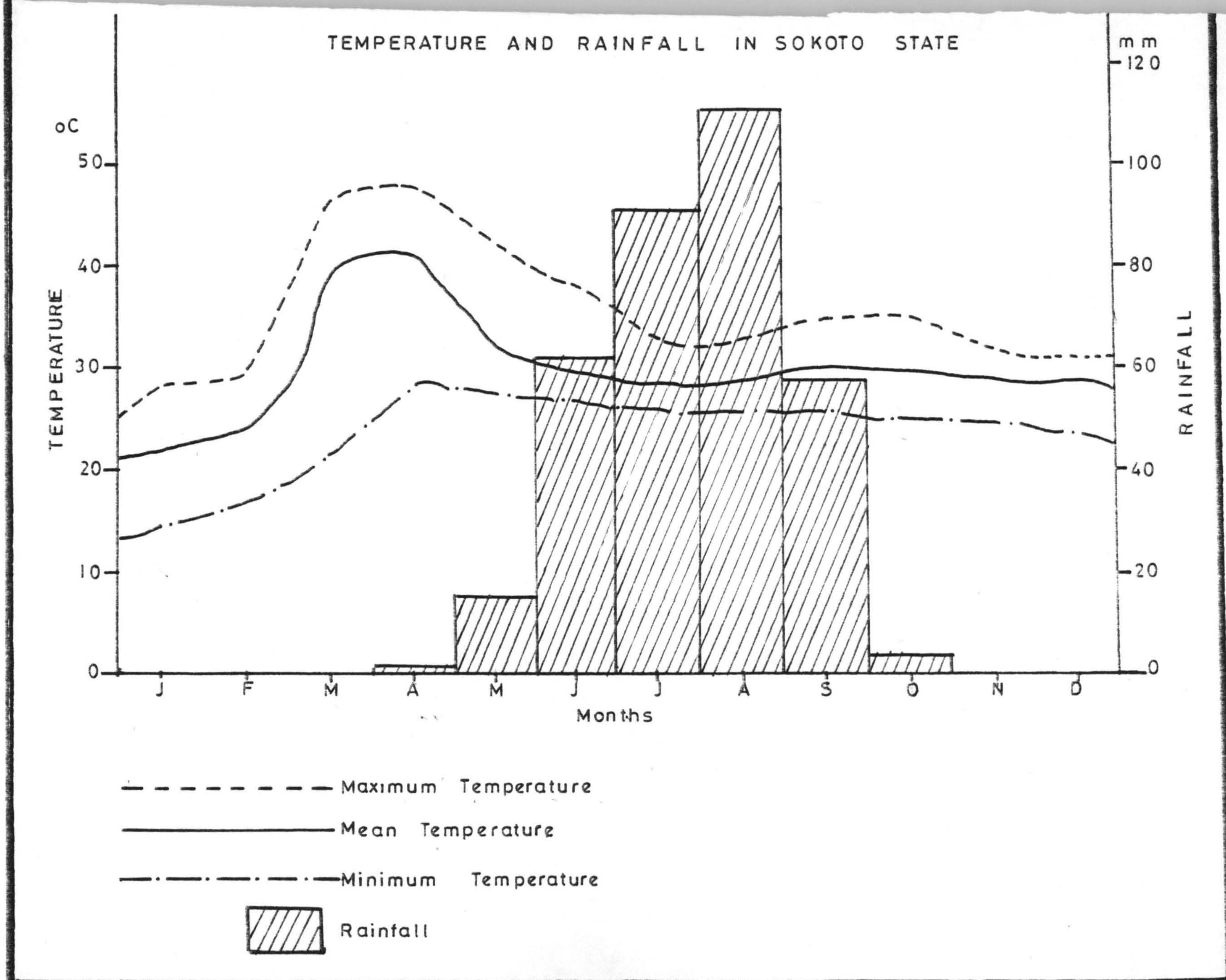
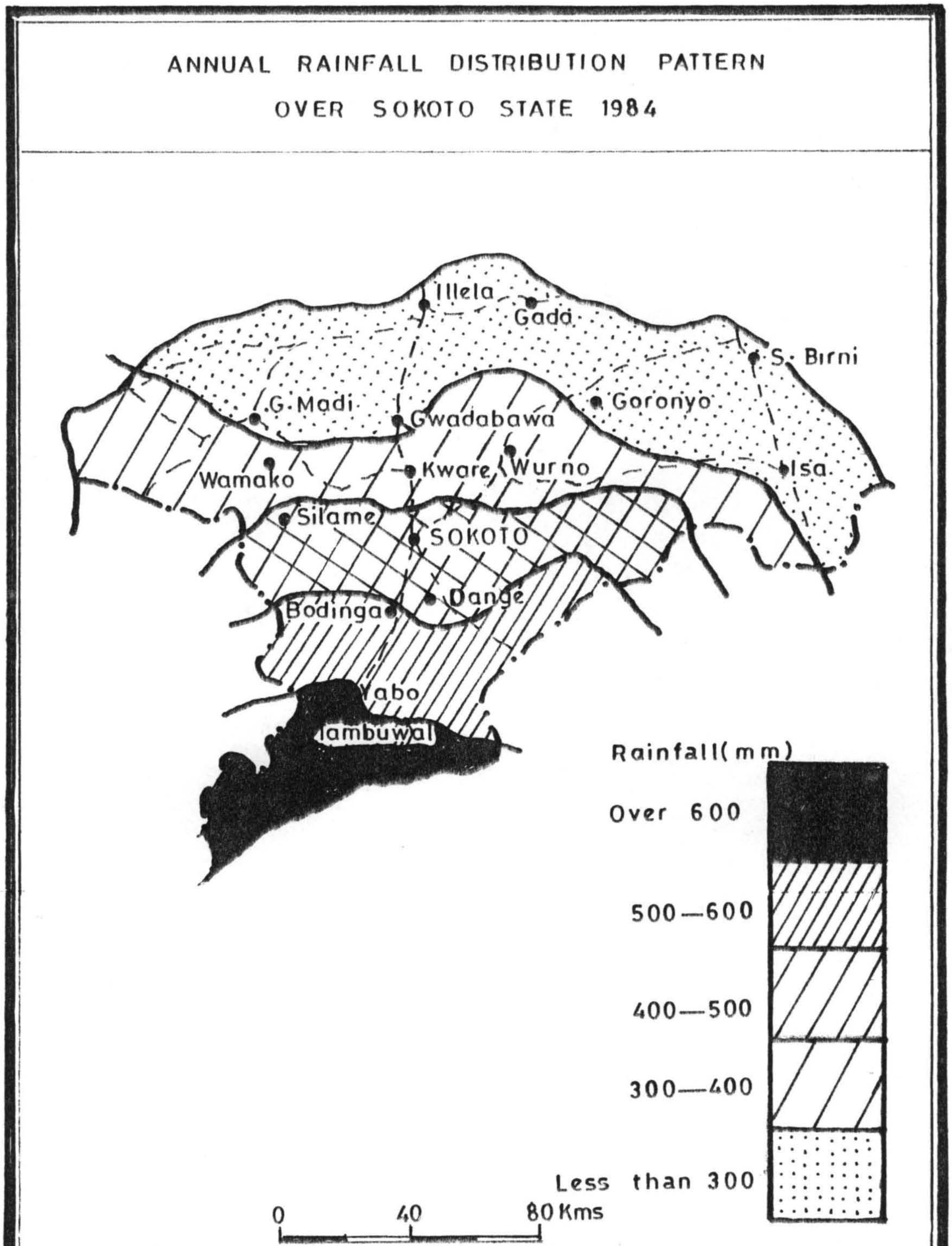

SOKOTO STATE SHOWING THE STUDY AREA
4°
6°
8°
14°N
12°
10°
8°
2°E
4°
6°
8°E
ILLELA L.G.A.
GADA L.G.A.
GWADABAWA L.G.A
GORONYO L.G.A
KWARE
WURNO L.G.A
S.Birni
G.Madi
Wamako
Isa
SOKOTO
Dange
KEBBI STATE
Bodinga
Yabo
Tambuwal
ZANFARA STATE
International Boundary
State Boundary
Local Govt Boundary
Roads
Study Area
0 20 40 60 80 Kms
HAD

