RAINFALL VARIATION AND YAM PRODUCTION IN SHIRORO LOCAL GOVERNMENT AREA OF NIGER STATE.

BY

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APPROVAL PAGE

This research Titled "Rainfall Variation and Yam Production in Shiroro L.G.A. of Niger State" was carried out by Mr Ahmadu Zegi under the Supervision of Prof. D. O. Adefolalu for the award of Master's in Technology (M.Tech), degree in Meteorology in the Department of Geography, School of Science and Science Education (SSSE), Federal University of Technology, Minna.

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DEDICATION

This project is dedicated to Almighty God who made it possible for me to start this programme and finished successfully. Also to my beloved wife Moyo and my son Victor.

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My thanks and gratitude to Almighty God, the provider of all good things that makes it possible for my successful completion of my M. Tech programme.

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Zegi Ahmadu

TABLE OF CONTENT

ABSTRACT

The agroclimatological parameters such as rainfall, the on set, cessation, and length of the rainy season are closely related to agricultural variable such as yam. Using regression equation in relating the above climatic and agricultural parameters, on attempt is made to analyze how much the climatic variable affects the yield of yam.

The study examined rainfall variation in Shiroro Local government Area for about ten years (1991 – 2000). The rainfall data in Shiroro Local Government were identified and examined. These were, the mean annual distribution, the year to year trends in the study area.

The result of the research shows that variability in rainfall causes fluctuation in yam production. It also shows that non-climatic factors affect the production of yam, but most of these, to some extent depend on climate.

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND

Rainfall is the most variable element of the tropical climate. All characteristic such as amount, frequency, intensity etc vary widely in time and space. Variable in rainfall characteristic has significant effect on economic activities particularly rainfed agriculture.

These theses therefore, focus on the spatial and temporal variation of rainfall characteristics. The movement of the inter tropical discontinuity (ITD) and its associated zones of rainfall during the course of the year is the major factor controlling rainfall generally (Adebayo, 1997).

Rainfall variability is not limited to seasonal fluctuations and year to year variability of the onset, cessation and duration of the rains. Rainfall during the growing season may also be associated with dry spells of unpredictable magnitude.

The effects of dry spells on crop growth have been stressed in the literature (Ramon and Krishnon 1960, Niewolt 1972; Kowa and Kassam 1993; Berger and Goosens 1983, Olaniran 1991, Owonubi et al 1992).

It is generally observed that the knowledge of occurrence of wet and dry spells is important in any assessment of moisture resources reliability and potential for crop growth.

Apart from socio-economic problems facing Nigeria farmers climate variability constitutes a major limiting factor in crop yield. This is so because the bulk of food produced in Nigeria is grown as rainfed. In spite of its place as the piller of any agrarian venture, climate particularly precipation, has not been accorded the deserved priority in agricultural planning in Nigeria. The general neglect of this natural resource might be based on the impression that tropical climate is equitable. However experience have shown that several attempt to boost food production are being failed by persistent drought spells (Adefolalu , 1991). As strategies to increase food production are being evolved, there is the need to appraise climate as a resource affecting food production along with other agronomic factors. This will serve as a basic for the cultivating of different crops. In this regard, the application of agroclimatology becomes imperative in providing fundamental climate information for sustainable agricultural development.

The variations in the annual, seasonal and monthly precipitation each year are sharply reflected in the total crops yield. Short term variability in

precipitation in Northern Nigeria which is characterized with late starts of rainfall and early cessation have led to a wide cry of drought in perhaps normal (or above normal) total annual rainfall but characterized by delayed onset or premature cessation (or both) of the rainy season is worse for plants then one with definite shortfall in total amount but normal dates of onset and cessation. Also shortened rainy season with above – normal rainfall implies with intensity precipitation which could be bad for arable land with top soil washed away by erosion. Hence precipitation effectiveness is to be associated with those and other factor perhaps least should be the total rainfall amount.

The character of rainfall varies not only from place to place but with time at a particular place. The nature of rainfall can vary during the growing season and this will have major implications.

The effect of rainfall condition are not constant varying not only with other physical conditions such as soil type and relief but also with economic technology, social and political conditions. More over, the human factor varies with time and it is easy to mistake their influence peasant activities were well adapted to the environmental conditions but changes often induced from outside, can lead to a break down in the system or make it

more difficult for communities to adapt to harsh conditions such as a series of fluctuations in seasonal rainfall.

Ogallo 1984) point out that although rainfall variability has important impact on agricultural production, also many human factors played various roles in crop yields. He contract the situation in some tropical latin America countries and part of Asia such as Indian, where sound planning and increased in food production resulting from technology innovation which have greatly reduced famines and deaths.

(Micheal 1983) used a modelling approach to assess climatic sensitivity of yield variety "green revolution" wheat in India and Mexico. Increased adaptation of the high yielding "packaging had to significant increase in yield sensitivity to important climatic factors including variation in rain fall. Onset, cessation and rainfall effectiveness should be taking into account. However, rainfall is an important element and in general, the amount intensity and frequency of rainfall is also very essential.

Of all the climatic elements rainfall is probably the most important as far as crop production is concern and indeed the availability of water is one of the major climatic factors that effect crop yield. The significant of the illustrate the need to study onset, cessation daily and monthly variation in rainfall in relation to crop yield. Climate fluctuation short-term variability is

becoming of increase importance. The high degree of precipitation variability that has plague different parts of Nigeria particularly the Northern region has been of great public concern, precipitation in such areas has become unreliable. The large –scale variation of rainfall in space exert a great influence upon agricultural system and water supply. Not only do amounts depend from average condition in individual year but also the way in which they vary differs from area to area. For a particular period, rainfall can be well above average in one region but below average in another.

Large-scale variation and effects of "permanent" influence such as relief an important aspect is the nature of individual tropical rainstorms. These are often of very limited spatial extent with considerable gradient in intensity and amount. Even when a large area can be described as rainy, in reality the rain will comprise cells often intense rain separated by area of dry condition or only light falls.

The marked spatial variation in tropical daily rainfall have considerable implication. The consequence of this precipitation variability, which is of special importance of extended period with much less that normal precipitation. The sensitivity to precipitation variation of agriculture, the hydrological cycle and the pastoral normalism in Northern parts of Nigeria.

1.2 PROBLEM STATEMENT

Unfortunately, it has been realized that increase in demand for yam in recent time has not accompanied with corresponding increase in production. In order words has the production of yams been able to satisfy the demand? The variation in the production of yam is stimulated principle by interaction of climate such as rainfall. The climate and meteorological factors owe allegiance to nature as observed by (Inah 1990).

The principle of these agrometic variables on agricultural production has through legendary evidence been linked to a cause by God (Alingbe 1983). Thus this influence of traditionalism rooted with agricultural productivity without due considerations to various or interactions of natural phenomenon is viewed paramount in this work. It is purely change or fluctuation in rainfall that brings about variation in production.

At this point, the question now is has the production of yam been able to meet the demand? What are those factor that militate against yam production? Can farmers optimize their production if knowledge of climate resources is given to them.

The above question when critically analysis provides on insight on crop climate relationship existing between rainfall variation and crop (yam). Yam production in Kuta and environment. These questions seem to be the

bedrock of this research which is geared towards analyzing the interaction of crop yield (yam) and variation in rainfall as well as predicting yam yield.

1.3 AIMS AND OBJECTIVE OF THE STUDY

The aims of this study is to examine variation in rainfall and crop (yam) yield in Kuta and its environs. Using mean monthly data. Under this general aims, the specific objectives are:

i. To assess the length of raining season to yam production.

ii. To know how crop yield respond to rainfall variation.

iii. To assess environmental factors that offers the yield of yam.

iv. To promote or create awareness about conventional parameter of mean, annual, monthly length of rainy season as a guide for planting.

v. To enable the planner guide against fluctuation of rainy season in Kuta and it environs.

1.4 JUSTIFICATION

The poor harvest of food in various regions of world and failure of some major agricultural development scheme points to the necessity for study of the effect of climatic and hydrologic factors on the agricultural production (WMO 1976).

In Niger State and particularly in Shiroro Local Government Area and other parts of the guinea savannah region of the country , climatic parameters are the primary control of crop production. Yam is relatively an old crop in Niger State and in the study area (Shiroro Local Government Area) . As a result much has been done to increase the production rate of the crop. Through the introduction of new high yield varieties to the concern people which are they farmers and the application of the fertilizers, the production of yam is very important to the farmer because there is no crop that generate income like this crop. It is also very easy to be prepared for consumption. Presently the demand for the crop is higher than the supply. These are every need to increase the production to meet the demand.

1.5 SCOPE AND LIMITATION

The research covers Kuta, Shiroro Local Government head quarter and its environment.

The locations serve as good representation of the study area as far as this study is concerned. The limitation of this study is that, the researcher would have love to carry out this investigation to cover all Niger State or all the Yam producing areas in Niger State, but hindered majority by time and money.

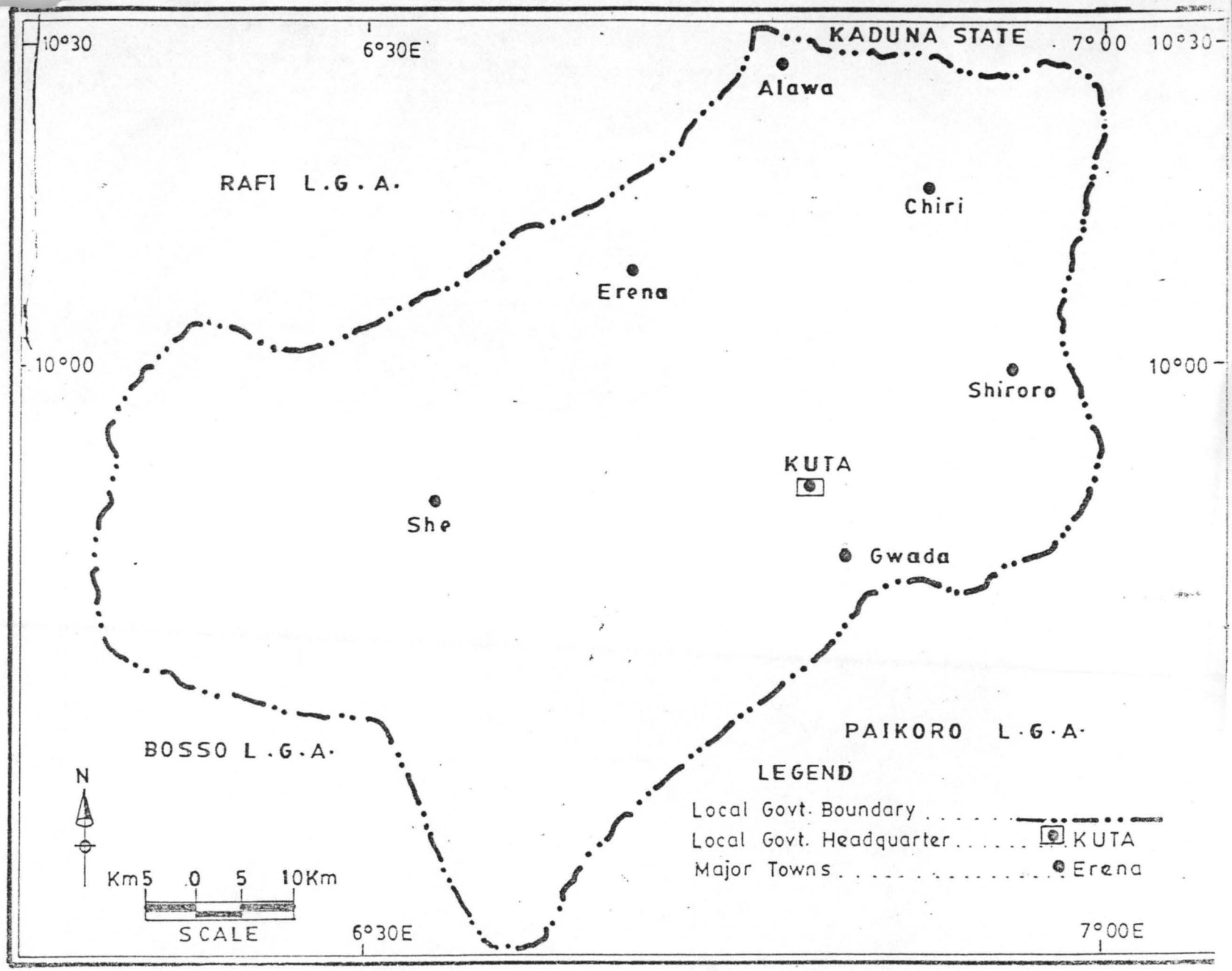


Fig. MAP OF SHIRORO LOCAL GOVERNMENT SHOWING THE STUDY AREA.

Source :- Author's field Survey, 2000.

CHAPTER TWO

2.0 STUDY AREA

The study area for this works is Kuta and environs. It is located approximately on longitude 65° North and Latitude 9.8° East.

Kuta share common boundaries with Muya Local Government , Rafi Local Government , Chanchanga Local Government and Bosso Local Government .

2.1 GEOLOGY

The basement complex and the sedimentary basin are two different geological unit in Kuta . It consists of various suits of metamorphic and igneous rock. The sedimentary basin consists of two confining units of aquifers. These are confined and semi – confined aquifers. The unconfined acquifer is limited to the small area.

2.2 TOPOGRAPHY

Over most of the areas there is a close correspondence between the landform and the underlying rocks flat lying or gentle dipping rock series tend to be eroded into tabular relief. These are invariably terminated by steep scarps, examples of which is in Kuta plains on each major rock group,

different types of landform which can be identified such as a slightly elongated type, which is about 500m in length and 200-300 in width.

Also there are some hills, which are not massive, nor too high but dissected which occupy up to 30-35% of the surface area of egwa. The rest area are flat cover with vegetation – which are both natural and man made.

2.3 CLIMATE

The present climate of the study area is the tropical wet and dry type coded ad AW by W.Koppen, although climatic changes are believe to have occurred in the past. The characteristic of the major elements of the present climate.

