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FOOD SECURITY MEASURES DURING UNCERTAIN CLIMATIC CONDITIONS IN NIGERIA

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ABSTRACT

Food security is a function of a few variables such as technological input, capital, government policies and environmental (climate) factors. Good control of all these dependent variables except the last, and the thorough understanding of the last can take the nation to food security level. Possible ways of controlling the first three variables (technological input, capital, government policies) are suggested. To have thorough understanding of the climate factors, time series analysis of climate variables precisely temperature and precipitation data in twelve locations covering the various climatic belts of Nigeria were carried out. Nigeria rainfall has a usual zonal pattern and the vast majority of precipitation falls within a well-defined period. The coastal stations received more rainfall than the inland locations. The northern locations received less rainfall than southern locations. The onset period for the northern stations is May/June while the cessation period is September/October. The southern stations have April as their onset month while October is their cessation month. The southern stations have two peaks of rainfall in June/July and September. A period when rainfall ceases within the wet season exists in the south, and is referred to as 'August break'. The northern stations have only one peak, which is in August. Annual trend of precipitation is positive in most of the southern stations while it is negative in most northern stations. At the ninety-nine percent confidence limits, all the stations have mean annual rainfall close to or within the limits except during El Nino Southern Oscillation (ENSO) years. Harmonic analysis reveals 3 to 4 and 7-8 years inter-annual cycle of precipitation which correspond to the warm and cold ENSO cycle.
Temperature has a bimodal variation through the twelve months in a year. The two maxima occur in March/April/May and October/November while the minimum is in July/August. Annual temperature trend is positive (small slope) in some stations while it is negative in some not necessarily depending on the position.

Key words: Climate-variability, confidence limits, productivity, drought

INTRODUCTION

Food security is attained when adequate or more than enough crops (food) are produced for active and healthy live of the people. Agricultural productivity is affected by a few factors such as: amount and quality of inputs (technology), human ability or expertise in implementing technology (human capital), environmental factors (climate) and agricultural policies [1, 2]. An ecological and environmental working paper series showed that besides climate there are other factors that affect productivity, among which are: size of farm-land (input), price of crops (policies), availability of technology of production and the time elapsed after the settlement of the farm (capital) [3]. When all these factors are favourable, bountiful crop productivity is assured. All these factors can be controlled by man except the environmental factor. Climate varies on yearly, decadal and centennial time scales due to natural and anthropogenic effects. El Nino and the North Atlantic Oscillation are key natural aspects of climate variability. The major cause of African climate variability is West African Monsoon (WAM) and its variability [4].

El Nino Southern Oscillation (ENSO) is a phenomenon that recurs at irregular intervals ranging from two years to a decade with varying intensity and this has been shown to affect rainfall in Nigeria. Warm phase of ENSO leads to drought in Nigeria [5]. It was hypothesized that the Pacific anomaly patterns contribute to the reduction of rainfall in sub-Saharan West Africa via the generation and maintenance of tropospheric equatorial winds, which extend as far as Eastern Africa [6, 7]. Dynamical and statistical models of various levels of complexity have not been able to give accurate prediction of the strength and timing of ENSO event, the detailed life cycle and Sea Surface Temperature (SST) climatology over the tropical Pacific [8]. When climate prediction is not certain there should still be a range of climate trend that can be depended upon. This is the rationale behind this paper. In this paper, we shall concentrate on such factors of natural occurrences as rainfall and other meteorological parameters.

THE STUDY AREA

Nigeria is a tropical country located between latitudes 4 and 11 degrees north. The tropical climate is influenced by two air masses. These are the cooler rain-bearing southwest monsoon originating from the Atlantic Ocean and the hot dry northeasterly continental air mass from the Sahara desert. The Intertropical Convergence Zone (ITCZ) is the interface between the two air masses. The location of ITCZ controls the amount, seasonal distribution and type of rainfall as well as the length of the wet season at any location in Nigeria. The region south of the ITCZ, depending on its distance, usually receives more rainfall while the region north of it experiences dryness. The ITCZ gets to its most northern position in July- August and its most southern position in December- January- February, at which time dry season sets in. Generally food production in sub-Saharan Africa is climate dependent [9]; therefore in Nigeria crops are planted according to the seasons of the year, when enough moisture is available to sustain plant growth and maximum yield.