FIG. 1.2



Based on data in Table 1·2 FIG. 1·3



Based on data in Table 1

H. A. DARI

FIG. 1.4

ANNUAL RAINFALL IN SOKOTO 1961——1984

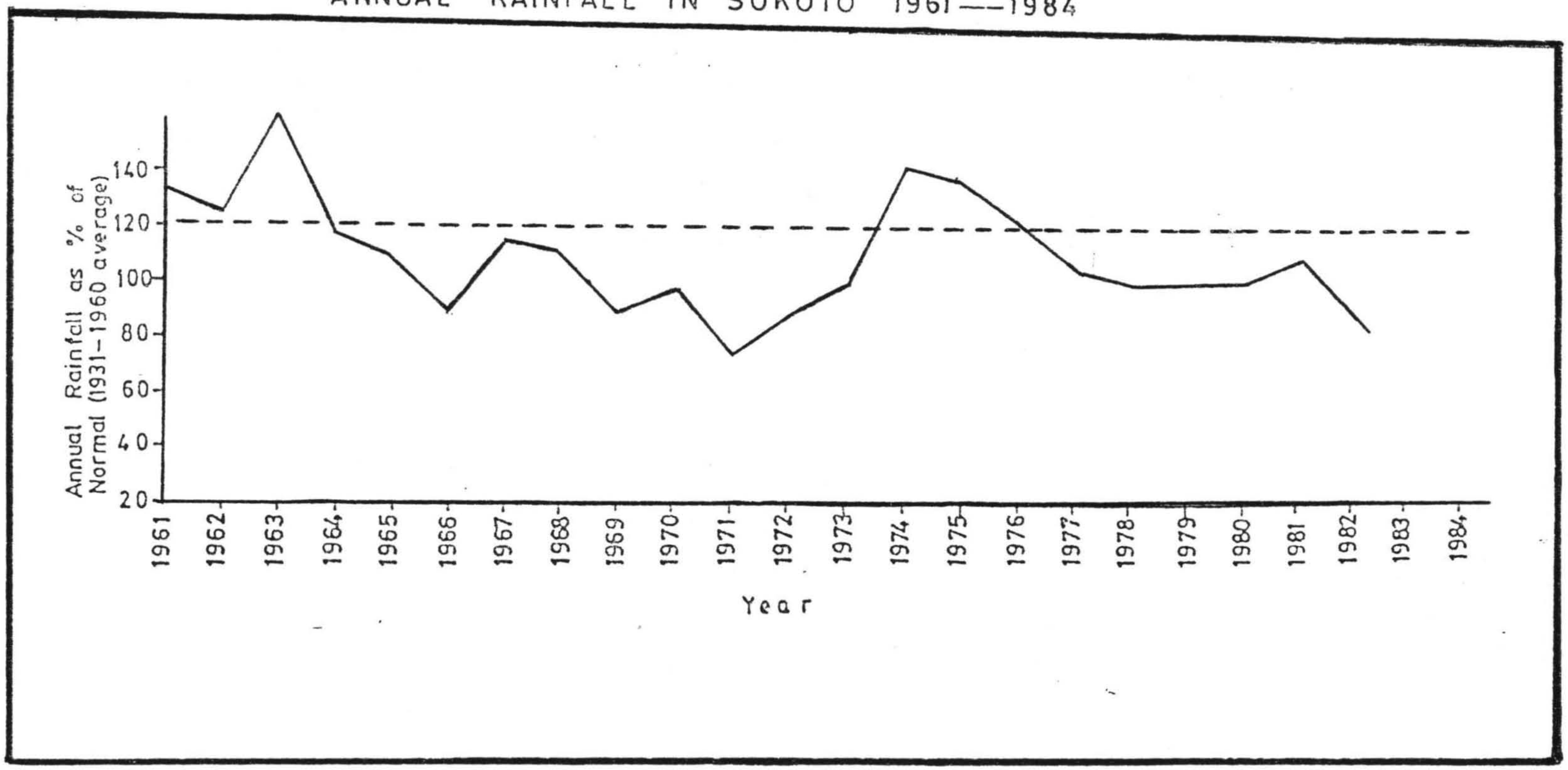


FIG. 1.5

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter aims at reviewing relevant literature for the study. There is no doubt that meteorological literature abound with reports on the studies of draught and impact of drought. Throughout Northern Nigerian, drought has had severe and sometimes catastrophic effects on vital human activities. Even at present, drought continues to affect this region.

2.2 Definitions

The literature concerned with drought is, nevertheless, replete with references to particularly dry years as being abnormal or anomalous. Yet, because perceptions about what constitutes a drought vary, there is widely accepted definitions of drought. However, the scores of definitions could be objectively divided into two types: meteorological and agricultural sub-groups (Plamer, 1964; Saarinen 1966). But one point that must be emphasised at the outset is that drought is not synonymous with aridity. As Landsberg (1967) has rightly pointed out, aridity is a natural state while drought is primarily an affliction of cultivated regions.

A meteorological drought could be defined as that time period when the amount of rainfall is less than some designated percentage of the long term mean. An agricultural drought, on the other hand, could be defined in terms of vegetation development. When the rainfall is not available to crops at crucial periods in crop development, the seedling or at some later state of crop development, the crops will wither and die (Ghantz and Richard, 1977).

According to Oladipo (1985), there is no universally acceptable definition of drought; there are natural and human factors that have been used to define drought. The natural factors include the climate of an area, the amount of soil moisture, spatial and temporal distribution of rainfall, water table fluctuations, water supply and soil type.

The human factors may include the degree of water storage distribution system, the number, locations and depths of wells, the pattern of water use etc. He, however, defined drought in terms of its meteorological, hydrological elimatological and the agricultural features.

Meteorological drought is regarded as dryness due to lack of precipitation. It may be defined as a significant decrease from normal precipitation over a wide area for an extended time. Two types of drought; absolute and partial drought are recognised by meteorologists. An absolute drought is defined as a period of at least 15 consecutive days without single drop of rainfall, while a partial drought is a period of at least 29 consecutive days, the mean daily rainfall which does not exceed 0.2 mm (Mclutosh, 1963).

Climatological drought is defined in terms of rainfall departures from the long term mean called the 'normal'. Thus a drought is said to occur when the rainfall received in a year or season is less than a specified percentage of the long term annual or seasonal average. The percentages often used vary to denote different intensities of drought and are normally expressed in terms of percentage derivations of received rainfall from the long term average (Table 2.1).

Table 2.1: Climatic Definition of Drought of Various Intensities

Drought Type	% Deviation from the Mean
Slight drought	11.25
Moderate drought	26–45
Severe drought	46–60
Disastrous drought	More than 60

As shown in Table 2.1, when the rainfall received is 11.25% below normal, the drought is regarded as slight. The drought is labelled disastrous if the rainfall is more than 60% below normal. Also the rainfall departures from the long-term average may be expressed in terms of number of standard deviation from the mean (Table 2.2).

Table 2.2: Climatic Definition of Rainfall Deficiency of Various Intensities

Rainfall Values (mm)	Types of Deficiency
Below -30	Extremely subnormal rainfall
-30 to -20	Greatly subnormal rainfall
-20 to -0	Subnormal rainfall
-0 to +10	Normal rainfall
+10 to +20	Above normal rainfall
+20 to +30	Greatly above normal rainfall
More than +30	Extremely above normal rainfall

Source: J.O. Ayoade (Drought and Desertification in Nigeria)

Rainfall is regarded as normal if it lies within one standard deviation of the mean. It is extremely above normal if it is more than three standard deviations above the long term mean. Conversely, it is regarded as extremely sub-normal if it is more than three standard deviations below the long term average.

Hydrological drought is defined with reference to river flow and the level of water in ground water storage. Therefore hydrological drought occurs when the river discharge is virtually nil or falls below a critical amount, or when wells which do not run dry are dry or their water levels are very low owing to lack of replenishment from inadequate precipitation.

An agricultural drought occurs when the water demands of crops are not met by falling precipitation is inadequate to maintain soil moisture supply.

Under such condition, the crops do not grow well or may even wither and die. Four types of agricultural drought have been identified (Thornthwaite, 1944). They are permanent, seasonal, contingent and invisible drought. Permanent drought is found in arid environments where there is not enough water to satisfy the needs of crops. In such areas cultivation is impossible without irrigation. Seasonal drought occurs in areas with wet and dry season as in most parts of the study area. This type of drought can be expected every year owing to seasonal changes in atmospheric circulation patterns.
Contingent and invisible droughts result from rainfall that is irregular and variable. Contingent drought occurs over a period of time when rainfall fails to drop, and it poses great hazard to agriculture. Invisible drought is less easily recognised by wilting of crops or lack of much vegetative growth as in the study areas. Generally it does not allow crops to grow at their optimum rates and occurs any time the daily supply of moisture from the soil and/or falling precipitation fails to meet the daily water needs of crops. A slow drying of the soil takes place and crops fail to grow at their optimum rate thus resulting in less than optimum crop yield, (Plate 1).

The above definitions demonstrate the apparent difficulties in giving an object definition of drought. A drought may exist in the agricultural sense before it is evident to the hydrologists. Conversely, an agricultural drought may be ended at least temporarily by rainfall that replenishes soil moisture or stream flow. An agricultural drought can also exist because of poor temporal distribution of rainfall for the years even though the years would be statistically normal or above normal without any meteorological drought in evidence.