Basically rain start towards the end of March or very early April, August and September use to be the month that has high down pour which the mean average some time is 832.3m per annum and the rainy season cease by ending of October. At least crops have adequate rainfall for high yield.

2.4 TEMPERATURE

The temperature of the study area is about 34^{o} on the average and this show very little variation throughout the year the relative humidity is up to 56% and usually higher in summer than in winters owing to the prevalence

of tropical maritime airmass which originates from the Atlantic ocean and hence moisture harden, and blowing across the area from March to October (W. Weke, 1988) .

The observe or derived parameters of climate such as seasonality of rainfall onset date of rains cessation date of the rains and the length of rainy season (LRS) has influenced and/or control crops growth and development and contributed to high crop yield in the area.

2.5 SOIL AND VEGETATION

The soils and vegetation communities of the study area occupy an important position in her development. The soils in he study area were derived from hydromorphic and organic soil develops on alluvia, and fluvial deposits of variable texture notably along the river flood plains.

The terrazzos, developed especially on sedimentary rock this classification is based on the food and agricultural organizations. Flood plain soils are found along the river line areas of the study area. These favour the production of vegetable and sugar cane.

There is only one brand type of vegetation in the study area which is the guinea Savannah with light forest which also favour the production of various crops.

2.6 DRAINAGE AND HYDROLOGY

The drainage of the area is part of the Shiroro dam which flow toward the northwest area apart from this there are other streams such as Ose river and Kurumana river all. These are influence by climate, rock structure and human activities. To the west and south of the area there is high surface water and ground water is very much available which is under utilize. The climate of the area control the amount of water that is available both on the surface and at sub-surface at any given time within a water year. The climate also controls the region and other characteristic of the rivers. For example, water is abundantly available during the wet months both on the surface and at sub-surface.

2.7 SOCIO – ECONOMIC ACTIVITIES

The study area which is Kuta and environs is an area that lies within the agriculturally prolific zone of Nigeria. Farming is the major occupation of people, who seem to take advantage of the good soil to cultivate a great variety of crops. Crops produced include yam, maize, sorghum, rice, groundnut and soyabeans.

Fishing occupation is practice in the riverine area of the study area but in small quantity other menia service such as trending and civil service work is practiced here too.

2.8 FARMING PRACTICE

More than 75% of the Gwaris are farmers thus farming is the major occupation of the people of the study area. About 10% practice trading, weaving and fishing while 15% engage in civil service and related works.

The major crops commonly cultivated in the study area include yam, guinea corn, maize and groundnut. Nevertheless, the majority of the people are still using traditional methods of cultivating land. The crop seed tuber are planted before beginning of the rainy season or at the beginning of rainy season yam is planted either as a sole crop or mixture with other minor crops. More than 60% of the inhabitant complement yam with other crops but a substances level weed control in yam is usually done by use of hoe or chemical (harbisis) however, very recently with the improvement of the agriculture from the Niger State government has established a centre for the farmers to have tractor to boost agricultural activities in the area of study. The Niger State Government supplies at a subsidized price in order to improve agricultural productivity in the country.

CHAPTER THREE

3.0 LITERATURE REVIEW

Although an appreciable number of scholars have written on the rainfall variability and crop production in Nigeria. It appears none has written on the rainfall variability and crop production in Kuta and its environs, like wise work done on the rainfall variation and yam production in Kuta and its environs are very scarce. In an attempt to do so, the researcher will rely partly on the work of others else where which are found relevant to the research and the few ones in Niger State.

Some issues raised by scholars with regard to rainfall variability and crop production in Nigeria and Africa at large include the onset, cessation and distribution of the rain during the growing season in a particular area.

The moisture agrometerological indices (rainfall, evaporation, soil moisture and humidity) provide the medium for the processes of plant growth. Thus in the tropics the impact of the interaction among these indices on plant growth vis-avis regular supply of food for mankind cannot be over estimated of all the moisture agrometerological indices, rainfall is critical to plant growth in the tropics. In particular, rainfall modifies both the nature and extent of the effects of other components of plants. For instance, low rainfall might lead to low humidity and humidity vis-avis low

vapor pressure of the air induces increased evaporative loss of moisture through transpiration. Thus, rainfall might influence not only the potential atmospheric moisture but also the soil moisture status of the plant. It follows that variation of rainfall can change the significance of other hydrometerological factors in producing different growth processes, adaptation to the moisture environment, and different rate of photosynthesis (Critchfield 1974) Regrettably, rainfall is the most variable and least predictable agrometerological index in the tropics and in Nigeria in particular. Thus, in order to effectively mitigate the effect of rainfall variability on food production. It is important that rainfall producing mechanisms and pattern of water availability of seasonal rainfall in most parts of tropical Africa may be divided into two main categories. Forcing from the ocean surface and forcing from the land surface (Hocking and Thompson 1979, Newell and Kidson 1984, Druyan 1989, Nicholso 1989).

Therefore, since a good understanding of the characteristics of occurrence of rainfall is pertinent to its predictability for agricultural purpose attempts have been made in this study to model the characteristics of onset, cessation, distribution and duration of the rain and to asses the reliability and sufficiency of rainfall for crop growth and development in Nigeria.

Climate of any part of Nigeria can therefore be regarded as a micro – climate of West Africa (Garnier 1967).

Oguntayinbo 1978 important work describing part of climate of West Africa include those of Adefolalu, 1986, Oguntoyinbo, Ojo 1977 Adejokun 1964 , Garnier 1965, Hayword 1987 and walker 1988.

Recent trends in climatic studies and researchers in Nigeria since independent were centred on climatic impact studies Adefolalu 1984 did on extensive work on problem of flood in the south, when rainfall of more than normal was recorded in 1963 which led to inadequacies in mass haulage of goods. This in effect affected planning generally to some extent.

Treworth et al 1986 noted that the movement of the rain is similar to that of the sun. The emphasized that marked north –south shifting of precipitation belts follows a similar migration of solar radiation belts (Oguntoyinbo and Adefolalu, 1985) further noted that the pattern of rainfall is much that the equatorial zone has a double rain belt. This implies that areas within this belt are liable to flood and erosion. In agricultural regions that rely on irrigation production varies from year to year because of precipitation uncertainties in the catchment area that supply the water for irrigation. This is however not to say that precipitation alone can explain variation in crop yield (Henghto 1985).

The change in rainfall pattern with time may be explained in terms of changes in general atmospheric circulation which cause south word and northward movement of climatic zones. This according to Lamb 1968, 1972, will affect the growing season or the length of the growing period of crops which will in turn after crop yield. The monsoon factor and the seasonality of rainfall distribution in Nigeria by Olajide .J. Olaniran 1972 concluded that seasonality of precipitation is the tendency for a place to have more rainfall in certain months or seasons than in others.

In relation to subject matter, (Yam dioscorea spp). It is one of the staple foods in some parts of Nigeria and West Africa at large. The crop is one of the most popular tuberous crop in the world and the second best tuberous crop in the world.

The crop contain poisonous alkaloids that is why they must be boil, fried or rost before eating. However, some of these alkaloids are useful drugs particularly the steroids. The crop is high in carbonhydrates which it can be used in starch production. The main uses of the crop is for preparation of yam flour.

The crop require at least 1000mm of rain per annum, most of which should fall within the growing season. It mature between six to seven months after planting, yams are specifically grown for consumption.

Planting of yam depend on the nature of the ecological zone of the area and nature of onset and cessation of rainfall.

Four types of yam production depending on the ecological zone of the area. Mounds system this is the most dominant traditional method of preparation for yam production. The size of the mounds varies depending on the ecological zone. The height of the mound ranges between 50-60cm in diameter and 50cm to 70 cm lights. Mound are made with hoe and some should closer to this ridges is a recent and improved land preparation method. It is used in mechanized yam production. Ridging is amenable to improve agronomic practices, especially the use of tractors. Interspacing for ridges ranges 75cm to 160cm x 100cm. Although ridges are made manually in the field in forest zones.

In addition to this yam can also be planted on flat ground which is common in the forest zones areas like Delta, Ondo, Edo and others in Nigeria. After clearing the land and burning and removing the residue, holes are made at intervals and as much as possible in raw. Seed yam are sown and the holes are covered.

Adequate land preparation is another prerequisite to high yield of the crop. There are various species of yam among them are white yam, yellow yam, bitter yam and water yam. Despite all human effort such as application

of fertilizer, good planting material rainfall can still be a primary limiting factor in yam production.

3.1 RAINFALL VARIATION

The rainfall variation are generally accepted to be important because they control largely the calendar of many activity. For example, the time of the start and end of the rainy season are important for agricultural activities.

There are two main seasons in the study area namely the dry season and wet season. The dry season is usually between November to April and some in the month of May. This period when rainfall is entirely absent and vapours pressure is low. The weather during the dry season is characterized by hot and dry air.

The wet season started in March/April and the length of the wet season varies from place to place. In the study area the length of wet season is between April and October. The peak of rainfall occur in August and September with a short slightly drier spell called the "August breaks" or little dry season occurring in the intervening period.

The rainy season virtually comes to an end in October and in the later part of the month marks the beginning of dry season.

3.2 REVIEW OF CLIMATIC FACTORS

TEMPERATURE

Temperature does not constitute major constraint to the crop production, but it is essential for the growth of crops in the tropical region. The temperature is usually high, some times higher then in the south because of distance from the moderately effects of the Atlantic Ocean. The highest temperature is usually recorded in March (31°C) and the lowest in August (25°C) Yayock et al, 1988). The critical temperature which the crop will not well is 45°C and the maximum temperature for the crop (yam) to grow well is between 25 - 30°C.

3.3 LIGHT

Light is very essential for plant development. Crop required light in the day time, when the day – light is shorted below on critical value. This makes it to be regarded as a short day plant. Photo periodic response is an important factor for crop production crop will remain vegetative almost indefinitely if the days are long enough. Empirical observation in the field within the tropics has indicated that the above photosensitivity of the crop fits best in the tropics.

3.4 RAIN FALL

Rainfall is often the primary factor in crop production and this is on important management concern. In area of low rain yam can not perform well. A water deficiency of 1000mm is the limit for growing yam without irrigation system. (Mota, 1978).

Generally speaking the growth of yam from germination to maturity is proportional to the available adequate and well-distributed rainfall. Yam required average of 6 months of rainfall anything less than this can be injurious to the crop.

3.5 RELATIV HUMIDITY

The seasonal variation in relative humidity in the study area January and March relative humidity is low and it starts increasing, as from April and reach the peak in August and September. This is due to influence of humid maritme our mass. Relative humidity starts to decline again as from October following the cessation of rains. In relation to crop production, the mean sunshine hours in the study area is adequate throughout the year to provide the drying power of the air required by field crops.

CHAPTER FOUR

4.0 METHOD OF DATA COLLECTION

Data used for this work were obtained from various sources. Rainfall data were obtained from meteorological station, airport at Maikunkele. Some of the data was obtain from NEPA Shiroro and also from Agricultural Development Project Minna. Location selected for this study are Kuta, Chiri, Gunu and She.

Rainfall data for about ten years were collected for each different location from the station near the study area. The information above will be used to determine the effect of rainfall variation to yam production.

Other information were extracted from various sources such as the work of scholars related to this research, ~~during~~ seminars as well as topographical map of the study area. Some materials used for this research work were also extracted from other various sources such as the work of Kowal and Kassam (19930 and ecological zone of Niger State. However, the various parameters ~~studied~~ لمعدة in this research work were either compiled from the various sources or computed from the various data mentioned above.

In addition to the monthly and annual data obtained from meteorological station airport at Maikunkele, the annual rainfall data collected from Niger State Ministry of Agriculture used for the project.

The yield data wee collected from various sources particularly, the Ministry of Agriculture, Minna. Agricultural Development Project, Minna and Federal Office of Statistics in Minna.

These were supplemented with those obtained from questionnaire from selected stations of the study area for the period under study . The information received from the above sources were from 1991 – 2000.

4.1 DATA ANALYSIS

Statistical method used in carrying out the data analysis. These are combined with the graphical method. The mean annual rainfall was computed by using the method below:

$$x = \frac{\underline{x}}{n}$$

Where x = annual rainfall for a given period.

n = number of year

The use of mean rainfall which assumed a central tendency shows what is expected for each period standard deviation (6) is another statistical method used in this research work this can be express as

$$\delta = \sqrt{\frac{(k1 = x)^2}{n-1}}$$

When xi = Annual rainfall for given period.

x = The average annual rainfall (monthly)

σ = Standard deviation

Climatic Index (c.i) is also used to annualized the rainfall data in this research work..

The index represents the extents of variation of a parameter from an established normal. The climatic index can be expected as follow:

$$c.i = \frac{x1 - x}{\sigma}$$

Where xi = rainfall of a particular year or period.

X = mean annual rainfall for the location.

0 = standard deviation of the precipitation record. When the value of the climatic index (c.i) is in the range of 0 and –0.5 it indicate mild dryness. When the climatic Index is between 0 and + 0.5 it indicate mild wetness.

When the Index is between –0.6 and +1.0 indicate severe wetness and lastly if the climatic index is greater than +1 it indicates extreme wetness.

Similarly, regression analyses is also used in the present research. This expressed below.

$$R = \frac{n\Sigma xy - (\Sigma x)(\Sigma y)}{[n\Sigma x^2-(\Sigma x)^2\ (n\Sigma y^2-(\Sigma y)^2]}$$

Where x = annual total rainfall of a particular year.

Y= Yam yield of a particular year

n = Total number of all cases or year

CHAPTER FIVE

5.0 DISCUSSION OF RESULT

This chapter discuss and analyzed data collected from variation and with regard to rainfall variation and crop production. The chapter examine the rainfall variation in the study area, followed by a more detailed analysis of the year to year rainfall variation. The typical dry and wet years are also discussed. Also annual rainfall and department from the mean, the trends in climatic indices are examined.

In addition to this, the relationship between yam and rainfall, and other ~~favours~~ factor affecting the growth of the crop in the area under study are all examined.