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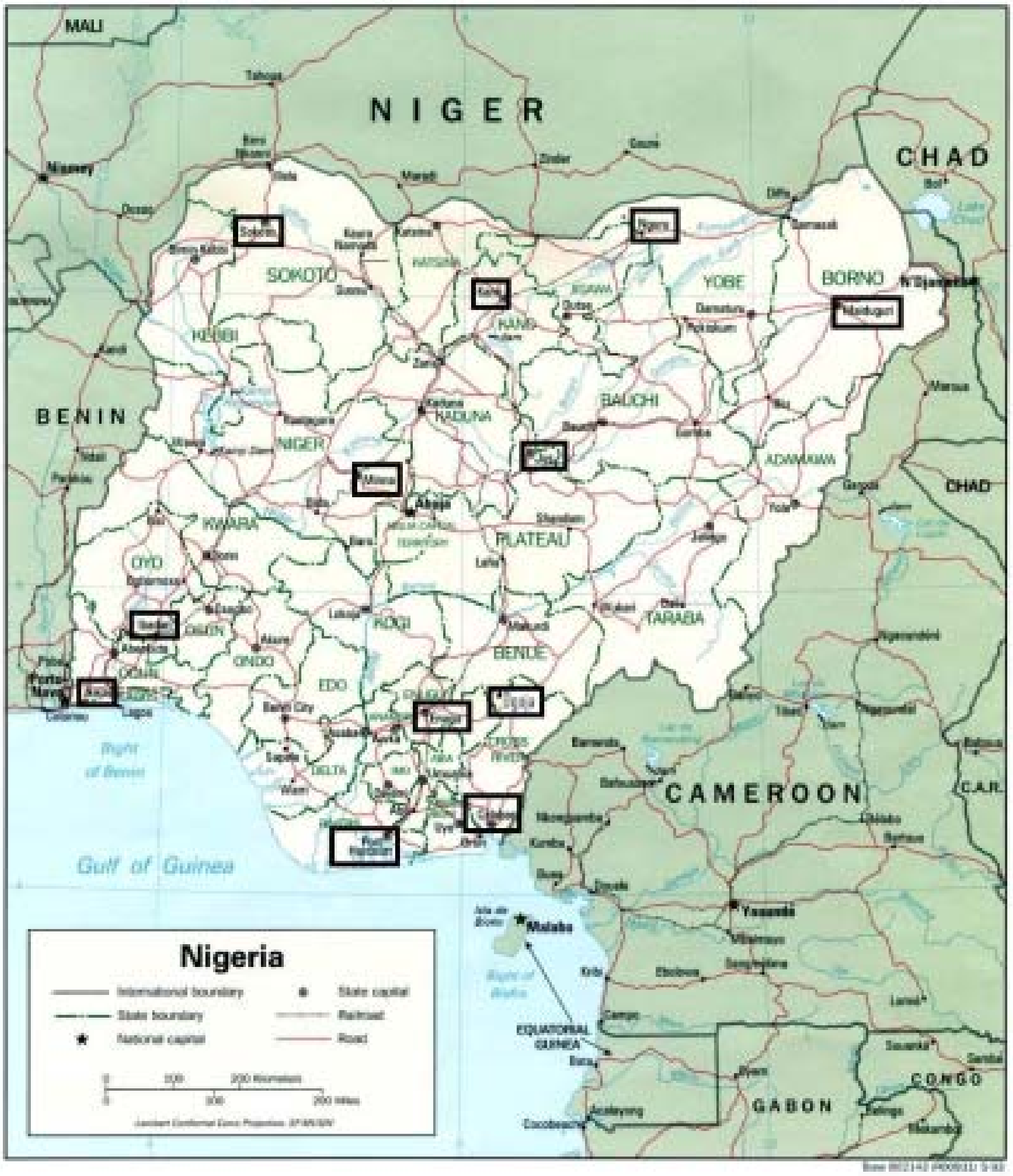

Figure 1: Map of Nigeria showing the twelve locations of the study.

MATERIALS AND METHODS

Rainfall and temperature data were extracted from the daily meteorological registers kept by the Federal Meteorological Agency (NIMET) Oshodi, Lagos.

Rainfall data in twelve locations covering all the six geopolitical zones and the various climatic belts in Nigeria were used in this study. The maximum number of years of data used is 50 and the minimum is 20 (Table 1). The data were analysed and linked to agriculture and hence food security using the models below

.

Model that links factors of Agricultural Productivity to Productivity

The input –output model assumes that man is in control of all important variables of productivity factors. We apply the model to agricultural productivity in Nigeria. The model states that.

Science (Technology) + capital = increased production [10, 11].

Science (Technology) is a neutral tool that raises production and increase efficiency of productivity.

Provided the environmental (climate) factors and agricultural policies are favourable to productivity, the input output model works very well [12]. The quality and quantity of input are proportional to those of output. When the right technology is applied productivity is raised to the desired level.

Production-Function Approach of measuring Productivity

A production function can be defined as the specification of the minimum input requirements needed to produce designated quantities of output, given available technology. This approach is used, where differences in output are explained by the differences in input [13].