In summary, it is glaring from the foregoing that rainfall deficiency is the only major causes of drought, is the most important of all the

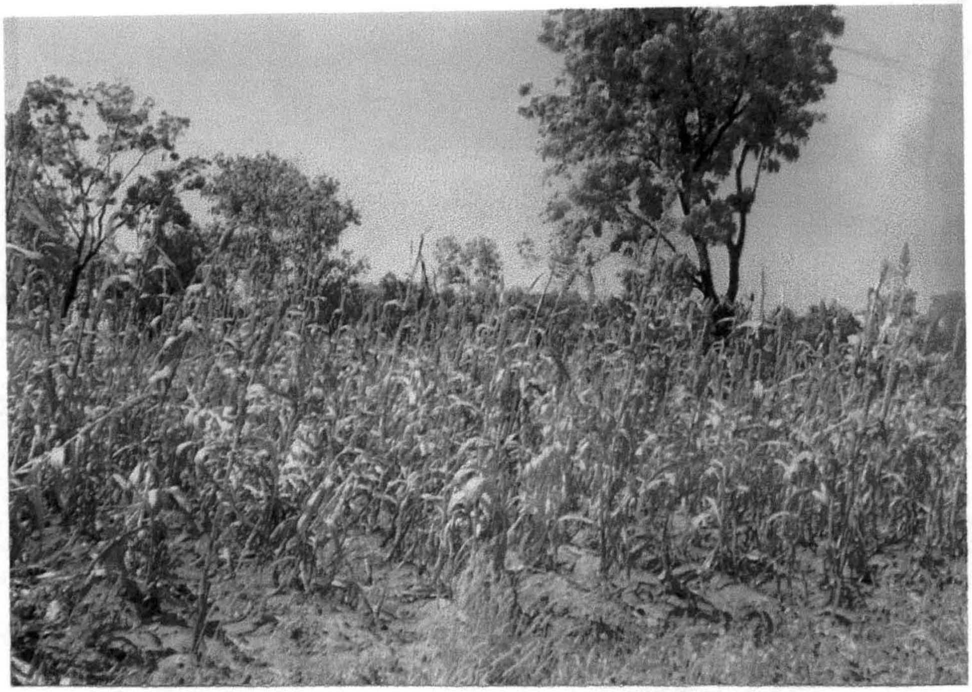


PLATE 1 WILTING OF CROPS

PLATE 2 DRY AND DEAD CROPS

meteorological and hydrological factors and as a result, used by many authors to assess the impact on agriculture.

In concluding, the meaning of drought in this research is defined as period when crops fail due to inadequate to water supply and grazing has become so scarce and the supply of water at the drinking places become so diminished which may result in the loss of livestock and other hardships.

Table 2.3: Terminology of Dry Lands in Sahara and Surrounding Zones

Climatic Zone	Mean Annual	Geographical Areas
Desert Zone	Below 100 mm	North and South Sahara Middle East deserts
Aid Zone	100-400 mm	Mediterranean Steppe of North Africa. Sahelian Zone of South of Sahara
Semi Arid Zone	400-600 mm	Mediterranean Semi arid, Sudano-Sahelian Zone of West Africa

2.3 The 1972/73 Drought and Its Aftermath

From about 1961 the Sudano-Sahelian region of West Africa began to suffer from increased irregularity of rainfall and a rather progressive decrease in the annual rainfall totals (Fig. 2). This rainfall deficiency reached its peak in 1972/73 in almost parts of Nigeria. The annual rainfall distribution patterns over the country during the two drought years of 1972 and 1973 are show in the Table 2.4. Many stations in the northern parts of the country recorded their lowest rainfall either in 1972 or 1973. During the two drought years, rainfall received were 10-40% below the 1931-60 normal in many parts of Nigeria especially the northern part.

PROGRESSIVE DECREASE IN ANNUAL RAINFALL IN THE SUDANO SAHELIAN TOWNS OF NIGERIA 1961—1984

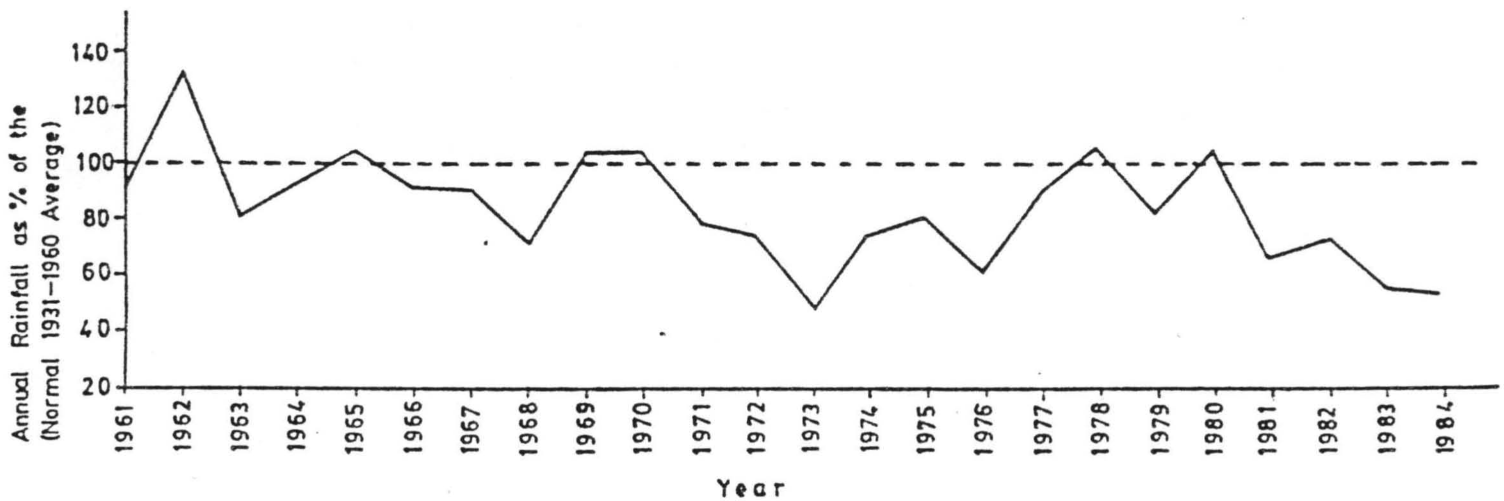


FIG. 2.0 H.A.Dari

During the same period some areas received annual rainfall totals that were between 2 and 27% above normal. In 1972 for instance, Nguru received only 248 mm of rainfall which is 47% of the annual mean while Lokoja received 1329 mm of rainfall which is about 22% above normal. Other notable stations with above normal rainfall in that year were Enugu with 1870 mm or 50% above normal and Minna with 1368 or 7% above normal. In other areas rainfall was much below normal (Table 2.4).

Table 2.4: Rainfall During the 1972/73 Drought
Compared with Normal (1931-60) Average at Selected Stations

Station	1931-60 Average Rainfall (mm)	1972 Rainfall As % of Average	1973 Rainfall as % of Average
Bauchi	1114	77	68
Bida	1223	68	95
Calabar	2987	99	71
Enugu	1781	105	87
Ibadan	1186	88	117
Ilorin	1278	95	114
Jos	1345	99	101
Kaduna	1255	97	98
Kano	872	77	48
Lagos	1828	70	91
Lokoja	1086	122	86
Minna	1279	107	78
Ondo	1683	76	89
Sokoto	659	68	67
Yola	949	93	102

The year 1973 which was the driest year in many areas was also the year in which some stations received more than average rainfall. In the extreme northern parts of the country rainfall was persistently below normal during 1972 and 1973. But thee was deficiency of rainfall in one year or the other all over the country.

2.4 How Droughts Occurs

According to Barry and Chorley (1984) drought is associated with one or more of the following:

i. increases in areas and persistence of the subtropical high pressure cells such as in the West Africa Sahel,

ii. changes in summer monsoonal circulation causing a delay on failure of incursions of maritime tropical air mass as in the sahel or Indian subcontinent,

iii. lower ocean surface temperatures produced by changes in currents or increased upwelling of cold waters as occurs in Chile, California and northeast Brazil, and

iv. the displacement of mid latitude storm tracks associated with either an expansion of the circumpolar westerlies into lower latitudes or with the development of persistent blocking patterns of circulation.

The Sahelian drought of 1972/73 and indeed, subsequent droughts can be ascribed to three main factors. These are (i) climatic factors (ii) disruption in the ecological system as a result of improper use of land by man and the increasing pressure of human and animal populations on the available land resources, and (iii) the failure of the areas concerned to develop adequate water control projects owing to ignorance and lack of expertise and capital (Ayoade, 1977).

Various theories were put forward to explain the courses of drought for example Bryson (1973) has suggested that drought may be due to changes in the would distribution of temperature, and he attributed these changes to an increase in the amount of CO_2 and particulate matter in the atmosphere as a result of industrial, commercial and agricultural activities and the burning of fossil fuels. An increased CO_2 in the atmosphere will increase the surface temperature of the earth as well as the vertical temperature gradient thus decreasing the rains in the southern fringes of the Sahara. He concluded that increased CO_2 and increased of temperature and turbidity both act to suppress the monsoons of the world which further suppresses the pattern of rainfall.