5.1 DISTRIBUTION PATTERN OF ANNUAL RAINFALL AMOUNT

The mean annual rainfall experienced in the study area varies from year to year and from place to place. For instance the yearly annual rainfall in Kuta 809.5mm to above 1400mm, in 1999 kuta recorded rainfall amount of 1434.5mm. This marks the highest rainfall amount recorded during the study period. The lowest rainfall recorded during this period was in the year 2000 when the rainfall recorded was about 809.5mm as can be seen in Apendix 1.

In Erena rainfall recorded during the staudy period (1991-2000) also varied from year to year. The highest rainfall was recorded in 1999 (1336.2mm). then following year witnessed a declined in the rainfall amount to 780mm.

In She rainfall recorded was relatively low, the highest rainfall amount recorded in She was in 1993 and the lowest recorded rainfall amount in She was 755.2 as can be seen in Appendix 3.

It is to be noted however that annual rainfall amount is not as significant as spread of rainfall for agricultural activities.

5.2 RAINFALL VARIATION IN SHIRORO LOCAL GOVERNMENT AREA.

Rainfall variation as widely accepted as an important key factors which controlled the calender of the agricultural activities, for instance the onset cessation days of rainy season are also important in the agricultural activities. Shiroro Local Government area under two different seasons, these are the wet and the dry seasons. The dry season starts between October ending and early November and the rainy season start by March or April.

The length of wet period varies from 170 to 200 days in the area from six to seven months. (A.S. Agboola 1978).

However, the rainfall variation in the study area varies from one location to the other. For instance the places in west and eastern both recorded rainfall amount of above 1000mm also to the northern part (fig. 5.7) shows this rainfall tends to increase from west direction to east direction.

The location in the southern part of the study area recorded rainfall amount of less than 1000mm. In the month of July the amount of rain varies from one location to the other, Kuta recorded the total annual rainfall of above 200mm while Erena and Chiri recorded less than 200mm rainfall amount. This can be seen in Fig 3.1.

However, in the month of October which is the cessation month of rainy season in the study area. In the month of October She recorded the mean annual rainfall of above 100mm (Fig 5.2) while Chir recorded less than 100mm which shows the cessation period of rains (Fig 5.2 the rainy season comes to an end at the end of October and virtually the dry season starts.

5.3 YEAR TO YEAR RAINFALL VARIATION

In Chiri which is located in the eastern part of the study area, the year to year rainfall variation during the period under study shows that between year 1991-2000 the highest was recorded in 1996 with the record of

3.6 EVAPORATION

Evaporation is the change of phase of water from liquid to vapor, is an indication of water loss in an environment. In an area where the rate of evaporation is very high, this may point to the need, as it is very essential for the growth and development of crop.

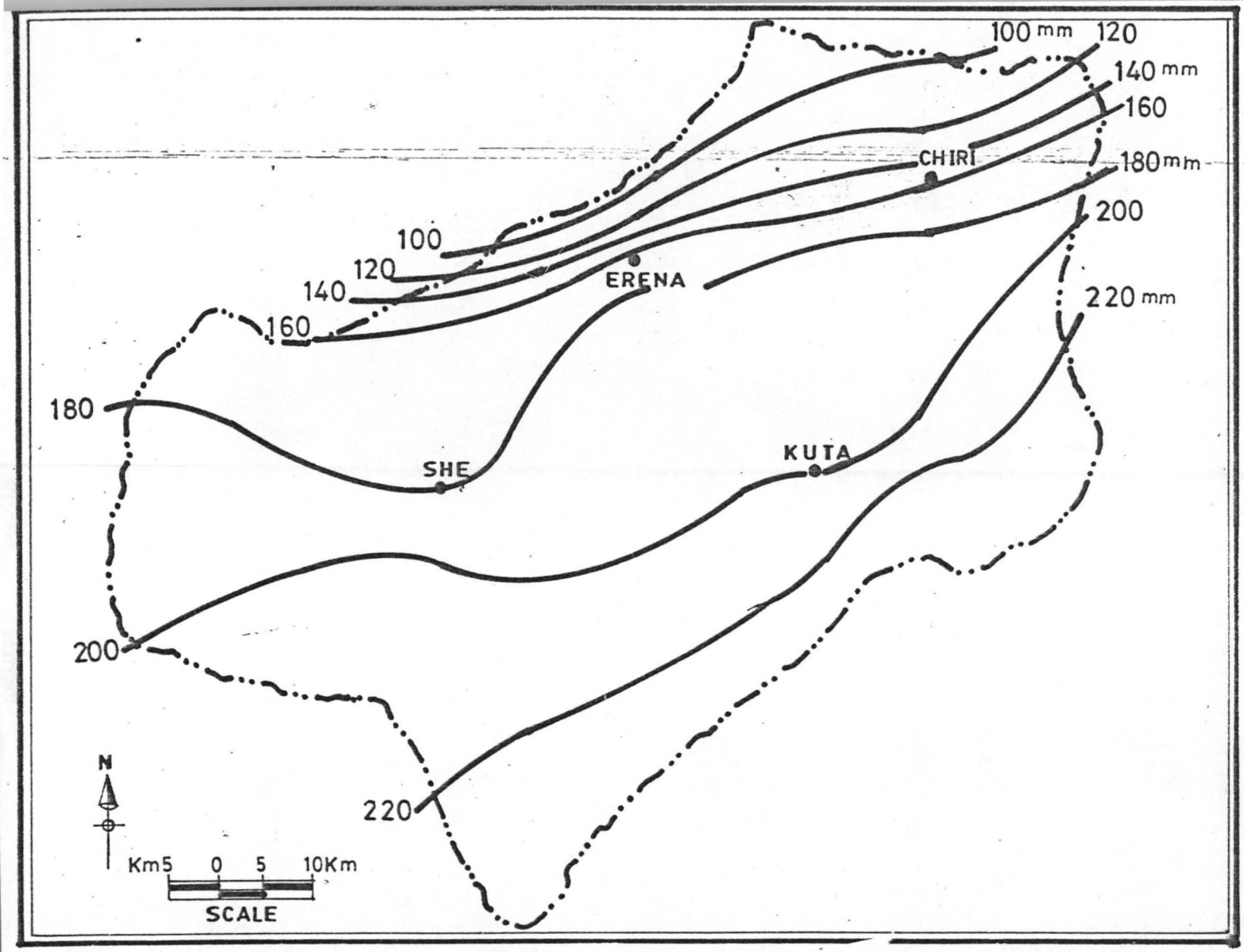


Fig-5 1 MAP OF THE STUDY AREA SHOWING RAINFALL VARIATION IN JULY (MM)

Source :- Author's field Survey, 2000

1223.2mm and the succeeding year 1997 witness a sharp fall in the annual rainfall with the record of 1195.3mm (Fig 5.14).

Kuta is located in the North/eastern part of the are under study. In Kuta the amount of total rainfall recorded from 1991 –2000 were all above the mean of 1059.6 (Appendix 2) the highest amount of rainfall was recorded in 1999 with the total recorded in 1434.3mm and the lowest recorded in 2000 with the record of 809.5mm (appendix 1)

In She lies to the western part of the study area. The amounts of rainfall fluctuate with highest record of 1289.2mm in and the lowest record of 809.5.

(Appendix 3) During the study period Kuta was the settlement having the lowest record of rainfall (Fig 5.7) Appendix 1

5.4 TYPICAL DRY YEARS

The typical dry year in the are under study varies from year to year (Appendix 1-4. The table shows that

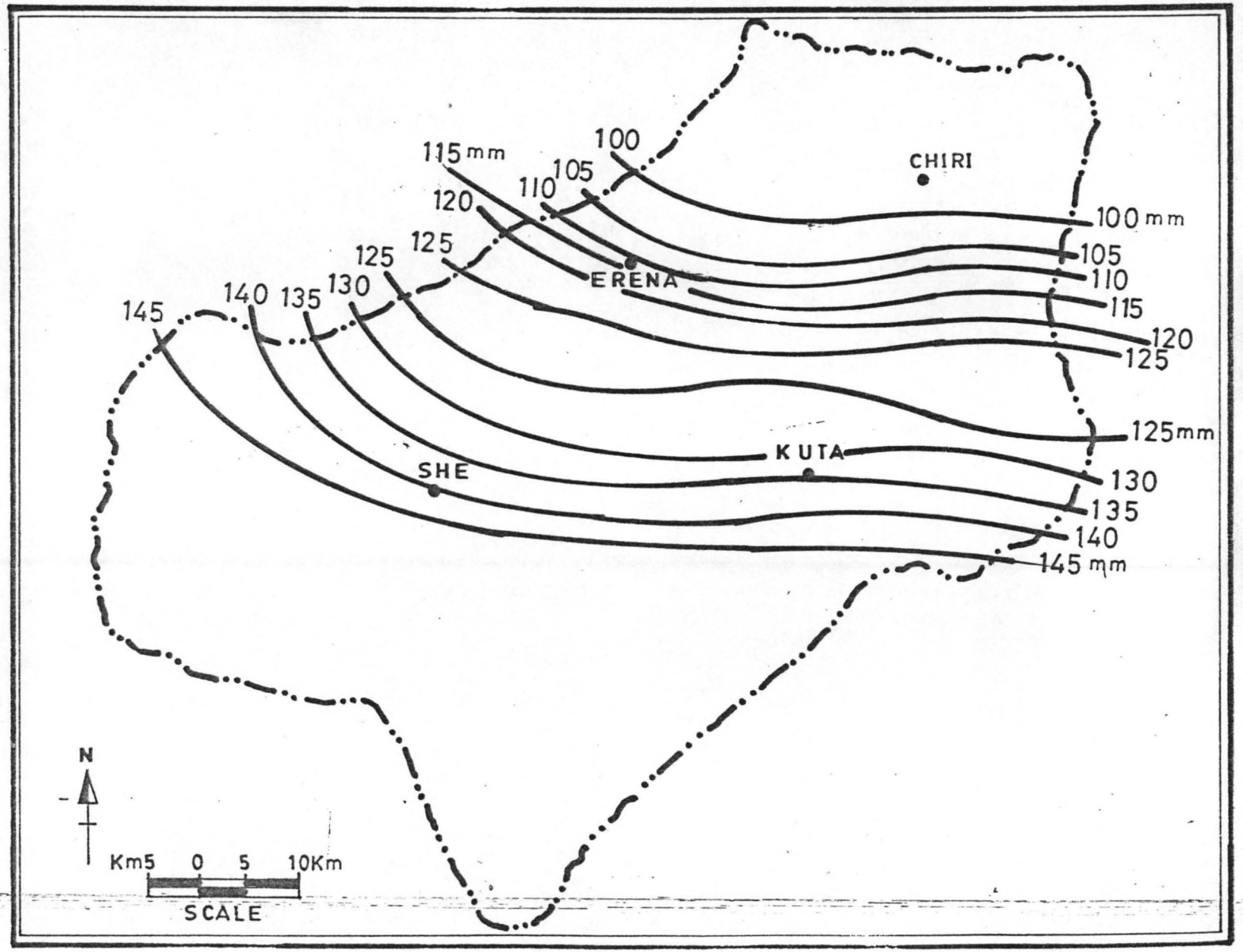


Fig.5.2: MAP OF THE STUDY AREA SHOWING RAINFALL VARIATION IN OCTOBER (MM).

Source: Author's field Survey, 2000

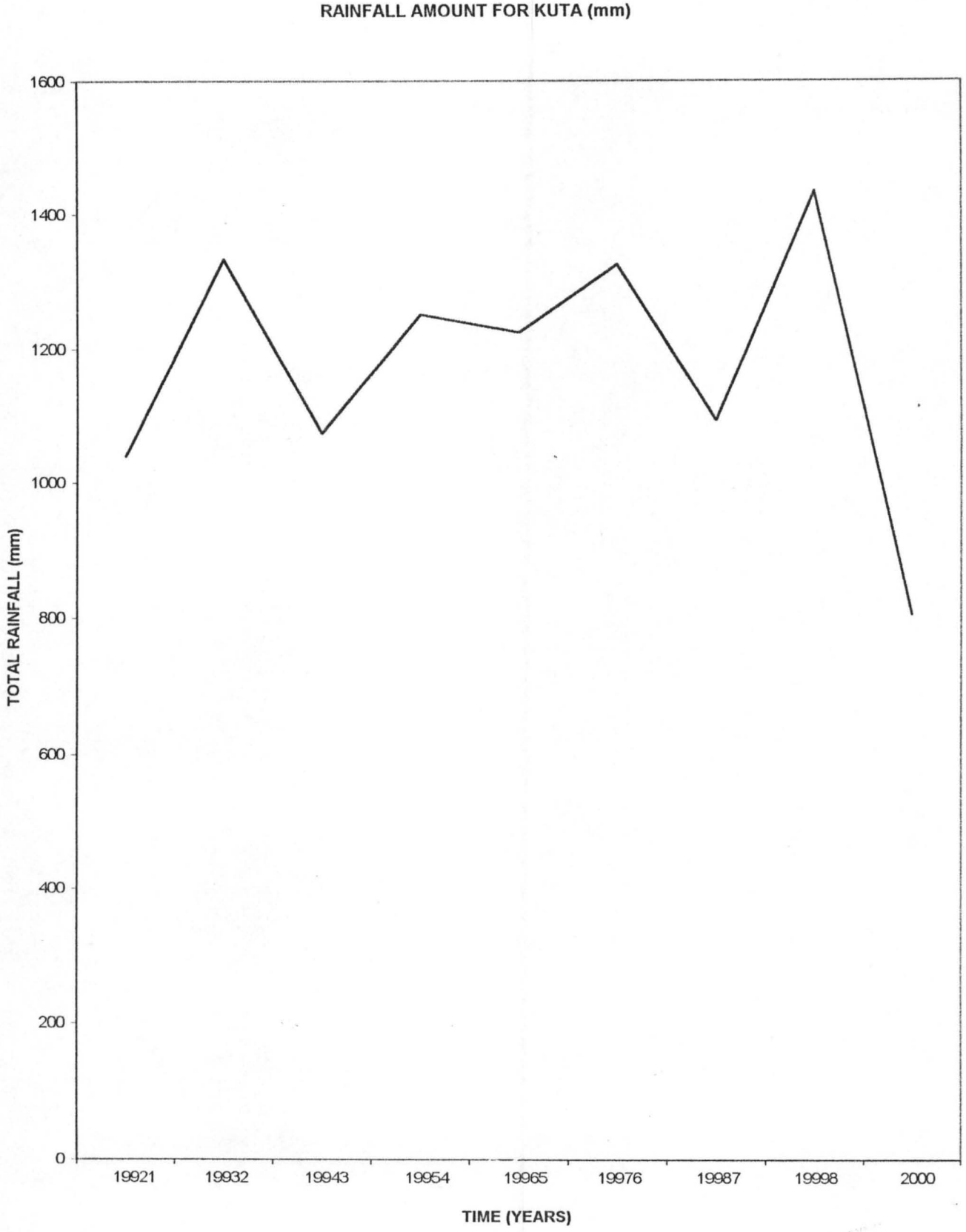

RAINFALL AMOUNT FOR KUTA (mm)
1600
1400
1200
1000
800
600
400
200
0
TOTAL RAINFALL (mm)
19921
19932
19943
19954
19965
19976
19987
19998
2000
TIME (YEARS)