Conceptual model that links climate variables to food production

Climatic parameters and their variability are known to affect plant growth and consequently food production. For example, in sub-Saharan Africa, rainfall constitutes the main water source for plants [9]. Energy and light are needed for plant growth, these are provided by the solar energy and light from the sun. Solar energy and light are used by plants to carry out photosynthesis which in-turn nourish the plant and make it develop. Water determines to what extent the available energy can be used. There is a direct and almost linear link between actual water consumption and plant production [14]. Energy and water balance of crops are related through crop evapotranspiration which determines potential biomass [15]. Wind constitutes less effect on plant growth than solar energy. It functions in the area of exchange of CO_2 and water between plants and atmosphere, pollen dissemination and some negative effects like physical damage to crops. Heat and temperature aid chemical and biological proceses. Higher temperatures are associated with higher productivity and shorter biological cycles [16]. Temperature follows the same variation as solar radiation since the former is as a result of the latter. Temperature and rainfall can conveniently represent climate variables affecting food production. Time series analysis is used to identify the nature of the phenomenon represented by the sequence

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of observations. It is also used in predicting the future values of the available time series variables. Climate is not under the control of man so there is need for time series analysis of the available climate (precipitation and temperature) variables in order to understand their variability and work out strategies of maximizing food production.

The rainfall data are analysed for month of peak rainfall, onset months, and cessation months; annual average rainfall and confidence limits for the rainfall population mean (percentage of years considered having suitable amount of rainfall for plant growth). Impacts of variations in weather parameters are stated following the production-function approach. The same approach is also used to measure the effect of amount and quality of input on productivity.

Mean monthly temperature data in locations covering the various climatic belts in Nigeria (1980-2001) are analysed for the months of maximum and minimum.

Annual trends were calculated for both temperature and precipitation, seasonal variations were analysed and cyclic variations were also found using Harmonic analysis.

Confidence limit for Rainfall Mean

The confidence limits for the 99% confidence level are calculated for the rainfall population mean from:

$$\bar{X} \pm Z_c \frac{\sigma}{\sqrt{N}} \qquad (18)$$

S can be used instead of σ, provided $N \geq 30$. For N <30 the confidence limits are represented by:

$$\bar{X} \pm t_c \frac{S}{\sqrt{N-1}} \qquad (19)$$

where,

Z_c = confidence coefficient

t_c = students't confidence coefficient

$\bar{X}$ = population mean

σ = standard deviation

Standard deviation, $S = \sqrt{\frac{\sum (X - \bar{X})^2}{N}}$ (20)

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Harmonic analysis

Harmonic analysis describes quantitatively the cyclical behaviour of variables of a periodic function. Fourier series (equation 21) is an expansion of a periodic function X_t in terms of an infinite sum of sines and cosines between sine and cosine [17].

$$X_t = \overline{X} + \sum_{i=1}^{N/2} A_i \sin\left(\frac{2i\nabla\pi t}{p} + \phi_i\right) \tag{21}$$

Where $\overline{X}$ = Arithmetic mean

A_i = Amplitude of the harmonic

ϕ_i = Phase angle of the corresponding harmonic

N = Number of observations

P = Period of observation

Annual Temperature and Precipitation Trends, Seasonal, Onset and Cessation of Precipitation

The slope of annual temperature and precipitation trends (linear) in the various climatic belts in Nigeria are found using the least square method. Graphical methods were used to get the seasonal variations, onset and cessation months of precipitation in all the locations.

RESULTS

Rainfall Variation in Nigeria

Nigeria rainfall follows a usual zonal pattern and the vast majority of precipitation falls within a well-defined period. The southern stations are characterized by two peaks of rainfall in June/July and September while the northern stations have only one peak per year. Rainfall starts earlier in the southern stations in April/May and it ceases last in this region in October. A period termed "August break" exists in the south when rainfall ceases for some days. The period of rainfall in the northern stations is 3-5 months; the onset month is May/June while the cessation month is September/October (Table 5). The coastal stations receive more rainfall (ranging from1487.9 to 2865.2 mm) than the inland stations (ranging from 473.3 to 836 mm) annually (Table 6). Total annual rainfall pattern in Nigerian stations has a seemingly random variation, while some years have rainfall amount far below the mean, some have amount of rainfall far above the mean and can be termed years of drought or flood, respectively, depending on the magnitude of deviation from the mean (Figure 2). Years of average, low (drought) and high (flood) amount of rainfall are revealed in Figure 2. Many of the points lie very close to and within the confidence limits with the exception of the ENSO years. The points far above the confidence limits are the

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flood years associated with the neutral and cold phases of ENSO The points far below the confidence limits are the drought years which correspond to the warm ENSO phase.

At the 99% confidence level, the following locations in Nigeria have the associated percentage of the years considered having average rainfall amount suitable for crop production: Calabar: 85.0, Enugu: 76.0, Ibadan: 68.0, Ikeja: 75.7, Jos: 72.0, Kano: 70.3, Maiduguri: 68.0, Minna: 68.0, Nguru: 68.0, Ogoja: 63.6, Port-Harcourt: 80.0, Sokoto: 66.0 (Figure 1 and Table 6).

Rainfall in all the twelve stations show strong cyclic variations of 7-8 years and weak cyclic variation of 3-4 years as indicated by the results of the harmonic analysis. Both of these cyclic variations correspond to ENSO cycle. Annual rainfall trend is positive in Calabar, Enugu, Ibadan, Ogoja, Port-Hacourt (southern stations) and Kano (northern station), other northern stations: Jos, Maiduguri, Minna, Nguru and Sokoto exhibit a negative trend in precipitation. The annual trend of rainfall in Ikeja (southern) is negative (Table 7).