2.5 Farmer'S Responses to Drought

These are two main reasons for studying the farmer's responses to drought. He is a source of information about drought and its consequence which can be used to supplement official climatic data and agricultural surveys. Secondly finding out what the farmer knows is a first step to understanding some of his decision making procedures, the action he is likely to take to overcome drought problems given suitable help and encouragement (Oguntoyinbo and Richards, 1977).

The peasant farmer is a careful observer and is capable of monitoring agricultural variable in a number of simple but in effective ways. A variety of this statement is presented in Oguntoyinbo and Richards (1977). The survey demonstrated the soundness of farmer's knowledge and judgements based upon his observation affected by (a) a scale considerable in the sense that processes observable from start to finish within the farm or village territory were well understood, but that farmers were at a disadvantage when trying to comprehend phenomena associated with large-scale systems, going beyond village limits, (b) the fact that ideas and data generated by the farmer himself reflected an immediate practical purpose.

Inspite of the usefulness of the farmer's information some of them according to Paddocks (1967)

> at the slightest absence of rainfall, their cry will go first "drought, famine. The famine will be genuine but the drought is not a one time factor. It is a frequently recurring, normally recurring, feature of climate.

More specifically related to the Sahelian drought of 1968-1977, Matlook and Cockrum (1967:238), observed that:

> by the end of the normally high rainfall period, about 1965, the expectations of people had risen to the point that a return to average conditions was considered to be a drought.

In view of the above reviewed literature, it can be conceded that, even though farmer's information about drought could be reliable to some extent, room should be given to misperceptions mainly because of their low knowledge of phenomena associated with drought.

2.6 Crops and Pasture Failures Due to Drought Stress

In 1968, 1972-74 and 1984 rainy seasons were particularly below average due to abnormality in the amount and distribution of rainfall. This resulted in drastic reduction of crop yields and in some areas within the study area, complete failure of crops and high livestock mortality was observed in Gada, Illela and Sabon Birni Local Government Areas.

According to Farlane (1977), plant water deficit results when plants require more water than they are able to absorb from the soil. Wilting occurs and water deficiency becomes more acute, resulting in closing a stomata, preventing gas exchange, and growth is reduced or stopped entirely. The views of Poole and Henley (1981). are not different. They observed that any plant species can only realise either its full genetic potential or genetically programmed phasic development in an ideal environment. Under drought stress, there is usually not enough water for plant absorption consequent upon which their growth cycles could not be facilitated and hence associated with the reduction of crop yields and crop failures.

The amount of grazing produced annually by a farm depends on the rainfall. But it the rainfall factor varies from year to year and furthermore without any apparent regularity than there was difficulties. In drought time one of the great difficulties herders face is to provide sufficient drinking water to their livestock, through the limited number of drinking places. Stock had often to travel long distance in order to water when in a weakened condition herders believed that an adequate water supply would often have mean live animals instead of dead ones (Glanta 1977).

Since it is highly desirable that there should be no misunderstanding regarding the supreme importance of an adequate water supply for livestock, it is necessary to review briefly the function of water in the animal life.

2.7 Water Function in Animal Life

According to Glanta (1977) an animal can live without food for several weeks because of the reserves of food stored up in its body, but of the reserves of water the animal system has none. For this reason an animal cannot lives many weeks without water.

Every call of the animal body must contain its quota of water, which has to be maintained against continuous heavy losses in the dung, urine, perspiration and breath. If by any reason an animal gets too little water to drink these vital processes rob the cells of the body of more water than they can spare. The blood begins to thicken and the temperature of the animal will rise until a state similar to that of fever is produced with a consequent rapid loss of body and ultimate death.

Another point with reference to water function is that as the drought proceeds the animal's water requirement increase which is due to the fact that the dry fibrous food available in drought times requires an increased quantity of water for its digestion and passage through the alimentary canal.

Unfcrtunately under drought stress the supply of water is usually a dwindling quantity. This is why many animals die during drought periods. It is no wonder that the stock of an area are congested where there is water to drink, regardless of food supply.

During drought years the last edible stalks are consumed by livestock. Herds must survive on a miserably thin diet gleaned from barren fields. To keep them alive herders lop entire branches from tress which their cattle then strip of foliage. It is therefore becoming difficult to manage them for survival during drought stress such as happened in 1972-74 and 1984.

2.8 Livestock and Crops Losses

Sokoto State was one of the states mostly hit by the 1968-70 drought. Reports indicate that there was 70-100% failures and over 1 million animals without food and water. The drought covered about twenty-seven (27) districts and affected over 2.5 million people and over 6 million animals during the 1972-74 drought. An estimated number of 400,000 livestock such as cattle, goats and sheep were lost in the same period.

There were also a very large number of cattle which were too weak to stand, their fate was not known. And there was an increase of dry meat trade following emergency slaughters all over the state and large reduction of prices of cattle, goat and sheep to ₦50, ₦5.00 and ₦15.00 respectively (Ministry of Agriculture and Natural Resources, Sokoto State).

According to the Ministry of Agriculture and Natural Resources in Gada, Gwadabawa and Illela Local Government Councils in 1982 an estimated of 9,598 hectares of guinea corn and millet were lost to drought. In the same year 952 baskets of cawpea were also lost to drought. These losses were valued at ₦505,700,000. In 1984 a total of 1,589 cattle died due to the inadequacy of water supply. In the year 1989/90 cropping season, millet, guinea corn, beans and cowpea losses were estimated at ₦1,380,910.00 in the study area.

In 1990, news media reported cases of agricultural losses in various state of Nigeria especially the northern part.

According to the New Nigerian newspaper of October 30, 1990, page 1 "Borno State lost crops and livestock worth about 1.6 billion naira to drought in the 1989/90 cropping season". In the same newspaper it was also reported that Gongola State (now Adamawa and Taraba States) lost about 29.185 tonnes of assorted crops to drought valued at 100 million naira.

In Kano State (now Kano and Jigawa States), according to the New Nigerian newspaper of October 18, 1990, page 1, at least 1.2 million tonnes of grains estimated at 1.2 billion naira has been lost to drought during the 1990 cropping season; foreshadowing an imminent food scarcity in the country.

The same paper also pointed that the Economic Intelligence Unit of Savanna Farmer indicated that there was going to be crop failure. This argues for the fact that even though drought could be foreseen if enough remedial measures are not taken it still strikes.

Table 2.5: Estimates of Livestock Population and Mortality During 1972/73 Drought in Sokoto State

Livestock	Population	Mortality	Mortality as % Population
Cattle	15,108,150	302,163	20
Sheep & Goats	43,780,500	874,999	20
Horses & Donkeys	867,864	163,300	19

Table 2.6: Graded Groundnut in Northern Nigerian between 1968/69 and 1972/73 Cropping Seasons

Year	Output in tons
1968/69	765,000
1969/70	650,000
1970/71	400,000
1971/72	250,000
1972/73	25,000

Tables 2.5 & 2.6 Source: Federal Office of Statistics, Sokoto

2.9 Summary of Review

The occurrence of drought appears to be cyclic, the reasons of which are not obvious. The literature concerned with this phenomenon is nevertheless replete with references to particularly dry years as being abnormal or anomalous. Yet, because perceptions about what constitutes a drought vary; there is no widely accepted definition of drought. The scores of definitions however could be objectively divided into meteorological and agricultural subgroups.

Studying what the farmer knows about drought is important because the peasant farmer is a careful observer ad is capable of monitoring agricultural variables in a number of simple effective ways. Hence he is a source of information about drought and its consequences. However the information are susceptible to misperceptions because of the farmer's low knowledge of what constitutes a drought.

Plants species can only realise their full genetic potential or genetically programmed phasic development in and ideal environment. Availability of water is paramount in this need. The amount of grazing produced annually by a farm depends on availability of water and foliage. Under drought stress, thee is usually not enough water supply for these plants and animals. Consequently the crops fail and the animals die. The loss of these crops and animals is usually quite enormous and has had negative impacts on the agricultural economy of the study area in particular and Nigeria in general.

Nyaba (1991), summaries it all,

> Drought generally affects marginal areas contaminous to desert areas. However occasionally, drought may be extended into higher rainfall areas. The most discernible effect of widespread drought is acute shortage of food for both human and livestock to hunger, starvation and death

CHAPTER THREE

RESEARCH METHODOLOGY AND DATA ANALYSIS

3.1 Methodology

The choice of study area was considered on several factors including the incrasing need to look into the impacts of drought on agriculture, time knowledge and resources available. In order to achieve the objectives of this reasearch the researcher contacted relevant works on drought by J.O. Ayoade (1977), Beran (1979) Charney (1975), Matlock and Cockrum (1976), Oguntoyinbo and Richards (1977) and Nyaba (1991) to gain knowledge about what information was relevant to the reseacher. From these secondary sources it was found that the relevant information to be collected were maps of the study area, data on rainfall (annually, monthly, raindays, beginning, intensity and distribution), data on crops/livestock production/losses annually.