Fig.5.3

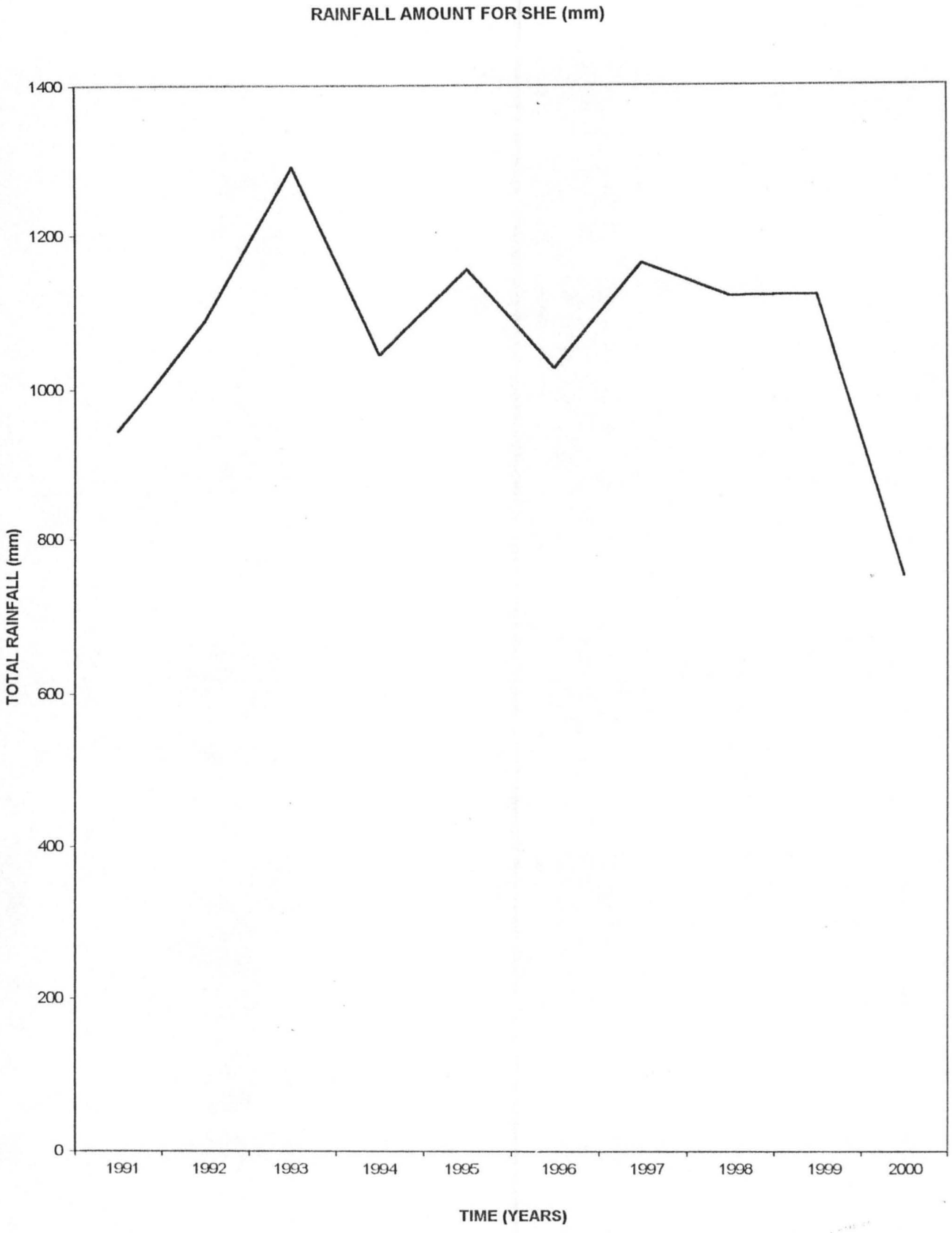

RAINFALL AMOUNT FOR SHE (mm)
1400
1200
1000
800
600
400
200
0
TOTAL RAINFALL (mm)
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
TIME (YEARS)

Fig.5.4

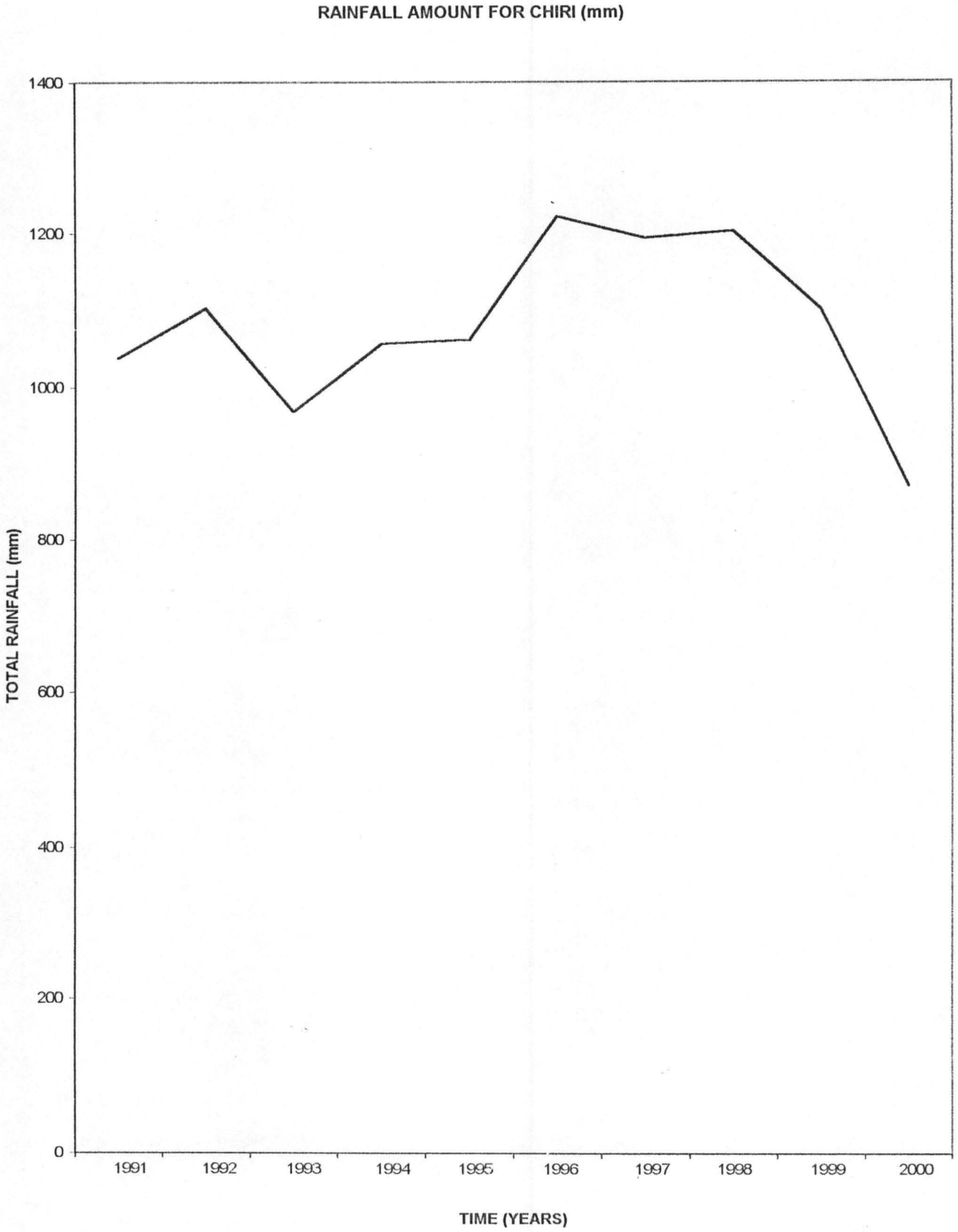

RAINFALL AMOUNT FOR CHIRI (mm)
1400
1200
1000
800
600
400
200
0
TOTAL RAINFALL (mm)
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
TIME (YEARS)

Fig.5.5

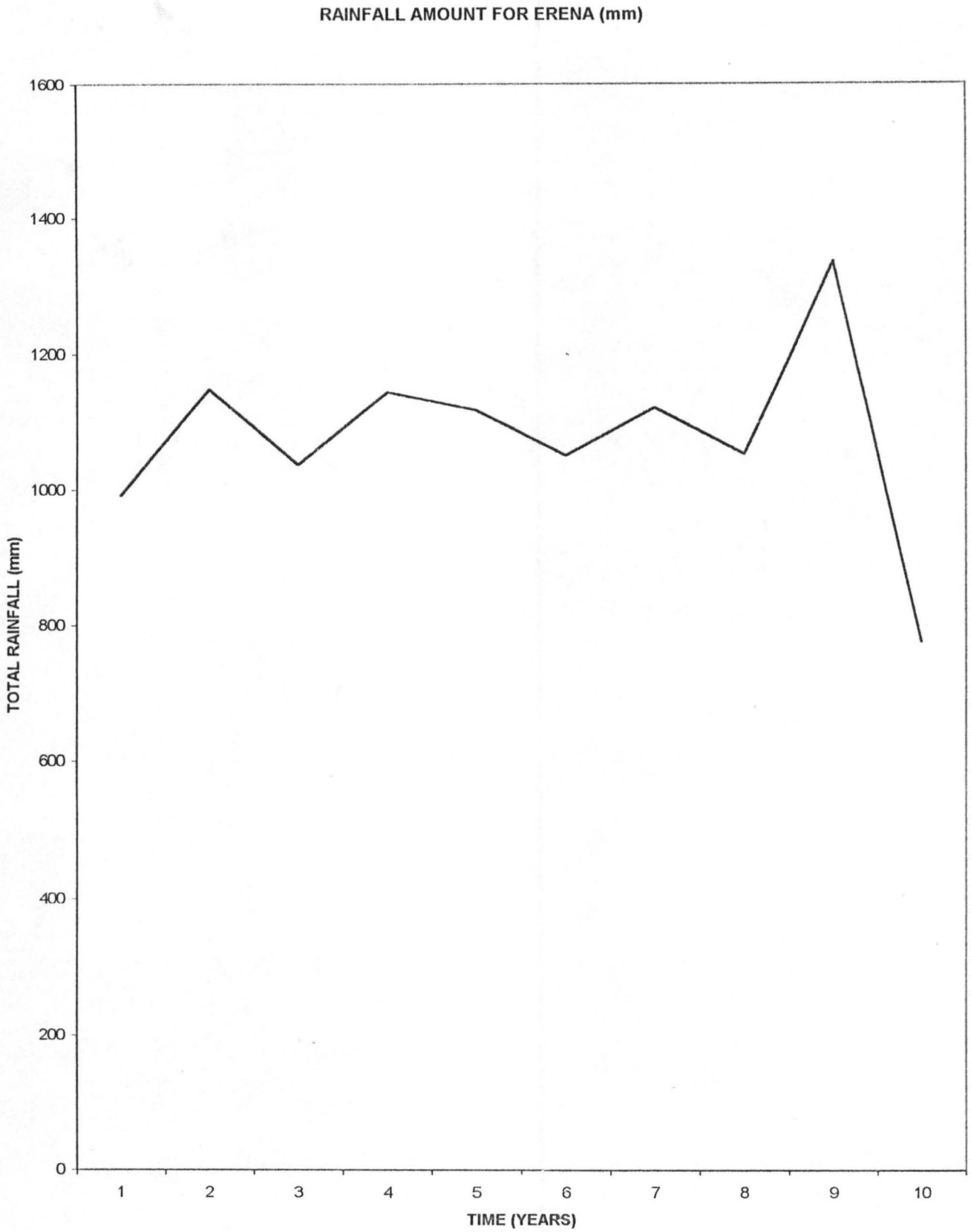

RAINFALL AMOUNT FOR ERENA (mm)
1600
1400
1200
1000
800
600
400
200
0
TOTAL RAINFALL (mm)
1
2
3
4
5
6
7
8
9
10
TIME (YEARS)

Fig.5.6

Table 5.1:

Location	Rainfall	Dry years
She	755.2	2000
Erena	780.0	2000
Kuta	809.5	2000
Chiri	874.2	2000

In 200 She had a total low rainfall (Table 5.1) Erena on the other had a low rainfall of 780.0mm in 2000. Kuta and Chiri had total low rainfall of 809.5mm and 874.2mm respectively. Of all the dry years he had the lowest amount of rainfall while Chiri had the highest total amount of rainfall as can be seen in the table above (Table 5.1)

5.5 TYPICAL WET YEARS

The typical wet years in the study area varies from one location to another. This wet period also varies form year to year as can be seen in table 5.2. The rainfall amount for Kuta, Erena, She and Chiri were 1434.3mm (1999) 1336.2mm (1999) 1289.2mm (1993) 1223.2mm (1996) ~~responding.~~ The table below shows the typical wet years in the area under study.