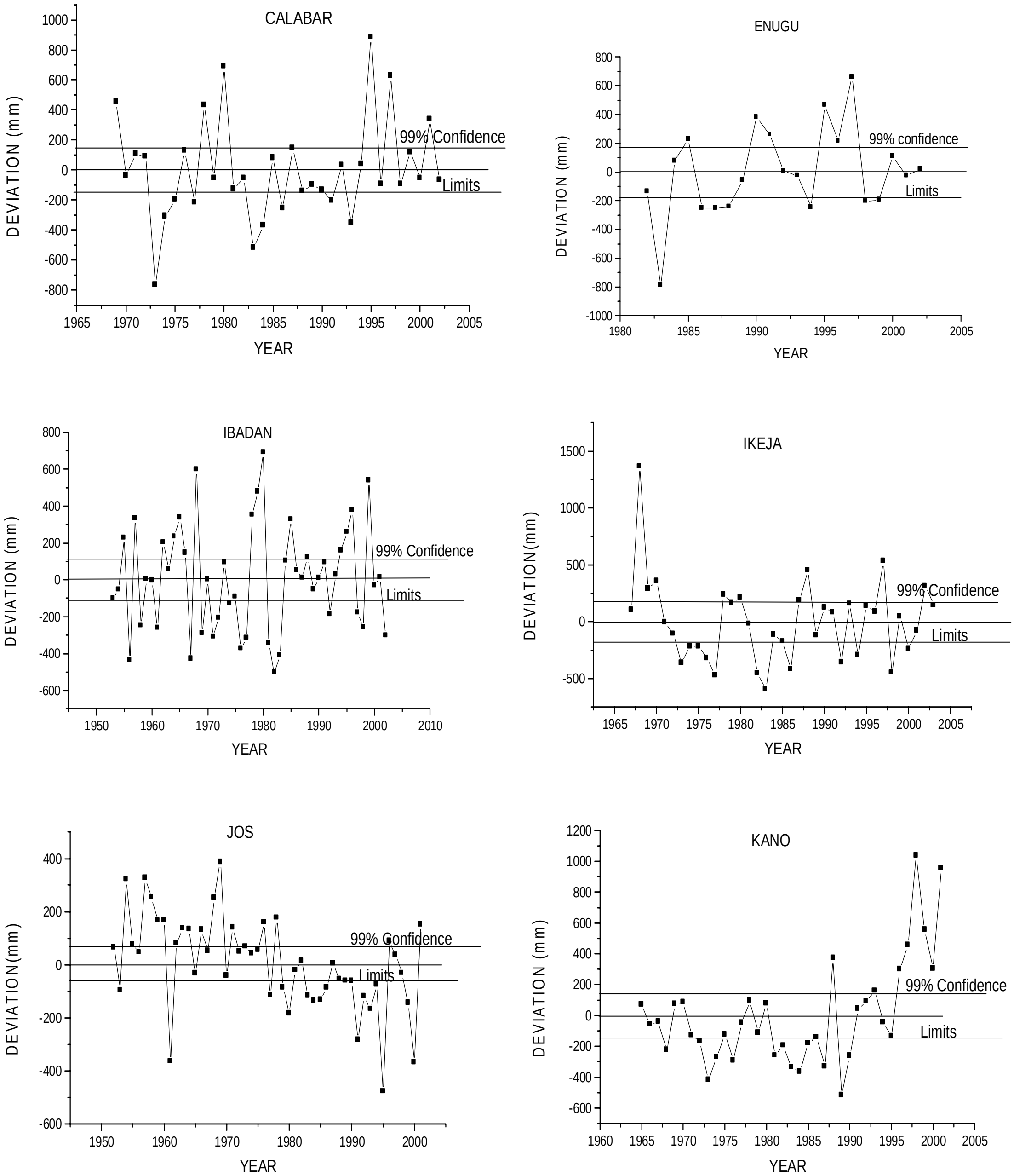

Figure 2: Mean Annual Rainfall Deviation from Mean for 12 Selected Locations in Nigeria.