3.2 Data Collection

With this need in mind, the researcher produceeded to the study area in November 1999 for the collection of these data. The required data was not completely obtined from the study area but some were collected from Sokoto State Ministry of Agriculture and Sokoto Agricultural and Rural Development Authority (SARDA). The researcher obtained data on livestock and crop losses from the Department of Livestock/Crop Production of the Ministry of Agriculture and Natural Resources, and on rainfall from the Local Government areas and SARDA respectively. However, the map of the study was reproduced by the researcher being a Catographer from the existing maps obtained from the Maps Sale Departmet of Ministry of Lands and Survey, Sokoto.

3.3 Presentation of Data

The data collected on rainfall, its start, end, monthly distribution, and annual totals rains days, LGAs-wise (1980-1999), 1999 and 1996 were presented in Tables 3.1, 3.2 and 3.3 respectively. Data on annual crop/livestock production (1%), and annual crop/livestock. Loss (1%) were presented in Tables 3.4, 3.5 and 3.6. All these data encompass the various Local Government Headquarter of the study area.

3.4 Analysis of Data

As Bruce (1972) observed the methods and techniques used in analysis of statistical data are in large measure determined by the character of the data involved, and the objectives of the study. In view of that, the analytical techniques used in this study were decided by the objectives of the study, as well as the nature of the collected data. These techniques include:

i. the use of mean as a measures of central tendency to summaris yearly or annual rainfall, crop/livestock production, and crop/livestock loss;

ii. the use of standard deviation as a measures of dispersion to show the degree of the spread of the distribution or variation of the variable; and

iii. the use of t-test to determine the relationship, if any, between rainall and crop/livestock production, and rainfall and crop/livestock loss.

Therefore this became necessary since as Bruce (1972) observed, that statistical method is a major aid for data interpretation and presentation. Using statistical testing, the researcher can compare groups of data to determine the probability that the differences between variables are based on chance, thereby providing evidence for judging the validity of hypotheses or inferences.

3.4.1 The mean

The arithmetic mean or the mean average of a set on N numbers or variables $x_1, x_2, x_3, \ldots x_N$ is the sum of these variable divided by N. The mean is denoted by x (read "x bar") and is defined in this study as

$$x = \frac{x_1 + x_2 + x_3 + \dots + x_N}{N} = \frac{\Sigma x}{N} \qquad \dots(1)$$

where

x = mean
$x_1 + x_2 + x_3 \dots N$ = the variable (observed)
N = number of variable

Equation 1 above was used in calculating the mean rainfal (mm) mean annual crop loss (%) and mean annual livestock loss (%) for the six local government areas in the study area; Gada, Gwadabawa, Goronyo, Illela, Kware and Wurno. The result obtained are summarised in appendices 1-15.

3.4.2 Standard deviation

The standard deviation (or various measures of dispersion or variation are available) shows the spread of a series of values from their mean. It is defined as

$$x = \sqrt{\frac{\sum_{f=1}^{n}(x_1 - x)^2}{N}} = S = \sqrt{\frac{\Sigma(x-x)^2}{N}} = \sqrt{\frac{\Sigma x^2}{N}} = \sqrt{\frac{(x-x)^2}{N}} \qquad \dots (2)$$

where

S = standard deviation
x = the deviations of each of the number x, from mean x
N = number of variable

The standard deviation can also serve as a measure of variability. Thus the standard devaition of rainfall, crop loss, and livestock loss indicate the mean variation of their values from the average for the period under investigation.

3.4.3 t-Test

The t-test technique was used to determine the relationship between rainfall distribution and crop-livestock loss and crop-livestock production. The test also provides an index 't' to represent the relation of the difference between means and standard deviations of given samples to varify the hypotheses if there is no significant drop in crop yields during drought periods, and also if there is no significant increase in livestock mortality rate during drought periods. It is expressed as

$$t = \frac{x - y}{\sqrt{\frac{S_x + S_y}{n_x, n_y}}} \qquad \text{... (3)}$$

where

x = mean variable of x
y = mean variable of y
S_x = standard deviation of variable x
S_y = standard deviation of variable y
n_x,n_y = sizes of x and y variables

Apart from statistical testing photographs showing crop under drought condition, cattle grazing and migration was also used to illustrate the nature of herding in the study area.

3.5 Problems of Collection of Data

Some difficulties were encountered in the course of data collection for this study. Some of the local government areas were newly created. In effect, the relevant data were not available because only one rainfall station in each old local government. This forced this reseacher to travel between these local government areas (about 60-120 km apart) several times as the right personnel were not present.

Perhaps, the most serious problem encluntered was non-availability of ranifall data at the various local government headquarters. This was informed by the fact that rainfall recording was only obtained at old local government headquarters or the divisional office of Sokoto Agricultural and Rural Development Authority (SARDA). Added to these was the non-availability of data on crop and livestock losses which were not kept by the farmers with regard to the 1974-76 drought.

Table 3.1: Monthly Rainfal Distribution (mm) in Northern Zone of Sokoto State

Year	J	F	M	A	M	J	J	A	S	O	N	D	Total	Aver
1980				1.60	16.24	62.25	91.07	110.02	56.11	3.50			340.82	48.
1981				1.96	17.92	65.43	121.00	107.25	41.13	2.80			357.49	51.
1982				0.33	13.71	50.28	69.14	117.03	55.62	1.20			310.31	44.
1983				0.65	17.04	56.13	58.20	92.56	68.09	2.70			295.38	42.
1984				0.42	15.00	65.40	57.90	54.90	83.10	-			276.72	40.
1985				1.00	8.30	49.50	85.90	188.03	94.40	-			433.40	72.
1986				0.8	4.90	29.30	171.10	125.30	118.60	14.6			464.50	65.
1987				2.7	23.40	22.10	65.90	143.90	54.60	1.0			313.60	44.
1988				4.5	1.60	55.80	125.90	269.90	119.90	-			577.60	92.
1989				-	8.10	61.20	102.40	190.20	61.90	12.4			436.20	72.
1990				0.40	19.00	43.00	208.20	116.30	40.80	3.70			431.40	61
1991				6.2	20.50	31.50	159.50	147.50	42.50	15.50			423.20	60
1992			1.60	6.5	22.50	29.50	140.50	180.50	65.20	12.50			463.30	57
1993				6.2	23.50	27.50	59.50	117.50	59.80	4.90			298.90	42
1994				6.2	8.50	30.20	69.70	128.10	113.20	11.70			367.60	52
1995				1.60	16.50	75.90	185.00	210.00	47.00	3.80			539.80	77
1996				1.80	17.50	42.50	172.20	190.40	129.50	11.50			565.40	80
1997				1.9	18.50	32.50	147.50	189.40	126.00	17.40			533.20	76
1998			1.40	4.5	20.60	48.40	198.90	189.90	136.90	23.50	0.90		621.10	69
1999				3.0	21.30	96.90	161.80	200.02	145.00	15.40	-		644.00	

Table 3.2: Monthly Rainfall Distribution(mm) and Rainy Days in Selected LGA (Northern Zone)

Month	LOCAL GOVERNMENT AREA COUNCILS											
	GADA		GORONY		GWADABAWA		ILLELA		KWARE		WURNO	
	Rain Fall	Rain Day	Rain Fall	Rain Day	Rain Fall	Rain Day	Rain Fall	Rain Day	Rain Fall	Rain Day	Rain Fall	Rain Day
April	1.6	1	-	-	-	-	-	-	-	-	-	-
May	-	-	8.5	1	9.0	2	-	-	-	-	1.6	1
June	16.5	3	10.5	2	17.0	2	18.5	3	19.6	3	11.0	2
July	95.5	6	102.5	5	190.5	8	180.5	7	110.0	8	180.5	7
August	166.6	8	170.5	9	210.0	11	190.5	12	210.5	12	210.0	13
September	170.5	16	175.5	14	190.0	10	131.5	9	170.0	9	160.6	10
October	12.5	2	10.9	2	11.5	2	12.5	3	18.5	3	21.7	3
Annual Total	503.2	36	518.4	33	598.0	35	523.5	34	598.5	35	625.4	36

Source: SARDA

Table 3.3: Total Annual Rainfall - 1998 in LGAs

Local Government Area	Rainfall (mm)	Rain Days
Gada	435	31
Goronyo	433	31
Gwadabawa	564	40
Illela	464	35
Kware	580	42
Wurno	507	38

CHAPTER FOUR

PRESENTATION OF DATA

4.1 Introduction

As mentioned in an earlier section of this study, data on rainfall (distribution averages, rain days and annual totals) were presented in the Tables 3.1, 3.2 and 3.3 respectively. Similarly data on annual crop and livestock losses were presented in Tables 4.1 and 4.2. These are data over the six local government area councils. They include Gada, Goronyo, Gwadabawa, Illela, Kware and Wurno Local Government Area Councils. The data were however discussed separately to show more light on their nature.