Table 5.2

Location	Rainfall	Years
Kuta	1434.3mm	1999
Erena	1336.2mm	1999
She	1289.2mm	1993
Chiri	1223.2mm	1996

From the above label the wet period varies from year to year (Appendix 1. 4)

5.6 ANNUAL RAINFALL AND DEPARTURE FROM MEAN

Oguntoyinbo (1978) noted that the geographical location size and shape allow West Africa to experience most of the annual rainfall pattern within the local government areas varies from place to place. The tends to increase West to East direction. For example She in the Western part recorded 1072mm of rainfall whereas Erena North direction recorded 1079mm . Chiri in the eastern direction recorded 3055mm (Fig 5.7). This indicates that rainfall in the study area are fairly evenly distributed.

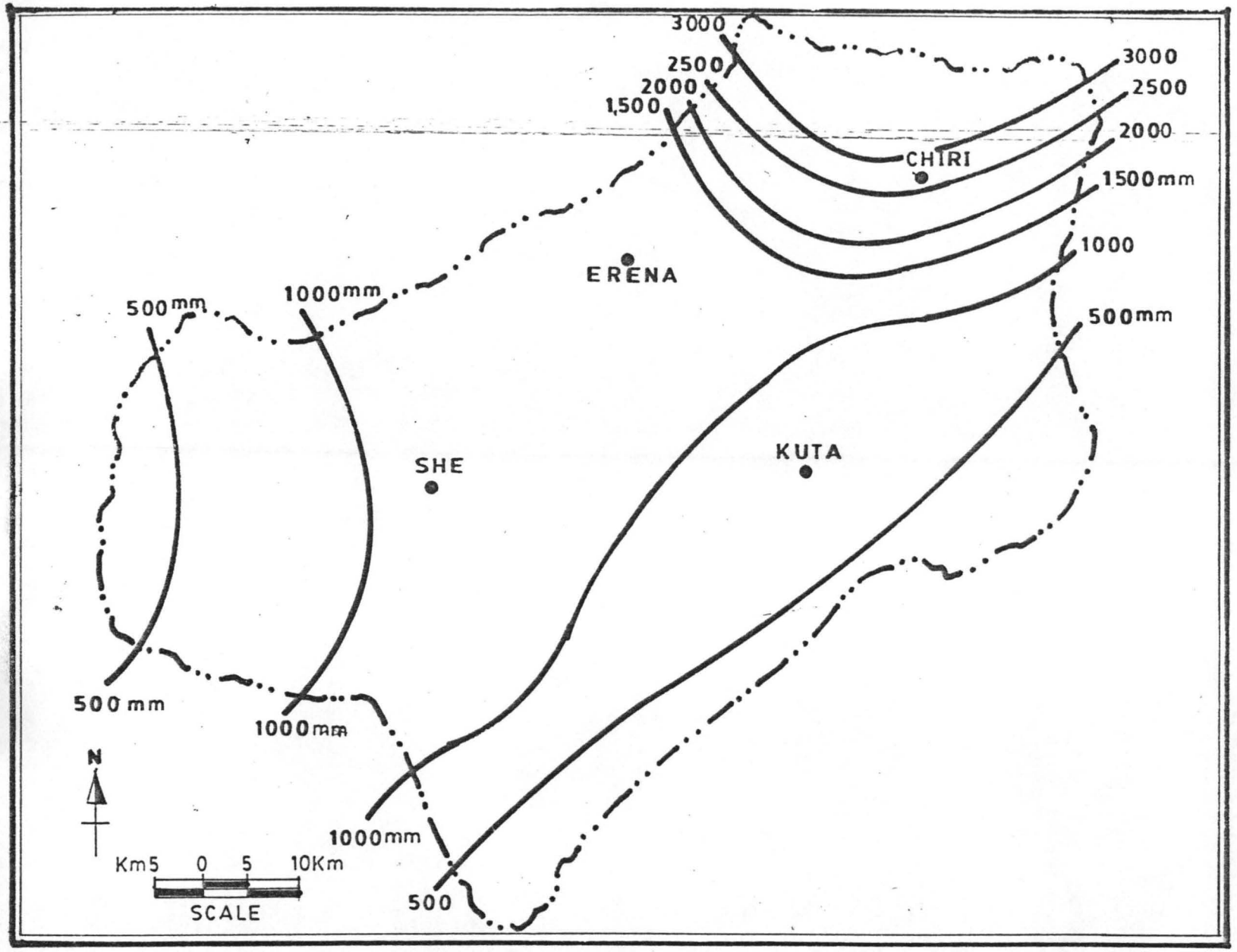


Fig.5.7 MAP OF THE STUDY AREA SHOWING MEAN ANNUAL RAINFALL (MM)

Soure :- Author's field Survey, 2000.

However, the year with the highest deviation from the mean in the local government recorded +374.3 this was in 1999 on the other hand the year with the highest negative deviation from the mean was –316.66 in the year 200 appendix 3. Kuta and Erena had highest positive deviation from the mean both of these two different locations recorded the highest deviation from mean in the year 1999 (Appendix 1&2). The highest recorded negative deviation from the mean in She and Chiri were –316.66 (2000) – 209 (200) respectively (appendix 3&4).

5.7 ANNUAL TRENDS IN YAM PRODUCTION IN SHIRORO LOCAL GOVERNMENT AREA.

Yam (dioscorea Spp) is one of the basic stable food crops in some part of Nigeria and West Africa at large. The main production area in Nigeria are Benue, Bendel, Edo, Lafia, Ondo, Niger State and others.

However, the yields of yam in the area under study, fluctuate with the rainfall amount. It most be noted that factors of climate are favourable to the cultivation of yam. Decline of yam cultivation is partly due to rainfall fluctuation. Dry spell as well as poor soil quality.

Table below shows the annual yield of yam for ten years from the selected location of the study area. For instance Erena recorded the highest

production rate both in 1992, 19994 and 1999 with the yield of 13,000, 13000 and 15,000 respectively with the rainfall amount 1149.3mm Fig 5.13 and 1145.2mm and 1336.2 (fig 5.13) Kuta is located in the southern part of the study area recorded low yield of yam in 1992. In 1992 the rainfall amount was 1040.8mm and the yield was 7500mm. In 1993 the rainfall amount increased to 1334.2mm the yield also increased to 10,500(fig 5.12). this indicates that when there is an increase in rainfall amount the yield of the crop also increase. This is not in all cases and this can be attributed to quality of the soil and improper weed control.

In Erena, the highest rate of production of yam was recorded in 1999 with the rainfall amount of 1336.2mm (fig 5.13) and the yield was 15,00. In the year 1991 the rainfall amount decrease drastically to 992.0mm with the yield records of 10,m000. These yield in 2000 was low (Fig 5.13). These could be due to anomalies in some climatic factors and the rainfall amount is evenly distributed in the area.

In Chiri the highest record of yam production was in 1996 with the rainfall amount of 1223.2mm and the yield was 12,200 and the following year 1997 when rainfall amount was 1195.3mm and the yield was 11,000. These show that yam required high rate of rainfall but not too excess water to produce high yield Fig 5.14 show the fluctuation of yam yield from year

FIGURE: 5.12

LOCATION: KUTA

YEAR	TOTAL RAINFALL	Annual yam yield
91	NA	8000
92	1040.8	7500
93	1334.2	10,500
94	1075.9	7,500
95	1251.9	8,500
96	1225.8	8,400
97	1326.9	10,000
98	1096.7	7000
99	1434.3	12,000
2000	809.5	6000

FIGURE: 5.13

LOCATION: ERENA

YEAR	TOTAL RAINFALL	Annual yam yield
91	992	10,000
92	1149.3	13,000
93	1037.2	11,000
94	1145.2	13,000
95	1118.1	12,500
96	1052.4	12,000
97	1122.9	12,800
98	1055.1	12,000
99	1336.2	15,000
2000	780.8	9,500

FIG. 5.11 DEVIATION FROM THE MEAN FOR KUTA

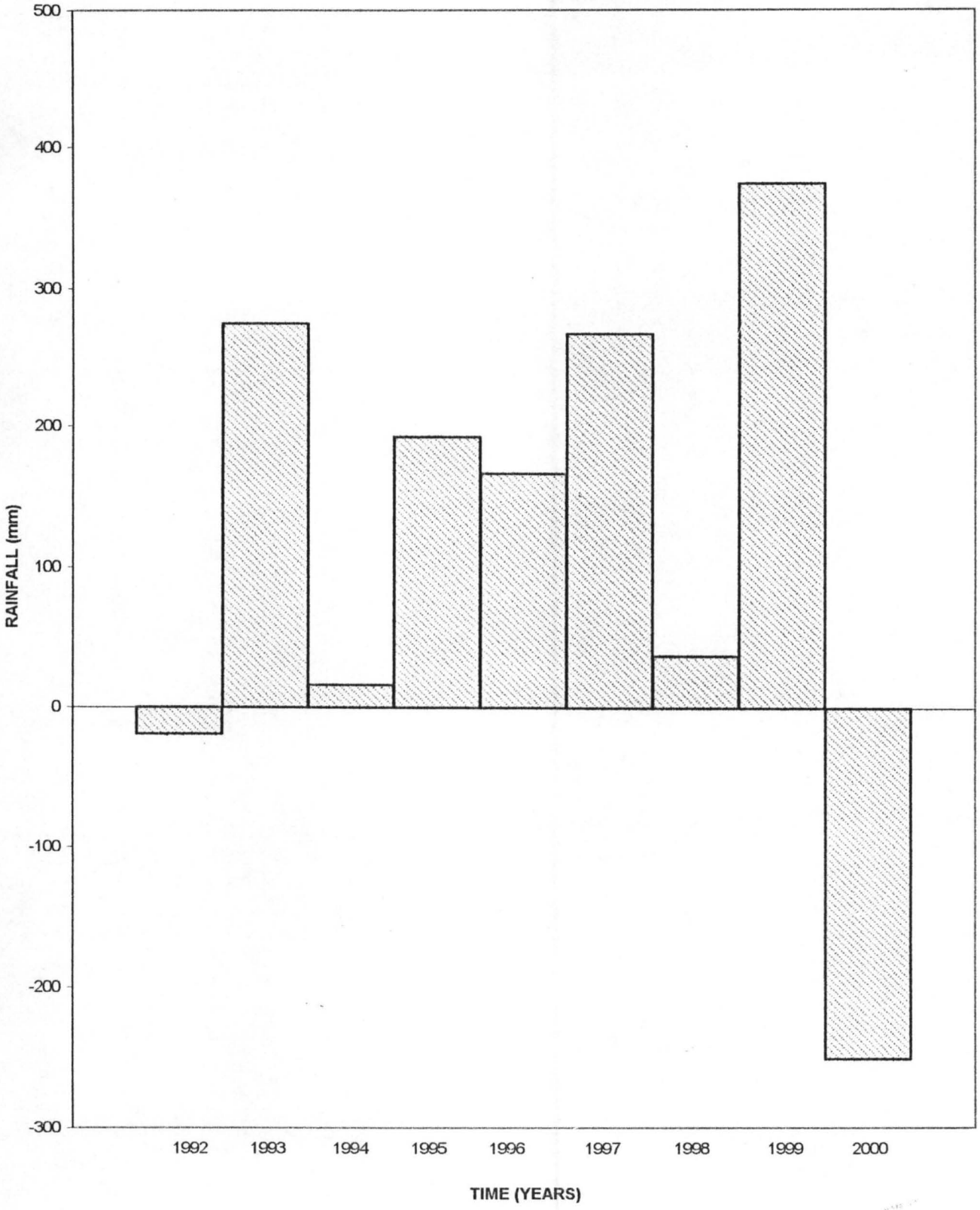


FIGURE: 5.14

LOCATION: CHIRI

YEAR	TOTAL RAINFALL	Annual yam yield
91	1038.2	10,000
92	1103.6	10,500
93	968.2	7,500
94	1057.7	10,700
95	1063.5	10,000
96	1223.2	12,200
97	1195.3	11,000
98	1204.8	12,000
99	1104.1	10,500
2000	874.2	7,300

FIGURE: 5.15

LOCATION: SHE

YEAR	TOTAL RAINFALL	Annual yam yield
91	944	7500
92	1087.9	8,700
93	1289.2	10,500
94	1045.3	8,500
95	1155.9	10,100
96	1029.6	8,400
97	1165.0	10,000
98	1122.3	9.900
99	1124.2	7300
2000	755.2	