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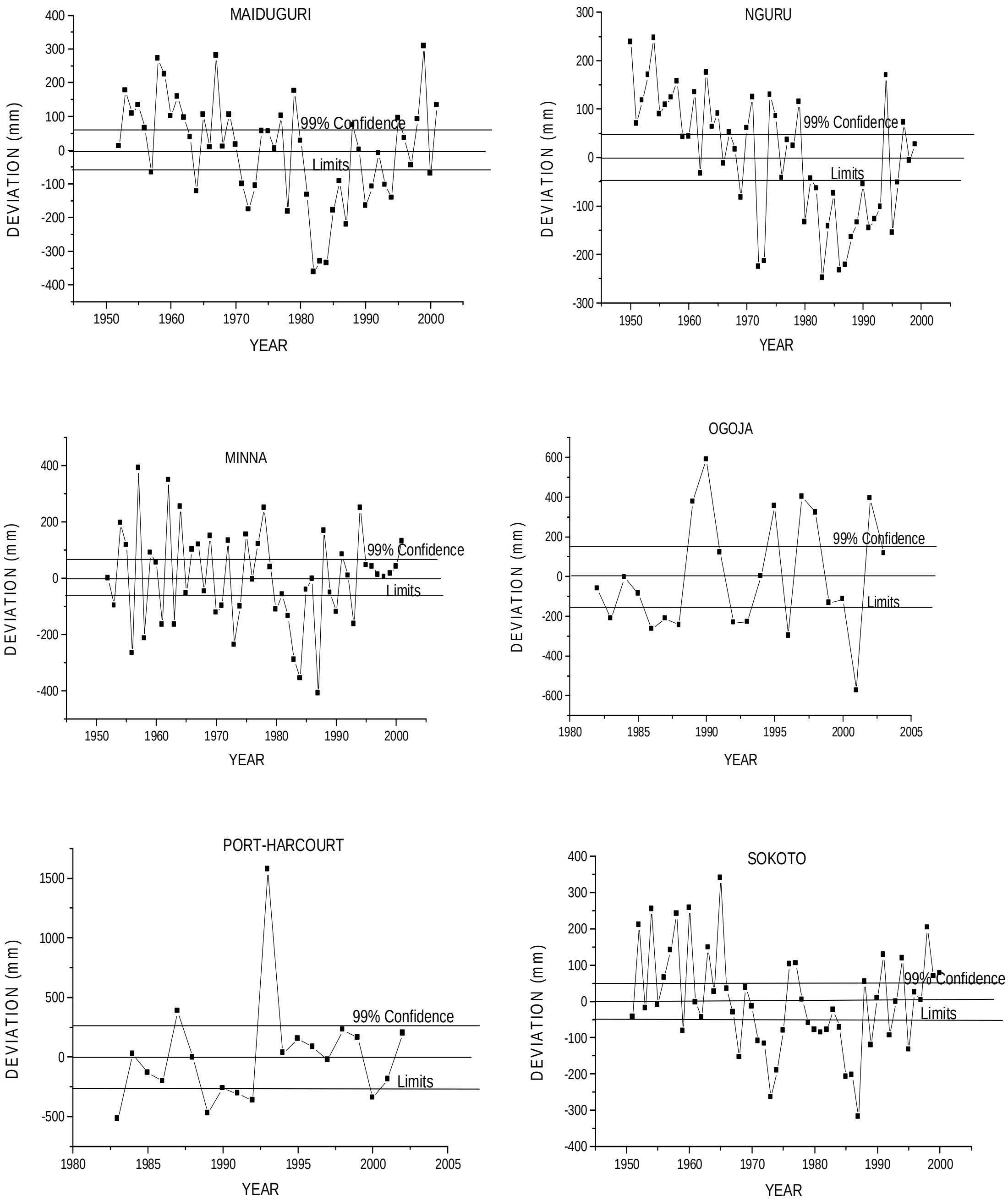

Figure 2 (continued)

4.2 Temperature Variation in Nigeria

Temperature follows a bimodal variation intra-annually in Nigeria. The higher peak occurs in March/April/May while the lower peak is in October/November and the minimum is in July/August (Figure 3). Annual temperature trend is negative in Calabar, Portharcourt, Maiduguri, Nguru and Sokoto but positive in Ogoja, Ibadan, Ikeja, Jos and Minna. Temperature data is not available for Enugu and Kano. The slope and intercept for the trend lines are given in Table 7. The harmonic analysis reveals 2-3 years, and 7-8 years annual cycle of temperature in all the stations.