As in the Table 3.1, rainfall is periodic, and monthly distribution varies from month to month, likewise annual totals vary from year to year. Therefore its distribution is unreliable. This unrealiability increases as annual totals diminish.

As shown in the Table 3.1 there is no rainfall between the month of November to March. In 1988, and 1985 thee was no rainfall in October and also in 1989, there was no rainfall in April. By implication these years experienced only half of the year of rainfall (6 months) and there was no rainfall for the other six months of November - April. Therefore the year had six months of rainy season and six months of dry season.

The annual total was highest in 1999 (657.0 mm) followed by 1998 with (624.1 mm), and the lowest was in 1984 with only 280.82 mm of rainfall. These annual totals show little variations of the monthly distribution of the rainfall. For example in year 1999 which recorded the highest rainfall, had only three millimetres of rainfall in the month of April and as high as 200 millimetres in month of August. On the other hand the years 1984 which was a severe year of drought had less than one millimetre of rainfall in April, and as high as 83 millimetres in September which is the end of rainy season in that year.

Table 4.1 shows that in 1980 Illela Local Government Area had the highest percentage of crop loss (67%). The lowest was recorded in Gada Local Government Area (41%). In 1981 the highest loss was recorded in Illela with the least in Kware Local Government Area. In 1982 the highest loss was in Gada, and Wurno recorded the lowest in 1980.

Table 4.1: Crop Lost (%) Northern Zone 1980-1995

Year	Local Government Areas					
	Gada	Goronyo	Gwadabawa	Illela	Kware	Wurno
1980	41.10	58.30	52.60	67.08	48.70	32.00
1981	48.01	50.39	47.20	55.92	36.12	60.17
1982	69.50	63.10	56.50	64.14	60.02	53.01
1983	71.20	69.50	58.20	69.53	61.23	65.28
1984	84.70	87.50	87.90	80.61	83.46	70.34
1985	21.00	23.00	25.00	24.75	21.00	21.00
1986	31.40	29.60	32.00	23.19	27.63	27.63
1987	68.20	45.80	54.80	62.50	69.24	69.24
1988	12.60	9.20	13.20	18.10	13.17	13.17
1989	21.10	24.00	26.50	25.04	24.82	24.80
1990	36.20	34.50	38.09	36.12	33.40	33.40
1991	21.80	32.00	39.02	22.12	30.10	31.00
1992	35.60	18.00	41.03	29.18	31.00	29.00
1993	37.40	17.00	27.05	30.12	29.00	28.10
1994	21.10	21.00	29.04	25.05	24.00	26.10
1995	20.50	26.00	18.04	19.50	21.00	25.10

Source: Ministry of Agriculture and Natural Resources, Sokoto State

In 1984, there were high percentage losses. The least 80% in Illela was more than the highest in the preceding years. The highest loss of over 87% in Goronyo and Gwadabawa were each more than twice the highest in 1985 (25%) and 1995 (27%) in Gwadabawa and Goronyo Local Government Areas. These however do not follow a fixed pattern of loss. The loss was generally decreased from 1994 to 1995. From 1988 to 1990 there was general increasing loss in the face of low rainfall.

Livestock loss is presented in Table 4.2, the characteristics of data is almost the same with drop loss. In 1980 for example the highest loss of 46% was recorded in Kare and the least in Gada. In 1981 the highest loss was recorded in Goronyo (56%) and the least in Gada (47%). In 1984 there were very high percentage losses. The highest as over 80% and least was 71%

Table 4.2: Livestock Loss (%) Northern Part of Sokoto State 1980-1995

Year	Local Government Areas					
	Gada	Goronyo	Gwadabawa	Illela	Kware	Wurno
1980	38.14	41.07	42.00	45.60	46.15	43.70
1981	47.05	56.15	47.21	48.09	50.74	52.60
1982	69.53	66.82	70.83	68.08	63.00	54.00
1983	45.61	52.01	61.17	53.30	57.81	68.90
1984	74.72	75.00	78.06	73.42	71.14	80.10
1985	64.51	59.40	41.03	40.50	43.01	47.18
1986	36.00	38.07	44.00	36.14	40.01	43.06
1987	38.16	45.43	39.78	42.00	41.12	38.30
1988	23.76	18.64	27.12	31.26	32.48	35.00
1989	35.01	26.14	39.08	35.18	27.95	41.92
1990	40.25	37.00	46.11	44.20	32.67	50.07
1991	32.25	30.15	31.00	33.00	29.91	24.01
1992	32.80	31.21	36.01	39.51	30.01	20.13
1993	21.29	27.20	23.11	21.60	20.21	18.12
1994	20.29	20.02	21.11	20.12	21.21	19.20
1995	19.18	17.21	14.25	20.16	14.25	12.50
1996						
1997						
1998						
1999						

Source: Ministry of Agriculture and Natural Resources, Department of Livestock, Sokoto State

as against the highest of 46% in 1980. In the years 1988-1995 there appear to be decreasing of livestock loss and there was no data in the esse of 1966-1999 as shown on the table.

4.2 Discussion of the Results

Hypothesis one. The result of t-test as calculated in Appendices (1-6) showed that there were significant drop in crop yield during the period

(1980-1999) investigated. Therefore the null hypothesis H_0 which states that there is no significant drop in crop yield during the drought periods was rejected and alternative hypothesis H_1 was accepted. And the relationship is illustrated in Table 5.1.

As earlier stated in this study, agricultural drought occurs when rainfall is inadequate to maintain crop to development or to grow at their optimum rates. Therefore drought periods are periods when crops cannot complete theory growth cycle consequent upon which they drastically reduce in yield and in the extreme cases completely fail. This is what happened in the study area during the period investigated.

4.3 Hypothesis Two

The results of the t-test as calculated in appendices (7-12) show a significant increase in the livestock mortality rate during drought periods. In view of this, the null hypothesis H_0 which also states that there is no significant increase in livestock mortality rate during drought periods was rejected and the hypothesis H_1 was accepted. The relationship is illustrated in Table 5.2.

As pointed out in the Chapter Two, during drought periods the available stalks foliage go dry and the consumption (which require frequent drinking of water) and water is insufficient for livestock at drought periods and they cannot store water, then the affected livestock die and others migrate with few livestock left behind with sufficient of feeds and water.

CHAPTER FIVE

CONCLUSIONS AND SUMMARY

5.1 Summary and Conclusions

The problem of this study stems from the fact that the recurrent droughts plagued this study area which tended to exacerbate the situation in which ecological deterioration by human and animals in a bid to survive was already in progress. However, plants and animals find it difficult to survive this precarious environment. In view of the need to investigate this relationship it was considered to present and analyse the collected rainfall data, crop loss, and livestock loss in the study area in order to evaluate or to assess the environmental impact.

In accordance with the problem and objectives of this study the main task was largely focused on the following points:

i. determination of the impact of drought on crop production;

ii. determination of the impact of drought on livestock production, and

iii. to make various recommendation and suggestions necessary on how to control or minimise the effects of drought within the study area.

Therefore based on these objectives, nature of data collection and analysis carried out the findings are summarised as follows:

1. Drought is not a recent environmental problem. It is a recurrent phenomenon that has for long been a threat to the agricultural developments to which indigenous responses have evolved.

2. A patchy rainfall distribution as much as a deficient annual total can also crate agricultural problems. this distributive aspect of drought is concealed by a superficial scanning of gross annual totals.

3. While the mean annual rainfall totals remain fairly constant, its economic value has been reduced by the alternation in the properties of the surface and soil of the study area for which human and animals are responsible. In this reduced utility of rainfall must be sought the secret of the recurrent droughts in the study area.

4. The effect of rainfall is dependable not only on time and nature of the fall. It is profoundly influenced by poor land management among other factors. Herein lies the explanation why rainfall records which take no cognisance of these factors are frequently at variance with the farmer in assessment of drought conditions.

5. Crops hardly complete their growth cycle during the drought periods. Likewise, livestock during same periods are handicapped by a low condition as well as little or not food in prospect which augur against their chances of survival.

6. In view of the foregoing, farming and harding are risky businesses in the study area, because these practices depend on rainfall which cannot be guaranteed with the coming of every rainy season. And if it does come, it is generally not adequate for the ideal production of crops and livestock.

Based on the above findings or observations, this study has been able to establish that droughts affect crop yields and livestock productions in the study area. The problems of water shortage for both livestock and crops had long been established in the study area. However the problems became more acute in the recent years as a result of increasing of human and animal populations and improper use of land. Consequently the capacity of the soil to hold enough water for crops use is also diminishing and hence the crops failed.