FIG. 5.8 DEVIATION FROM THE MEAN FOR ERENA

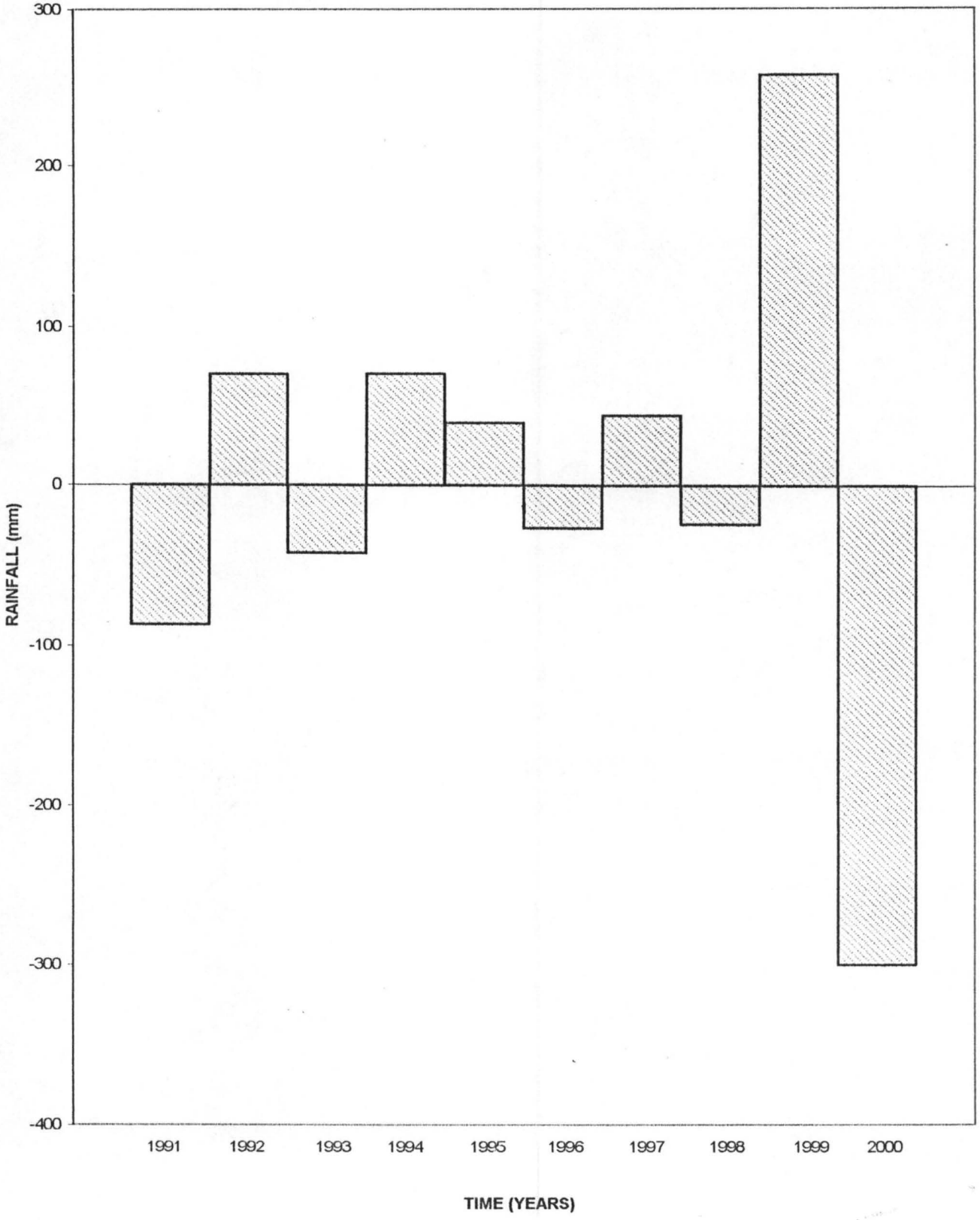


FIG. 5.9 DEVIATION FROM THE MEAN FOR SHE

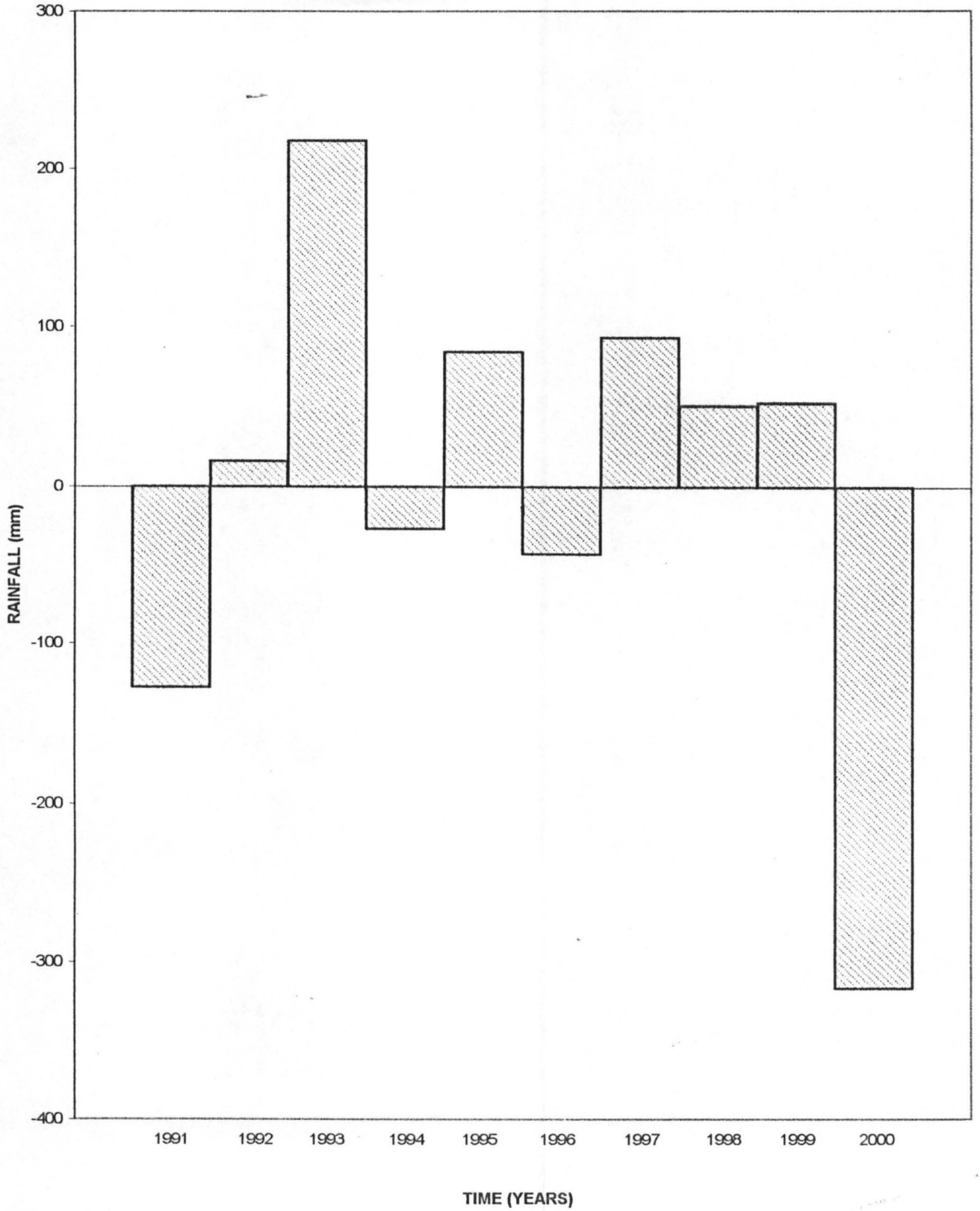
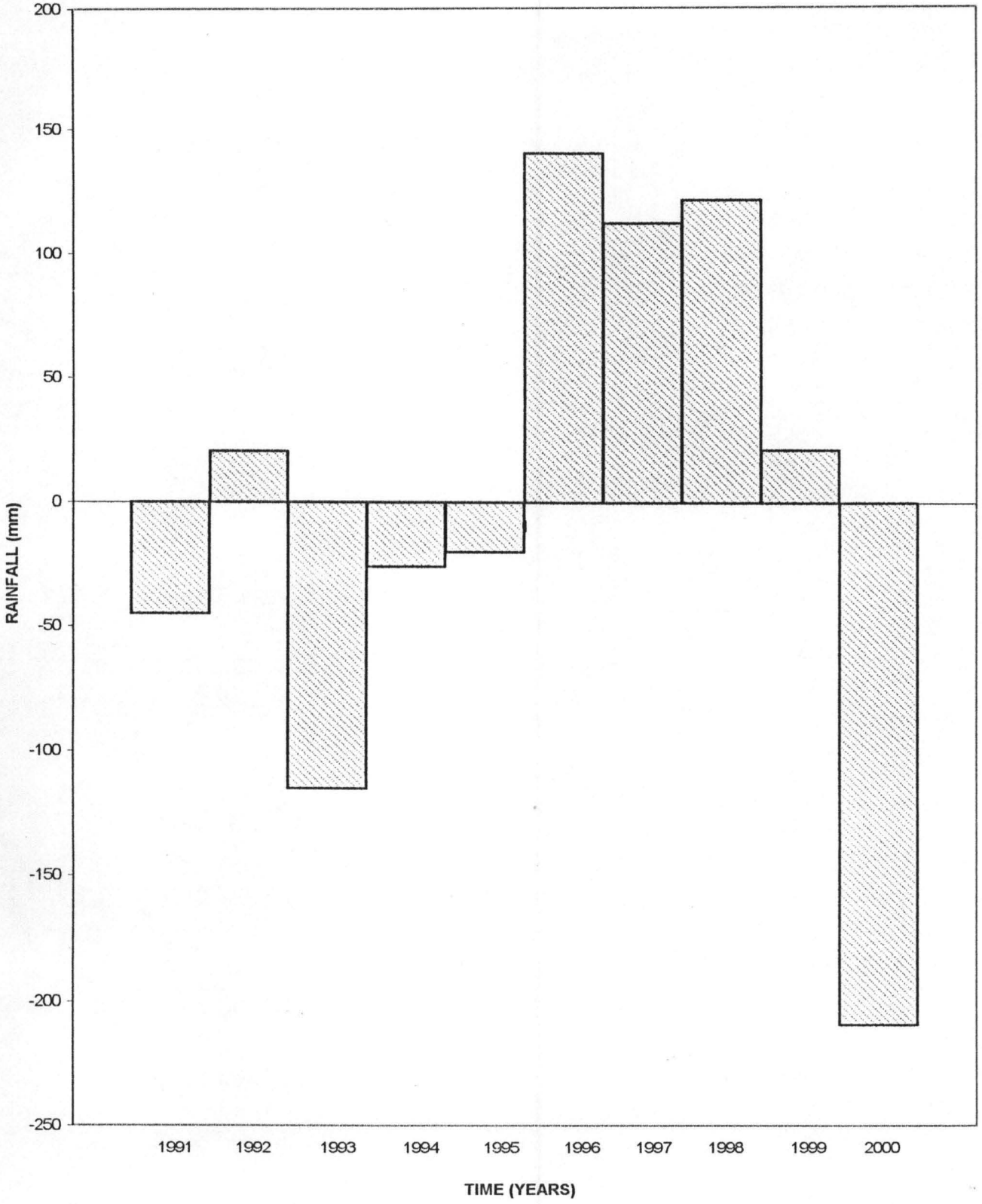


FIG. 5.10 DEVIATION FROM THE MEAN FOR CHIRI



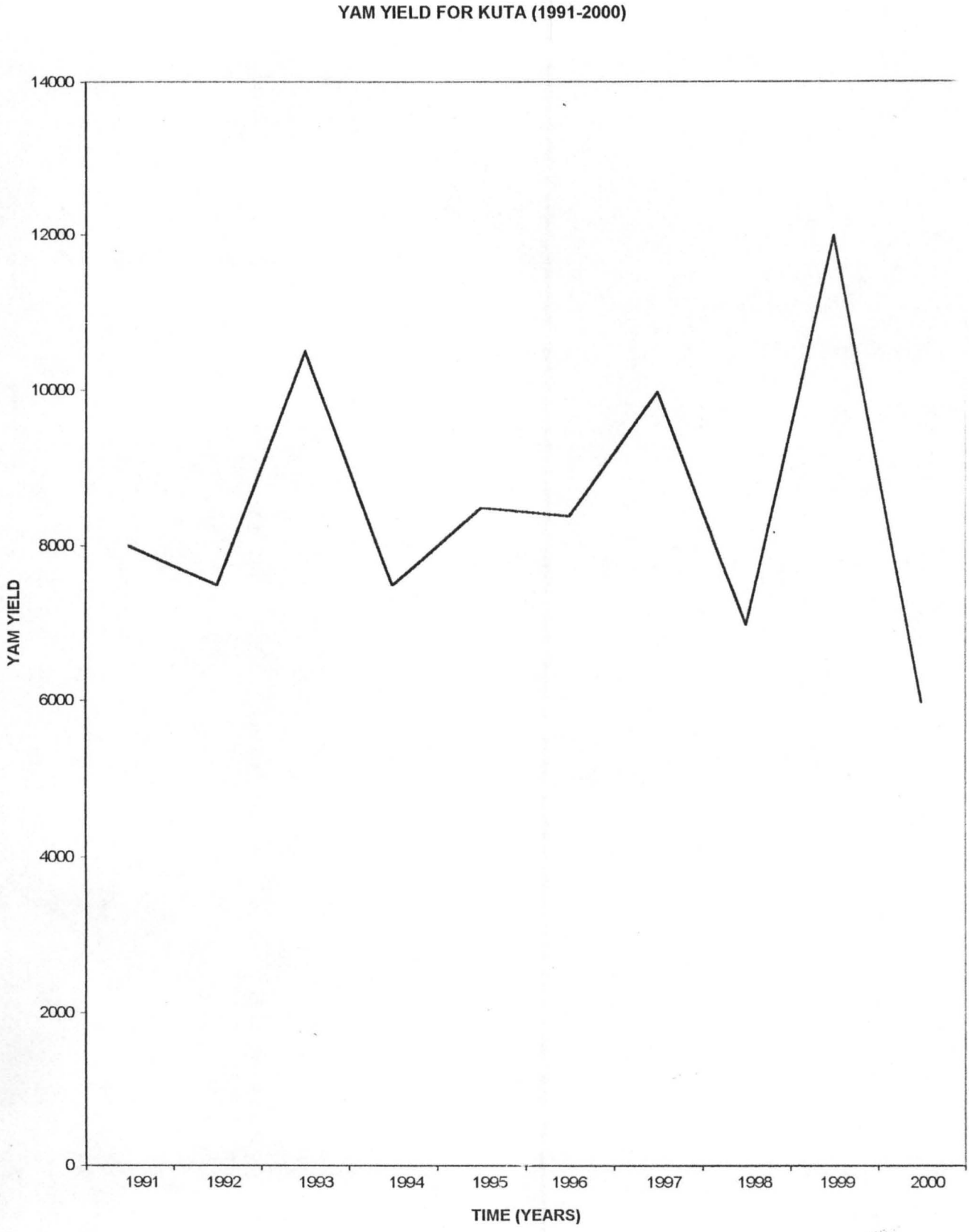

YAM YIELD FOR KUTA (1991-2000)
14000
12000
10000
8000
6000
4000
2000
0
YAM YIELD
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
TIME (YEARS)