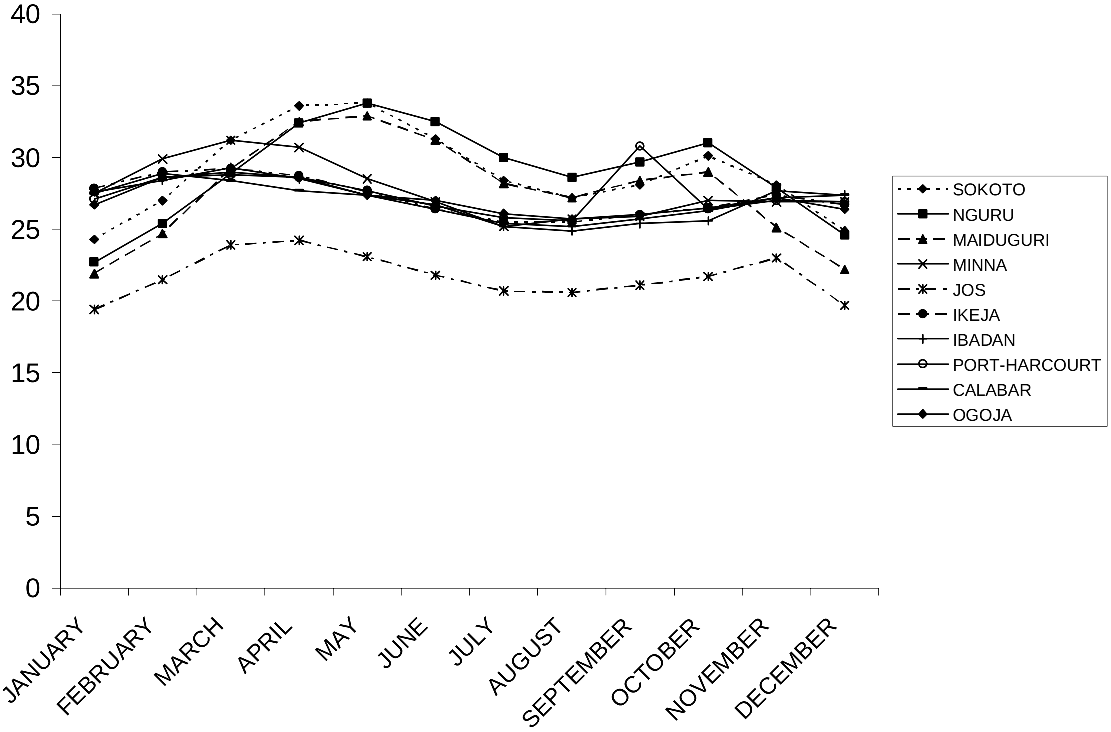

Figure 3: Mean monthly temperature variations in some stations in Nigeria (1980-2001).

4.3 Grain yield in Nigeria

The annual biomass yield is rainfall dependent. An example is the yield recorded at a government farm, Fasola farm settlement in the southwestern part of Nigeria as depicted in Table 2. The closest station to Fasola farm is Ibadan (~45km far). High precipitation in 1995 yielded greater biomass and grains of soyabeans, the reduced precipitation in 1996 led to a decrease in the biomass and grain of soyabeans produced at Fasola farm in south western Nigeria [18] (Table 2).

In the western and eastern zones of Nigeria, maize is grown twice in a year: the early and late maize. An example of rainfall dependent yield for Ibadan in the west at International Institute for Tropical Agriculture (IITA) is shown in Table 3. The total

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rain period for early maize in 1986 was 29 days with a total precipitation of 448.1mm while there were 27 rain days with 550mm of total rainfall for late maize in Ibadan (Table 3). Yield of early maize for all the varieties considered is higher than that for late maize (Table 4.) despite the higher amount of total precipitation available for the late maize.

DISCUSSION

Impact of variations of weather parameters on crop yield

The long term onset time of rainfall is normally used to determine the time of farm clearing and preparation for planting. Following the method of onset determination proposed by a Nigerian lightning study [19], the onset time of rainfall for each year can be specified and time of planting of various crops can be determined to get maximum yield. The known annual cycle of rainfall gives the range of expected amount of rainfall for each year, so the farmers can know the type of plant that can survive under such amount of rainfall. The confidence limits give the assurance of having amount of precipitation that is close to the long term annual mean except during the years of warm and cold ENSO phases. Generally the precipitation trend in the north is negative (due to desert encroachment), necessary irrigation can be employed in the north and also genetically modified crops that can survive under drought condition can be planted. In most southern stations precipitation trend is positive. The slope of precipitation trend ranges from 0.7 to 16.1. Temperature trend has negative slope in some stations while it has positive slope in some, this is independent on the position. Temperature slope is very small; it ranges from 0.001 to 0.34.

Weather parameters like temperature and precipitation have impact on the growth and yield of crops. At Fasola farm in 1995 and 1996 direct proportionality relationship was found between soyabeans yield and precipitation (Table 2). Some sub Saharan West African weather studies showed that water and temperature stresses affect crop yield [20, 21]. Maize needs only about 90-100 mm of precipitation for perfect growth and yield. When this is well distributed and temperature is high enough, high crop yield is ensured. Comparing Tables 3 and 4, higher precipitation for late maize yielded less maize grains. This shows that other weather parameters must be considered for perfect growth and yield. The distribution of rainfall during different growth stages is also important. The total amount of rainfall available for early maize is less than that for late maize but the distribution of rain days is more favourable for early maize: the last third division of the growing season has rain almost throughout, while this is not so for late maize. Table 4 shows that early maize yields higher than late maize regardless of the species planted. A period termed “August break” (when rain ceases for some time) is included in the late growing season; this can constitute water stress during the last third division of the growing season. Maximum temperature in a particular year occurs between February and early May (Figure 3). This condition is favourable for high maize yield. From late May to mid August the temperature is usually reduced and this may constitute temperature stress to the growth and yield of maize planted during this season.

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The years with average rainfall (rainfall amount within the confidence limits) (Table 6) can support maximum production of crops, while the flood years can support maximum production of some specific crops. The drought years too depending on the intensity of the drought can support some types of crops.