It is therefore necessary to minimise or if not to prevent, the negative impacts of drought on the agricultural productions. The following are some suggestions and recommendations of controlling the impact of droughts.

a. As everybody is aware, water is essential for life and the provision of adequate supplies of it is a prime factor in fighting or controlling the effects of drought; government should encourage farmers in every way possible to improve the supply of water to the farm either by building dams or by sinking of wells and boreholes.

b. Trees should be planted as shelterbelts in the appropriate places. And wood cutting, and burning down the existing vegetation should be prevented.

c. Heavy grazing which tends to destroy vegetation and encourage the growth of other plants should be discouraged or thee should be grazing control.

d. The Kraaling system which necessitates much driving of stock and an increased food requirement should be discouraged because driving is detrimental to the condition of the stock and seriously endangers their life when they are in weakened state.

e. As mentioned earlier, drought is essentially a water supply and demand problems, and the solution to such problems may be simplified into either increasing the supply or decreasing the demand or both. In short, there should be water use restrictions and water use education.

5.2 Suggestion

Partly due to the shortcomings of this research, the following suggestions may be considered for further studies.

1. A centre or institute for studies of drought should be established in this country. Such centre should be well equipped and funded to monitor and research into all aspects of drought, especially the causes effects, solutions and management.

2. The centre should establish weather stations in every local government area for the measuring all the elements of weather.
3. Well trained and responsible meteorological, elimatological, hydrological and ecological staff, and proper modern equipment should be provided to increase the reliability of data.
4. Experimental sites should be established in diverse ecological areas of the parts of the country most prone to drought. Such sites should be located in northern part of the country. This may be made possible through collaboration and support from international organisation such as UNDP, UNEP, FAO and WMO.
5. More rigorous statistical techniques other than t-test used should be employed in order to enhance the reliability of the work.
6. There is need to determine the carrying capacity of the available land and its optimum use.
7. Finally, there is need to encourage research into the development of stains of crops which are tolerance to one or both combination of the following:
    a. crops that are tolerant to drought,
    b. more tolerant to saline soils,
    c. ability to complete life cycle in a shortened growing season, and
    d. increasingly efficient use of water.

Table 5.1: Relationship Between Drought and Crops Lost

LGA	Calculated t	Degree of Freedom (df) = v	Value of Level %	Probability 5%
Gada	11.72	30	2.75	2.04
Goronyo	13.04	30	2.75	2.04
Gwadabawa	13.40	30	2.75	2.04
Illela	11.32	30	2.75	2.04
Kware	13.38	30	2.75	2.04
Wurno	13.75	30	2.75	2.04

Sources: Author's calculation

Table 5.2: Relationship Between Drought and Livestock Mortality Rate

LGA	Calculated t	Degree of Freedom (df) = v	Value of Probability Levels of	
			0.01	0.05
Gada	12.60	30	2.750	2.040
Goronyo	12.55	30	2.750	2.040
Gwadabawa	11.88	30	2.750	2.040
Illela	11.57	30	2.750	2.040
Kware	13.84	30	2.750	2.040
Wurno	11.96	30	2.750	2.040

Sources: Author's calculation

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Appendix 1

Statistical Test Calculation for the Hypotheses Posed Crop Losses

Crop Losses (%)
Gada LGA

Year	Annual Mean Rainfall (mm) x	Annual Crop Loss (%) y
1980	48.68	41.10
1981	51.07	48.01
1982	44.33	69.50
1983	42.19	71.20
1984	40.11	84.70
1985	72.23	21.00
1986	65.35	31.40
1987	44.80	68.20
1988	92.70	12.60
1989	72.26	21.10
1990	61.62	36.20
1991	60.45	21.80
1992	57.91	35.60
1993	42.70	37.40
1994	52.31	21.10
1995	72.10	20.50
Total	920.10	641.41
Mean x & y	x = 57.55	40.09
S	14.12	21.43

$$t = \frac{x - y}{\sqrt{\frac{Sx}{nx} + \frac{Sy}{ny}}}$$

$$= \frac{57.55 - 40.09}{\sqrt{\frac{14.12}{16} + \frac{21.43}{16}}}$$

$$= \sqrt{\frac{17.46}{0.88 + 1.34}} = \frac{17.46}{1.49}$$

$t = 11.72$

$df = nx + ny - 2$

$16 + 16 - 2$

$= 30$

Critical values of t at 1% when (df) = 30 = 2.75

5% when (df) = 30 = 2.04

Appendix 2

Statistical Test Calculation for the Hypotheses Posed Crop Losses

Crop Losses (%)
Gadabawa LGA

Year	Annual Mean Rainfall (mm) x	Annual Crop Loss (%) y
1980	48.68	52.60
1981	51.07	47.20
1982	44.33	56.50
1983	42.19	58.20
1984	40.11	87.90
1985	72.23	25.00
1986	65.35	32.00
1987	44.80	54.80
1988	92.70	13.20
1989	72.26	20.50
1990	61.62	38.90
1991	60.45	39.20
1992	57.91	4.30
1993	42.70	27.50
1994	52.31	29.40
1995	72.10	18.40
Total	920.10	605.6
Mean x	x = 57.55	37.85
S	14.12	20.40

$$t = \frac{x - y}{\sqrt{\frac{Sx}{nx} + \frac{Sy}{ny}}}$$

$$= \frac{57.55 - 37.85}{\sqrt{\frac{14.12}{16} + \frac{20.40}{16}}}$$

$$t = \frac{19.70}{1.47}$$

$$t = 13.40$$

$$df = n_x + n_y - 2$$

$$= 16 + 16 - 2$$

$$df = 30 = v$$

Critical values of t at 1% with v 30 = 2.75

5% with v 30 = 2.04

Appendix 3

Statistical Test Calculation for the Hypotheses Posed Crop Losses

Crop Losses (%)
Goronyo LGA

Year	Annual Mean Rainfall (mm) x	Annual Crop Loss (%) y
1980	48.68	58.3
1981	51.07	50.39
1982	44.33	63.10
1983	42.19	69.50
1984	40.11	87.5
1985	72.23	23.0
1986	65.35	29.60
1987	44.80	45.80
1988	92.70	9.20
1989	72.26	24.0
1990	61.62	34.50
1991	60.45	32.00
1992	57.91	18.00
1993	42.70	17.00
1994	52.31	21.00
1995	72.10	27.00
Total	920.10	609.89
Mean x	x = 57.55	38.12
S	14.12	21.38

$$t = \frac{x - y}{\sqrt{\frac{Sx}{nx} + \frac{Sy}{ny}}}$$

$$= \frac{57.55 - 38.12}{\sqrt{\frac{14.12}{16} + \frac{21.38}{16}}}$$

$$= \frac{19.43}{\sqrt{0.88 + 1.33}}$$

$$= \frac{19.43}{1.488}$$

t = 13.04

df = 30

Critical values of t at 1% with d = 30 = 2.75

5% with d = 30 = 2.04

Appendix 4

Statistical Test Calculation for the
Hypotheses Posed Crop Losses

Crop Losses (%)
Illela LGA

Year	Annual Mean Rainfall (mm) x	Annual Crop Loss (%) y
1980	48.68	67.05
1981	51.07	55.92
1982	44.33	64.14
1983	42.19	69.53
1984	40.11	80.61
1985	72.23	24.75
1986	65.35	23.19
1987	44.80	62.50
1988	92.70	18.10
1989	72.26	25.04
1990	61.62	36.12
1991	60.45	22.12
1992	57.91	29.18
1993	42.70	30.12
1994	52.31	25.05
1995	72.10	19.5
Total	920.10	652.92
Mean x	x = 57.55	40.80
S	14.12	20.91

$$t = \frac{x - y}{\sqrt{\frac{Sx}{nx} + \frac{Sy}{ny}}}$$

$$= \frac{57.55 - 40.80}{\sqrt{\frac{14.12}{16} + \frac{20.91}{16}}}$$

$$= \frac{16.75}{\sqrt{0.88 + 1.31}}$$

$$= \frac{16.75}{1.48}$$

$t = 11.32$

$df = 30$

Critical values of t at 1% with $v = 30 = 2.75$

5% with $v = 30 = 2.04$

Appendix 5

Statistical Test Calculation for the Hypotheses Posed Crop Losses

Crop Losses (%) Kwane LGA

Year	Annual Mean Rainfall (mm) x	Annual Crop Loss (%) y
1980	48.68	46.70
1981	51.07	36.12
1982	44.33	60.02
1983	42.19	61.23
1984	40.11	83.16
1985	72.23	21.00
1986	65.35	27.24
1987	44.80	69.24
1988	92.70	13.17
1989	72.26	24.82
1990	61.62	33.40
1991	60.45	39.10
1992	57.91	31.00
1993	42.70	29.00
1994	52.31	24.00
1995	72.10	21.00
Total	920.10	611.24
Mean x	x = 57.55	38.20
S	14.12	