Fig.5.16

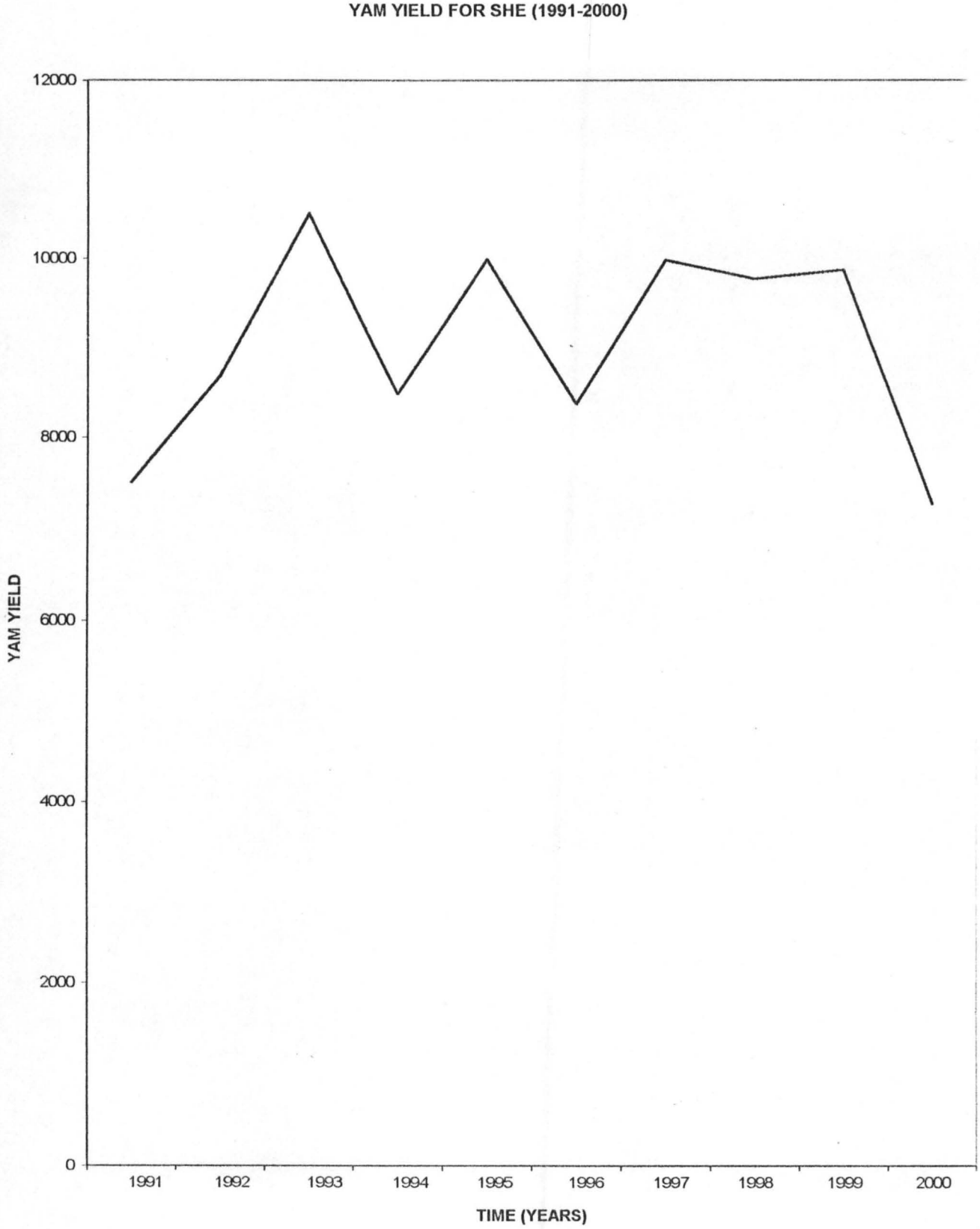

YAM YIELD FOR SHE (1991-2000)
12000
10000
8000
6000
4000
2000
0
YAM YIELD
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
TIME (YEARS)

Fig.5.17

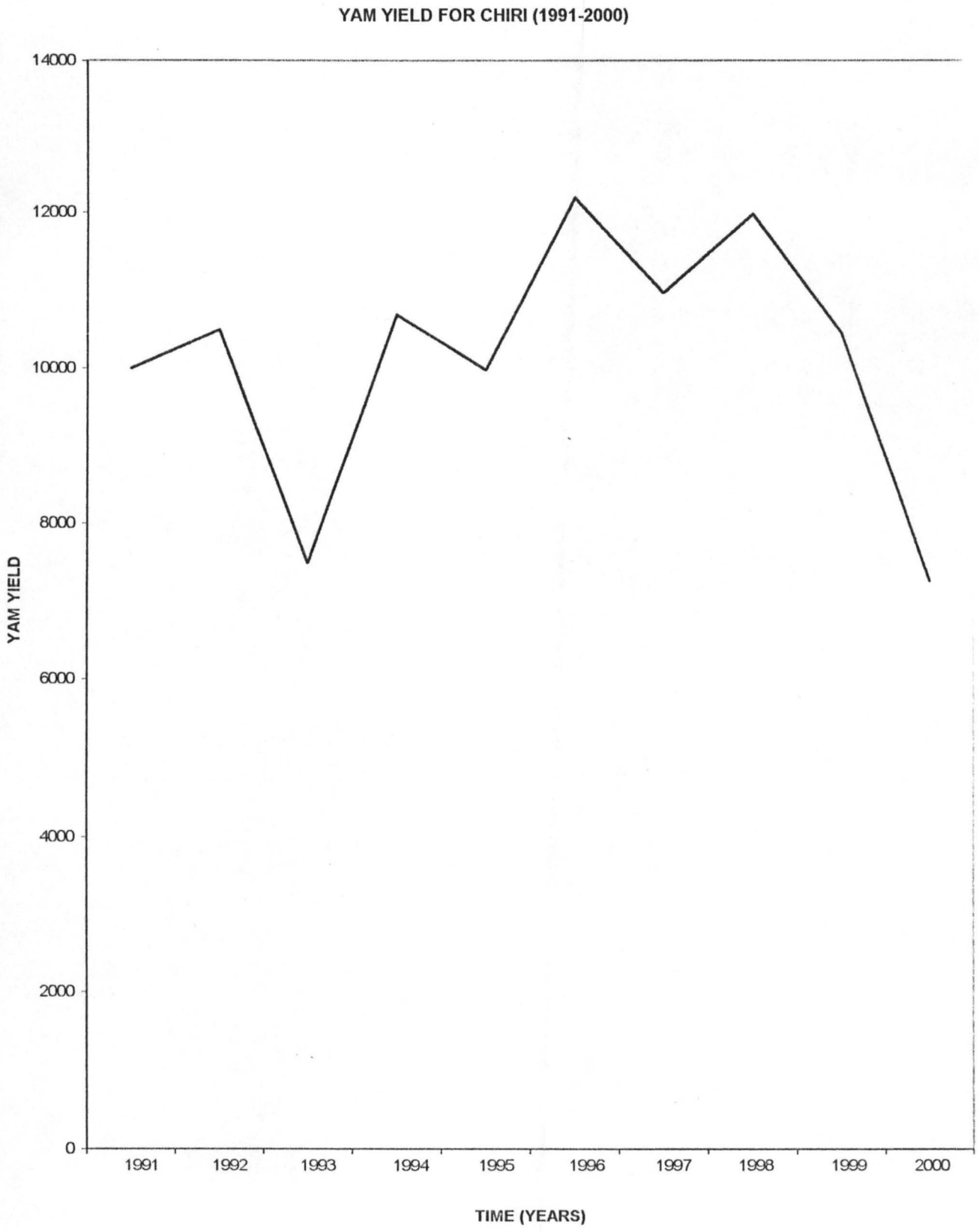

YAM YIELD FOR CHIRI (1991-2000)
14000
12000
10000
8000
6000
4000
2000
0
YAM YIELD
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
TIME (YEARS)

Fig.5.18

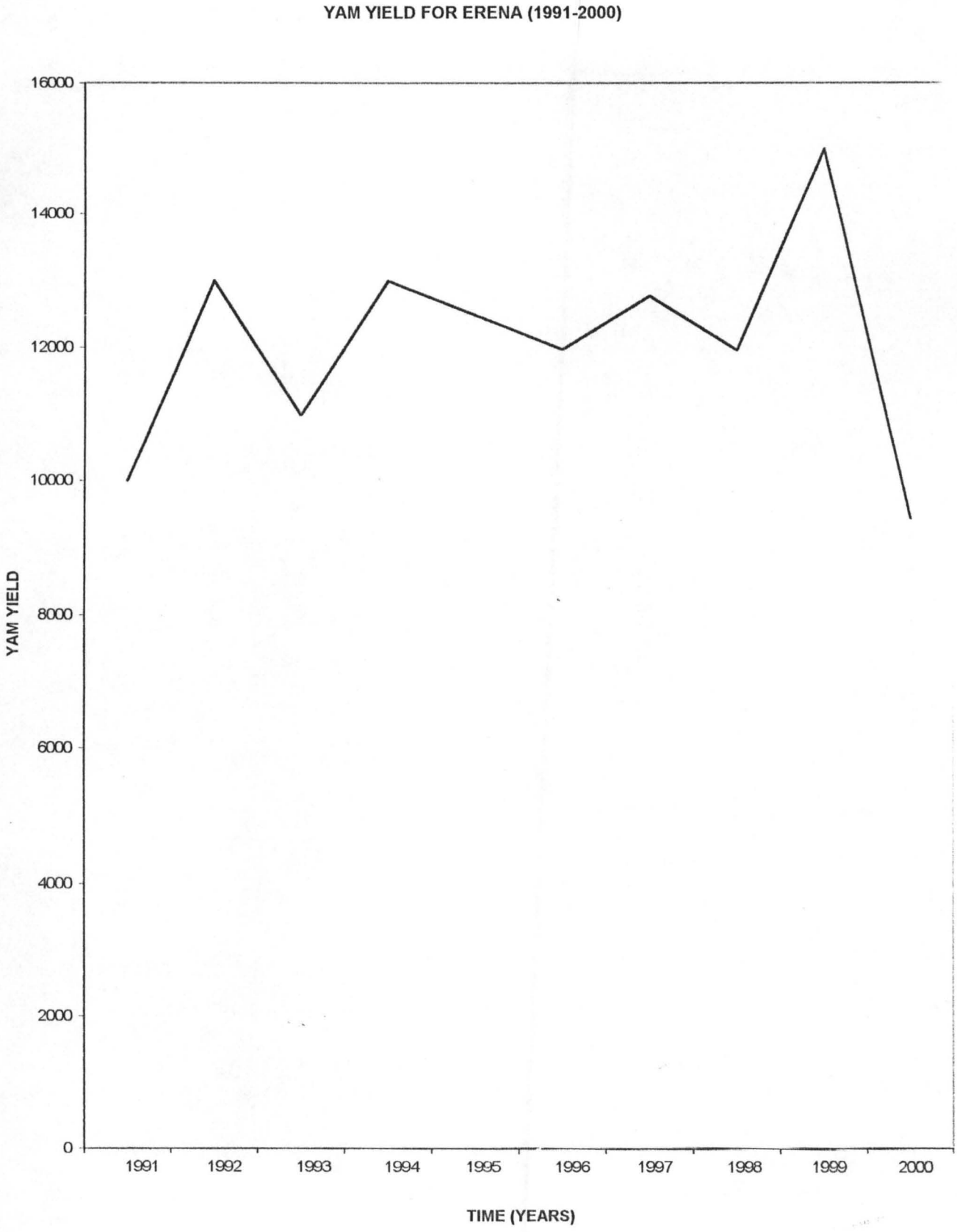

YAM YIELD FOR ERENA (1991-2000)
16000
14000
12000
10000
8000
6000
4000
2000
0
YAM YIELD
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
TIME (YEARS)

Fig.5.19

to year. In the four selected locations it was revealed that both the rainfall and yield crop production are all fluctuating .

5.8 YAM YIELD IN RELATION TO RAINFALL

Of all the climatic factors that affect yam production in only part of the world particularly to the study area, the availability of water is the most important. For instance Erena, using regression analysis to relate rainfall and yam production in the study area, an attempt is made to analyze how much rainfall of the study area (1991 – 2000) affect the yield of yam in Shiroro Local Government Area.

The analysis shows that less than 1% of the variance is the yield of yam in the study area could be due to different in the amount of annual rainfall while more than 99.55 are accounted for by other factor. From these analysis it is seen that rainfall was not an important factor affecting yam yield (Appendix 5.11). In She the relationship between rainfall and yam production using regression analysis reveal a correlation co-efficient of 0.00046 for the relationship between yam yield and annual rainfall amount. This indicate that about 60% of the variance in the yield of yam is accounted for by the amount of rainfall. The remaining 40% are due to other factor (Appendix 5.9)

In Kuta using the same regression analysis which reveal 0.000000006 that is about 40% of the variance in the yam yield is accounted for by the amount of rainfall and the remaining 60% are due to other factor (Appendix 5.6) in Chiri about 65% of the variance in the yam yield is accounted for by the 0.000111 amount of rainfall and the remaining 35% are due to other factor (Appendix 5.12).

5.9 OTHER FACTOR AFFECTING YAM YIELD

The factors affecting yam yield cannot be limited to climate alone. There are other non-climatic factors. These non-climatic factors whether directly or indirectly have some relationship with soil fertility. The crop required fertile soil if this is lacking it normally reduces the yield of the crop. In addition to this, after planting the crop if rain did not fall as expected the crop or the seed might even rot in the soil.

Poor crop management, particularly untimely planting and inadequate weed control, generally result in considerably yield reduction.