Sustainability of the Population

There are over 120 million people in Nigeria, with about 38 million being farmers on 71.2 million hectares cultivable land. The present agricultural growth rate of Nigeria as reported by the Federal Ministry of Agriculture is 4.5% which is below the rate (at least 10%) that could be sufficient for the population [22]. The average crop (grain) yield in Nigeria is between 1.5 and 1.6 ton/ ha [23, 24]. This is below the yield in some farms in Nigeria [20] which is about 6 ton/ ha. If all the factors affecting land productivity can be made favourable in Nigeria, we should be able to achieve at least 6 ton/ha yield which would constitute about 300% increase even without increase in farm area. When the farm area is increased more yields can be realised. If 10% increase will be enough for the population in Nigeria for a year, part of the remaining 290 % can be stored against years of unfavourable climatic conditions and the remaining part can be exported.

An Ekiti-Akoko study showed that by using a particular type of fertilizer, yield in ton/ha for grain increased in Ondo and Ekiti states: rice: 3.45, maize : 6.03 respectively [25]. In the teaching and research farm of the University of Agriculture Abeokuta, yield of up to 3.5ton/ha has been obtained for maize [26]. Also depending on the planting date in relation to the start of raining season, maize yield in Ibadan can be as high as 9.8ton/ha. Generally in Nigeria depending on the variety of maize planted, yield in ton/ha could be as high as 9.8 as it was in Zaria when the variety denoted as 4.5 was planted [20].

When the beginning of planting season is noted, one can approximately know whether the rain will lie within the confidence limit in that year or outside it and decisions can be taken on the suitable crops for the expected climate/weather. A Nigerian lightning study presented an accurate method of determining the start of the rainfall season, since agricultural practices in Nigeria depend mainly on rainfall [9]. The lightning index method gave an accuracy > 85%. This was tested in Ibadan, Calabar, Uyo, Lagos, Port-Harcourt, Kaduna and Minna over a period of 8 years [19]. This method can be utilized and when the start of the rainy season is determined, the staple crops peculiar to each location could be planted at the right time for maximum output.

From Table 6, it could be seen, as expected, that the southern parts have the heaviest rainfall and relatively short dry seasons. The staple foods in this area are root crops, including cassava, yams, cocoyam and sweet potatoes. The commercial produce in the area are tree crops like cocoa, oil palm and rubber. Cocoa grows mostly in the south- west. Oil palm predominates in the south- east and south- central area, while rubber stands are common in the south -central and south -eastern Nigeria ; sorghum, millet, corn and rice are also grown.

The northern part of the country experiences a long dry season of five to seven months. The annual mean rainfall is low compared to the other parts of the country, so the staple foods are millet, cowpeas, and a drought-resistant variety of sorghum (guinea corn) and corn. The commercial crops grown in the north are cotton, groundnuts and beans.

The middle belt lies in the Guinea Savanna region which experiences more rainfall than the northern parts and so have enough rainfall for growing root crops. The staples in this area include yam, sorghum, millet, cassava, cowpeas, corn and rice in some places. The most important commercial crop in this area is sesame (Benniseed).

Food Reserve

It should not be a difficult task for Nigeria to ensure access by all the people at all times to enough food for an active, healthy life. It is the responsibility of the government to ensure there is adequate food reserve for the country. Nigerian government constructed strategic grain reserve silos for food reserve [27]; government should stock these to the advantage of the farmers and the populace. During favourable weather/climatic conditions, production should be increased. From scientific research (genetically modified (GM) crops), plants and animals that survive under certain conditions can be identified and also new species that can survive under the severe climatic conditions should also be developed [22], for example Israel (a supposed desert) produces large quantities of plantain. Nigerian government is collaborating with Israel in “Desert- to-Food- Programme” to combat desert encroachment problem in the northern states [28]. Nigeria will be able to maximize food production under any condition, when this is done. Excess food produced can be stored and/or exported.

CONCLUSIONS and RECOMMENDATIONS

Majority of Nigerian farmers are smallholders, who apply simple production techniques, cultivating areas of one-half to two hectares of land. They should be encouraged to practice large-scale agricultural production, which will contribute to Nigeria’s balance of payment through export development and/or import substitution, and produce rural employment. As earlier stated, productivity depends on the area of farmland and also on the market price of the product. Size of farmland will depend on the available area and also on the business capital of the farmer and the surplus made. In order to encourage productivity, government should take the following measures: -

- Size of farmland, both for crop and animal farming should be increased. There should be regulations on land use, land reform, land ownership, land purchase and sale. Government should create an office that will make farmland available to interested farmers, at affordable cost on lease basis and gradually reduce permanent individual land holding, which accounts for more than 90% of the present farm lands.

- Agricultural credit should be made available to encourage the peasant farmers since they would need capital to get started. Conditions and guarantees should be given

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to the commercial banks so that they can accept the risk of providing credit facilities to agricultural producers on acceptable terms. Federal Government and Central Bank of Nigeria already have Small and Medium Scale Enterprises Equity Investment Schemes (SMIEIS) policy which requires all the operating commercial banks in Nigeria to set aside part of their profit as trade support for small and medium scale industries [29].