$$t = \frac{x - y}{\sqrt{\frac{Sx}{nx} + \frac{Sy}{ny}}}$$

$$= \frac{57.55 - 38.20}{\sqrt{\frac{14.12}{16} + \frac{19.38}{16}}}$$

$$= \frac{19.35}{\sqrt{0.88 + 1.211}}$$

$$= \frac{19.35}{1.446}$$

$t = 13.38$

$df = 30$

Critical values of t at 1% with $v = 30 = 2.75$

5% with $v = 30 = 2.04$

Appendix 6

Statistical Test Calculation for the Hypotheses Posed Crop Losses

Crop Losses (%)
Wurno LGA

Year	Annual Mean Rainfall (mm) x	Annual Crop Loss (%) y
1980	48.68	32.00
1981	51.07	60.17
1982	44.33	53.01
1983	42.19	65.28
1984	40.11	70.34
1985	72.23	21.00
1986	65.35	27.63
1987	44.80	69.24
1988	92.70	13.17
1989	72.26	24.80
1990	61.62	33.40
1991	60.45	31.00
1992	57.91	29.00
1993	42.70	28.10
1994	52.31	26.10
1995	72.10	24.10
Total	920.10	608.1
Mean x	x = 57.55	38.02
S	14.12	18.18

$$t = \frac{x - y}{\sqrt{\frac{Sx}{nx} + \frac{Sy}{ny}}}$$

$$= \frac{57.55 - 38.02}{\sqrt{\frac{14.12}{16} + \frac{18.18}{16}}}$$

$$= \frac{19.53}{\sqrt{0.88 + 1.136}}$$

$$= \frac{19.35}{1.42}$$

$t = 13.75$

$df = 30 = v$

Critical values of t at 1% with v = 30 = 2.75

5% with v = 30 = 2.04

Appendix 7

Statistical Test Calculation for the Hypotheses Posed Crop Losses

Livestock Losses (%)
Gada LGA

Year	Annual Mean Rainfall (mm) x	Annual Livestock Loss (%) y
1980	48.68	38.14
1981	51.07	47.05
1982	44.33	69.53
1983	42.19	45.61
1984	40.11	76.72
1985	72.23	64.51
1986	65.35	36.00
1987	44.80	38.16
1988	92.70	23.76
1989	72.26	35.01
1990	61.62	40.25
1991	60.45	32.25
1992	57.91	32.80
1993	42.70	21.29
1994	52.31	20.29
1995	72.10	19.18
Total	920.10	640.55
Mean x	x = 57.55	40.03
S	14.12	16.76

$$t = \frac{x - y}{\sqrt{\frac{Sx}{nx} + \frac{Sy}{ny}}}$$

$$= \frac{57.55 - 40.03}{\sqrt{\frac{14.12}{16} + \frac{16.76}{16}}}$$

$$= \frac{17.52}{1.39}$$

t = 12.60

df = 30

Critical values of t at 1% = 2.75

5% = 2.04

Appendix 8

Statistical Test Calculation for the Hypotheses Posed Crop Losses

Livestock Losses (%)
Gwadabawa LGA

Year	Annual Mean Rainfall (mm) x	Annual Livestock Loss (%) y
1980	48.68	42.00
1981	51.07	47.21
1982	44.33	70.83
1983	42.19	61.17
1984	40.11	78.06
1985	72.23	41.03
1986	65.35	44.00
1987	44.80	39.78
1988	92.70	27.12
1989	72.26	39.08
1990	61.62	46.11
1991	60.45	31.00
1992	57.91	30.01
1993	42.70	23.11
1994	52.31	21.11
1995	72.10	14.25
Total	920.10	656.41
Mean x	x = 57.55	41.03
S	14.12	16.94

$$t = \frac{x - y}{\sqrt{\frac{Sx}{nx} + \frac{Sy}{ny}}}$$

$$= \frac{57.55 - 41.03}{\sqrt{\frac{14.12}{16} + \frac{16.94}{16}}}$$

$$= \frac{16.51}{\sqrt{0.88 + 1.06}}$$

$$= \frac{16.52}{1.39}$$

$t = 11.88$

$df = 30$

Critical values of t at 1% with $v = 30 = 2.75$

5% with $v = 30 = 2.04$

Appendix 9

Statistical Test Calculation for the Hypotheses Posed Crop Losses

Livestock Losses (%)
Illela LGA

Year	Annual Mean Rainfall (mm) x	Annual Livestock Loss (%) y
1980	48.68	45.60
1981	51.07	48.09
1982	44.33	68.08
1983	42.19	53.30
1984	40.11	73.42
1985	72.23	40.50
1986	65.35	36.14
1987	44.80	42.00
1988	92.70	31.26
1989	72.26	35.18
1990	61.62	44.20
1991	60.45	33.00
1992	57.91	39.51
1993	42.70	21.60
1994	52.31	20.12
1995	72.10	20.16
Total	920.10	672.70
Mean x	x = 57.55	42.04
S	14.12	14.81

$$t = \frac{x - y}{\sqrt{\frac{Sx}{nx} + \frac{Sy}{ny}}}$$

$$= \frac{57.55 - 42.04}{\sqrt{\frac{14.12}{16} + \frac{14.81}{16}}}$$

$$= \frac{15.51}{\sqrt{0.88 + 0.93}}$$

$$= \frac{15.51}{1.34}$$

$$t = 11.57$$

$$df = 30$$

Critical values of t at 1% with v = 30 = 2.75

5% with v = 30 = 2.04

Appendix 10

Statistical Test Calculation for the Hypotheses Posed Crop Losses

Livestock Losses (%)
Kware LGA

Year	Annual Mean Rainfall (mm) x	Annual Livestock Loss (%) y
1980	48.68	46.11
1981	51.07	50.74
1982	44.33	63.00
1983	42.19	57.81
1984	40.11	71.14
1985	72.23	43.01
1986	65.35	40.01
1987	44.80	41.12
1988	92.70	32.48
1989	72.26	27.95
1990	61.62	32.67
1991	60.45	29.91
1992	57.91	30.01
1993	42.70	20.21
1994	52.31	21.21
1995	72.10	14.25
Total	920.10	621.72
Mean x	x = 57.55	38.86
S	14.12	15.46

$$t = \frac{x - y}{\sqrt{\frac{Sx}{nx} + \frac{Sy}{ny}}}$$

$$= \frac{57.55 - 38.86}{\sqrt{\frac{14.12}{16} + \frac{15.46}{16}}}$$

$$= \frac{18.69}{\sqrt{0.88 + 0.96}}$$

$$= \frac{18.69}{1.35}$$

$$t = 13.84$$

$$df = 30$$

Critical values of t at 1% with v = 30 = 2.75

5% with v = 30 = 2.04

Appendix 11

Statistical Test Calculation for the Hypotheses Posed Crop Losses

Livestock Losses (%)
Wurno LGA

Year	Annual Mean Rainfall (mm) x	Annual Livestock Loss (%) y
1980	48.68	43.70
1981	51.07	52.66
1982	44.33	54.00
1983	42.19	68.90
1984	40.11	80.10
1985	72.23	47.18
1986	65.35	43.06
1987	44.80	38.03
1988	92.70	35.00
1989	72.26	41.92
1990	61.62	50.07
1991	60.45	24.10
1992	57.91	20.13
1993	42.70	18.12
1994	52.31	19.02
1995	72.10	12.50
Total	920.10	648.90
Mean x	x = 57.55	40.56
S	14.12	18.23

$$t = \frac{x - y}{\sqrt{\frac{Sx}{nx} + \frac{Sy}{ny}}}$$

$$= \frac{57.55 - 40.56}{\sqrt{\frac{14.12}{16} + \frac{18.23}{16}}}$$

$$= \frac{16.99}{\sqrt{0.88 + 1.14}}$$

$$= \frac{16.99}{1.42}$$

$t = 11.96$

$df = 30$

Critical values of t at 1% with $v = 30 = 2.75$

5% with $v = 30 = 2.04$

Appendix 12

Statistical Test Calculation for the
Hypotheses Posed Crop Losses

Livestock Losses (%)
Goronyo LGA

Year	Annual Mean Rainfall (mm) x	Annual Livestock Loss (%) y
1980	48.68	41.07
1981	51.07	56.15
1982	44.33	66.82
1983	42.19	52.01
1984	40.11	75.00
1985	72.23	59.49
1986	65.35	38.07
1987	44.80	45.43
1988	92.70	18.64
1989	72.26	26.14
1990	61.62	37.00
1991	60.45	30.15
1992	57.91	31.21
1993	42.70	27.20
1994	52.31	20.20
1995	72.10	17.21
Total	920.10	641.70
Mean x	x = 57.55	40.10
S	14.12	17.07

$$t = \frac{x - y}{\sqrt{\frac{Sx}{nx} + \frac{Sy}{ny}}}$$

$$= \frac{57.55 - 40.01}{\sqrt{\frac{14.12}{16} + \frac{17.07}{16}}}$$

$$= \frac{17.45}{\sqrt{0.88 + 1.06}}$$

$$= \frac{17.45}{1.39}$$

$t = 12.55$

$df = 30$

Critical values of t at 1% with $v = 30 = 2.75$

5% with $v = 30 = 2.04$