Drought or dry spell contributed to low yield in the study area particularly Kuta and She.

CHAPTER SIX

6.0 SUMMARY

The study has focussed on the variability of rainfall and yam production. The climatic variable measured in this write up is rainfall which has known to play on important role in the production of the crop. The annual rainfall amount tends to increase from western part to southern part of the study area relief features help to modify rain fall pattern in some parts of the local government area.

For instance Chiri has higher amount of rainfall than other parts of the study area because of the present of hills in the area. The annual rainfall in the study area have spatial and time variation.

However, there are other agricultural variable in the study area other than yam but because there has been a great fluctuation of the crop over years. But the mean and standard deviation of such climatic variable (rainfall) were computed. These show the degree of deviation from the mean. The rainfall figures in Shiroro Local Government have a positive correlation co-efficient with yam. From the data obtained on yam yield, it is identified that Erena which is located in the North/West and Chiri in the North/east are the areas of high yam yield. With this information, the farmers in these area and the agricultural planner in the local government

area can take the advantage to put more land area into cultivation which will be of economic benefits to commercial yam farmers. Fairly high yield areas are Kuta and She.

6.1 CONCLUSION

There are many factors affecting the production of yam in Shiroro local government area. These factors can be grouped under two, the climatic factors and human factors. Of all the factors the climatic factors have been given a detailed consideration showing how much effect it has on yam production. The study shows and generally rainfall distribution in Shiroro Local Government Area, assume a zonal pattern increasing from North/West to south/East while the rainfall is low at the north/East. This indicates that completely different pattern are some times characteristic of the location close to one another.

The highest month total rainfall occurs in the month of September and the lowest in the mouth of October in the selected located of the study area. As shown in chapter five, a lot of variations occurred in the annual, seasonal and monthly rainfall from year to year.

However, these variation result in departures, some of which have serious consequences upon human life and the crop yield. Using regression

analysis, it was found that rainfall accounted for about 60% of the total yam yield. The result obtained from the above analysis between rainfall and yam production in the study area, revealed, that there are other factors influence yam yield apart from the climatic variable. The other factors that affect the fluctuation of yam yield in Shiroro Local Government are poor crop management, dry spell, soil temperature and poor soil fertility. From the look of things rainfall contributed more to yam yield in the study area.

LOCATION: KUTA APPENDIX 1

Mean (x) 1059.6

Year	Total R/F	Mean	Standard Deviation	x-x ° C.!	From Mean
91	N.A				
92	1040.8			0.54	-18.8
93	1334.2			7.92	274.8
94	1075.9			0.46	16
95	1251.9	1059.6	34.66	5.54	192.3
96	1225.8			4.79	166.2
97	1326.9			7.7	267.3
98	1096.7			1.06	37
99	1434.3			10.8	374.3
2000	809.5			7.21	-250
Total	$\Sigma = 10599$				

LOCATION: AREWA APPENDIX 2

Mean (x) 1079.4

Year	Total R/F	Mean	Standard Deviation	x-x ° C.!	From Mean
91	N.A				-86.6
92	992.6			0.63	-69.9
93	1149.3			0.51	-42.2
94	1037.2			0.3	70.3
95	1149.7			0.5	38.7
96	1118.1	107904	135.9	0.3	-24
97	1052.4			-0.17	43.5
98	1122.9			0.3	-243
99	10551			1.78	256.8
2000	780			1.1	-299.4
Total	10793.5			-2.21	

LOCATION: SHE APPENDIX 3

Mean (x) 1071.9

Year	Total R/F	Mean	Standard Deviation	x-x ° C.!	From Mean
91	N.A				
92	944			2.67	-127.86
93	1087.9			0.33	16.04
94	1289.2			4.54	217.34
95	1045.3			-0.56	-26.56
96	1155.9	1071.86	47.8	1.76	84.04
97	1029.6			-0.89	-42.26
98	1165.0			1.94	93.14
99	1122.3			1.06	50.44
2000	1124.2			1.09	52.34
Total	755.2			-6.62	-316.66
	Σ= 10718.6				

LOCATION: CHIRI APPENDIX 4

Mean (x) 1083.3

Year	Total R/F	Mean	Standard Deviation	x-x ° C.!	From Mean
91	1038.2			-2.4	-45
92	1103.6			1.09	20.3
93	968.2			-6.19	-115.1
94	1057.7			1.37	-25.6
95	1063.5	1083.3	18.6	1.06	-19.8
96	1223.2			7.52	140
97	1195.3			6.02	112
98	1204.8			6.53	121.5
99	1104.1			1.11	20.8
2000	874.2			-11.23	-209
Total	$\Sigma = 10833$				

LOCATION – ERENA (APPENDIX 5.5)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
91	0	0	0	8.1	101.0	26.1	126.1	204.1	205.1	187.7	0	0
92	0	0	4.1	3.9	153.1	241.7	201.0	201.0	211.2	143.0	0	0
93	0	0	8.2	4.0	80.3	122.0	261.0	261.0	203.2	135.6	0	0
94	0	0	0	10.7	102.5	156.0	340.1	340.1	2002	126.2	0	0
95	0	0	10.2	52.1	90.3	136.0	201.0	201.0	340.3	145.4	0	0
96	0	0	3.4	11.5	85.8	103.2	302.0	302.0	241.6	122.5	0	0
97	0	0	5.3	13.5	109.2	200.7	223.2	273.2	241.0	130.0	0	0
98	0	0	6.1	2.6	130.0	190.0	200.0	200.0	210.3	81.0	0	0
99	0	0	0	12.6	150.0	200.0	240	240	332.6	120.0	0	0
2000	0	0	44.6	26.0	48.0	215.0	201	201	206.2	68.0	0	0

LOCATION –CHIRI (APPENDIX 5.6)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
91	0	0	10.0	50.3	85.3	165.0	129.3	303	210.0	853	0	0	
92	0	0	13.0	16.4	80.0	145.0	286.2	250	217.1	95.6	0	0	
93	0	0	20.0	22.6	105.1	130.0	173.4	185	256.2	75.5	0	0	
94	0	0	12.0	40.4	96.0	145.4	158.1	238.0	260.4	101.1	0	0	
95	0	0	7.3	35.0	110.3	160.3	143.2	206.2	201.1	120.0	0	0	
96	0	0	0.0	45.7	106.0	201.6	188.6	229	301.3	131.0	0	0	
97	0	0	3.0	70.0	141.7	175.0	208	237.3	253.0	107.3	0	0	
98	0	0	TR	40.0	120.0	180.0	260	213.2	296.0	95.5	0	0	
99	0	0	4.0	37.3	142.0	150.6	250.3	200.3	210.0	109.5	0	0	
2000	0	0	2.0	20.1	80.1	100.0	195.0	22.0	187	700	0	0	

LOCATION – KUTA (APPENDIX 5.7)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
91	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
92	0	0	1.1	34.3	107.1	167.7	104.8	211.8	200.1	215.1	0	0
93	0	0	2.9	0.0	118.3	164.0	375.0	237.5	337.5	79.8	0	0
94	0	0	0	6.9	74.5	225.9	106.8	234.9	208.7	238.2	0	0
95	0	0	0	2.5	107.7	132.1	195.1	483.2	171.8	139.5	0	0
96	0	0	3.1	41.4	216	215.0	188.8	233.1	239.4	88.1	0	0
97	0	0	15.6	40.5	138.0	207.1	203.7	234.6	251.6	235.8	0	0
98	0	0	0	57.4	88.4	190.1	191.6	236.3	214.7	118.2	0	0
99	0	0	24.0	10.7	122.7	238.2	504.6	269.6	117.2	50.6	0	0
2000	0	0	5.6	20.0	72.8	NA	65.8	225.4	216.9	103.1	0	0

LOCATION – SHE (APPENDIX 5.8)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
91	0	0	NA	NA		160.0	145.0	209.2	2001	230.1			
92	0	0	3.1	20		175.2	104.5	223.8	246.3	195.0			
93	0	0	7.8	34.3		167.3	305.2	247.6	306.2	105.3			
94	0	0	0	204		125.9	305.1	2001	2516	137.2			
95	0	0	0	395		180.2	205.5	250.0	185.0	175.0			
96	0	0	7.2	41.3		195.3	190.5	240.4	245.5	109.1			
97	0	0	108	406		201.4	230.0	200.6	201.0	140.6			
98	0	0	0	50.3		132.2	200.3	234.3	217.5	198.3			
99	0	0	3.6	15.7		205.2	304.1	219.6	130.0	95.0			
2000	0	0	0	25.0		105.0	68.8	169.1	209.1	103.2			

LOCATION KUTA (APPENDIX 5.7)

YEAR	X R/F	YAM YIELD	XY	X2	Y2
1991	-	8000	-	-	64000000
1992	1040.8	7,500	7806000	1083264.64	56250000
1993	1334.2	10,500	14009100	1780089.64	110250000
1994	1075.9	7,500	8069250	1157560.81	562500000
1995	1251.9	8,500	10641150	1567253.61	722500000
1996	1225.8	8,4000	10296720	1502585.64	705600000
1997	1326.9	10,000	13269000	1760663.61	100000000
1998	1096.7	7,000	7676900	1202750.89	490000000
1999	1434.3	12,000	17211600	2057216.49	144000000
2000	809.5	5,000	4047500	655290.26	250000000
	10596	84400	93027220	12766675.58	747560000

$\Sigma x = 10596$ $\Sigma y = 84400$ $\Sigma xy = 93207220$ $\Sigma x^2 = 12766675.58$

$$rn\left[\frac{(\Sigma xy)-(\Sigma x)(\Sigma y)}{n(\Sigma x^2)(\Sigma x)^2(n\Sigma y^2-\Sigma y)^2}\right]$$

$$r=\frac{932072203-894302400}{12766755.8-(112275216)(7475600000-7123360000)}$$

$$r10\left[\frac{(93027220)-(10596)(84400)}{10(12766675.58)-(10596)^2(10x74750000-84400)^2}\right]$$

$$r=\frac{35969800}{15391539.8x352240000}$$

$$= 0.000666$$

LOCATION SHE (APPENDIX 5.10)

YEAR	X R/F	YAM YIELD	XY	X2	Y2
1991	244	7,500	7080000	891136	56250000
1992	1087.9	8,700	9464730	1183526.41	75690000
1993	1289.2	10,500	13536600	1662036.64	11025000
1994	1045.3	8,500	8885050	1092652.09	72250000
1995	1155.9	10,100	11674590	1336104.81	10201000
1996	1029.6	8,400	8648640	1060076.16	70560000
1997	1165.0	10,000	11650000	1357225	10000000
1998	1122.3	9,800	10998540	1259557.29	26040000
1999	1124.4	9,900	11129580	1263825.64	98010000
2000	755.2	7,300	5512960	570327.04	53290000
Σ	10718.6	90700	86930690	11676467.08	83290000

$$rn\left[\frac{(\Sigma xy)-(\Sigma x)(\Sigma y)}{n(\Sigma x^2)(\Sigma x)^2(n\Sigma y^2-\Sigma y)^2}\right]$$

$$r=\frac{10X86930690-(10718.6)(90700)}{10X1167647.08-(107186)^2(-X834350000-90700)^2}$$

$$r\frac{869306900-972177020}{(116764670.8-114888386)(8343500000-8226490000)}$$

$$r=\frac{-102870140}{1876284-8X117010000}$$

$$=0.000468$$

LOCATION ERENA (APPENDIX 5.11)

YEAR	X R/F	YAM YIELD	XY	X2	Y2
1991	992.6	10,000	985254.76	10,000000	9926000
1992	1149.3	13,000	1320890.49	169000000	14940900
1993	1037.2	11,000	1075783.84	121000000	11409200
1994	1149.7	13,000	1321810.09	169000000	14946100
1995	1118.1	12500	1250147.61	156250000	13976250
1996	1052.4	12,000	1107545.76	144000000	12628800
1997	1122.9	12,800	1260904.41	163840000	14373120
1998	1055.1	12,000	111323601	144000000	126612000
1999	1336.2	15,000	1785430.44	225000000	20043000
2000	780.0	9500	668400	902500000	20043000
					74100000
Σ	10793.5	120800	122039768.4	148234000	246265370

$$rn\left[\frac{(\sum xy)-(\sum x)(\sum y)}{n(\sum x^2)(\sum x)^2(n\sum y^2-\sum y)^2}\right]$$

$$r=\frac{10X246265370-(10793.5)(120800)}{10X122039768.4-(10793.5)^2(10X101482340000)-(120800)^2}$$

$$r\frac{10X246265370-(10793.5)(120800)}{(1220397684-116499642.3)(1482340000-1.459X10^{10})}$$

$$r=\frac{1057589430}{(1103898042)(230760000)}$$

$$=0.000000004$$

LOCATION CHIRI (APPENDIX 5.12)

YEAR	X R/F	YAM YIELD	XY	X2	Y2
1991	10,000	10,000	10382000	1077859.24	10,000,000
1992	10,500	10,500	11587800	1217932.96	110250000
1993	7,500	7,500	7261500	937411.24	262500000
1994	10,100	10,100	10682770	1118729.29	102010000
1995	10,000	10,000	10635000	1131032.25	10,000000
1996	12,200	12,200	14923040	1496218.24	148840000
1997	11,000	11,000	13148300	1428742.09	121000000
1998	12,000	12,000	14457600	1451543.04	144000000
1999	10,500	10,500	11593050	1219036.81	110250000
2000	7,300	7,300	6383120	764575.36	532900000
Σ	10833	101100	97905830	11843080.52	104890000

$$rn\left[\frac{(\Sigma xy)-(\Sigma x)(\Sigma y)}{\left[n(\Sigma x^2)(\Sigma x)^2\left(n\Sigma y^2-\Sigma y\right)^2\right]}\right]$$

$$r=\frac{10X97905880-(10833)(101100)}{(118430805.2-117353889)(1045890000-1.022X10^{10})}$$

$$r=\frac{-116157500}{(1076916.2-9175320000)}$$

$$r=0.0000000111$$

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