- Development of agricultural extension services should be supported through which farming techniques and technology could be made available for easy farming. Farmers should be informed on how to guard against pests, diseases, and nematodes, which can affect land productivity even when climatic conditions are favourable. They should also be taught how to prevent erosion during flood, and choice of suitable crops for a particular climatic condition. Both government and non-governmental organizations (NGOs) can embark on this.

- Support should be given to agricultural research – getting species of crops and animals that can survive under difficult weather conditions. Genetically modified crops that are drought resistant should be grown during years of drought. A Nigerian genetic modification study enumerated some important Nigerian crops, their major productivity constraints and the genetic modification (GM) intervention [22]. Generally the constraints are weed, drought, insect pests, nematodes, viral diseases and food quality. Various research institutes are already working on specific crops in Nigeria. The Nigerian government has already put in place a National Biotechnology Advanced Laboratory and National Biotechnology Development Agency (NABDA) which formulates policies that would enhance acquisition of biotechnology in Nigeria. Glyphosphate-tolerant crops have been developed in some laboratories, these are being widely grown in several countries like USA and Canada [22]. Nigeria can also adopt this to combat weeds. The International Institute of Tropical Agriculture (IITA) Ibadan, Nigeria has found that Bacillus thruringiensis crystal proteins, plant chitinases, lectin and protease can control Maruca Pod- Borer so cowpea cultivars in Nigeria can be encoded with these proteins. Research at IITA has also led to the development of African Cassava Mosaic Virus (ACMV) resistant cultivars [22]. This can be adopted by other farmers, Biotechnology can also be used develop cultivars that are resistant to more virulent biotypes of the virus. Golden rice (transgenic rice with enhanced vitamin A content) is available for planting in Nigeria to improve the health of the Nigerian population. Scientists at Ohio State University, USA generated cyanogens-free transgenic cassava [22]. Nigeria can adopt this variety of cassava. Biotechnology in Nigeria is expected to produce nematode resistant genes into banana/plantain genotypes of economic importance.

- Farm products should be facilitated to become profitable. Government should invest continuously in rural infrastructure (electrification, road maintenance, irrigation) As part of policies aimed at gaining control over the public finances, stability and convertibility of the national currency, farmers should be educated on basic requirements of exporting to international markets. There should be market transparency and export promotion measures. Nigerian government had banned the importation of poultry and livestock in order to protect the local industry. Traders in other African countries should be encouraged by liberalizing tariffs for such countries.

- Government and Non governmental Organizations (NGOs) should develop food processing sector by investing on workshops exposing farmers to value addition processes of some farm products so as to meet common international health and quality standards, and the set –up and operation of regulatory agencies operating under internationally accepted standards. Nasarawa state government, All farmers Association of Nigeria (AFAN) and Federal Ministry of Agriculture, Water Resources and Rural development have already started this [30].

- Storage technology should be developed; government should sponsor research on this so that surplus products can be stored up for emergency periods. Most surplus fruits and tomatoes now waste away. This can be stopped or minimized by proper storage and/or processing. Nigerian government had already constructed strategic grain reserve silos, but research should be intensified for maximum result [27].

- If we have enough food for everybody in the country and even a large quantity for storage, that is still not enough because some people might still not be able to afford it due to poverty. Poverty should be alleviated; all categories of people should be able to have access to sufficient, healthy and reasonably priced food. All population groups should have at least a subsistence income allowing them to purchase a minimum monthly food basket. Government should define a minimum subsistence allowance that will be related to the evolution of price of the minimum monthly food basket. Minimum requirements of social schemes like the pension scheme, the unemployment scheme, and mother and child protection scheme should be set up and implemented. NGOs can also go into provision of poverty alleviation programmes.

Government should set up a body that will work against natural and manmade calamities. The most frequent sudden calamity in Nigeria is usually flood, which can be controlled by providing proper drainage system. Production could be increased by planting crops that can survive floods. When there is drought, appropriate crops could be planted. Desertification is also a problem; a body is already set up by the Nigerian government to collaborate with Israel in “Desert- to-Food-programme” to combat desert encroachment problems in the northern states of Nigeria [28], effort should be made to study the fundamental factors that enhance desertification which involves all Nigerian scientists with relevant expertise and not another bureaucratic unit in a ministry. This will enhance the utilization of existing results. When the situation is dire, the country can fall back on reserve food. Calamity fund can be set aside for times like this for food security.

The above measures can constitute long term objectives when they are properly designed. The country will be able to maximize production whatever the climatic condition and enough food for active, healthy life will be accessible to all the people of Nigeria. This will also boost the economy of the nation.

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Table1: Summary of locations and number of years of rainfall data used in this study.

Location	Geo-Political Zone	Climatic belt	North Latitude (^{0}N)	East Longitude (^{0}E)	Altitude (feet)	Number of years
Calabar	SS	Forest	04.58	08.20	170	34
Enugu	SE	Forest	06.27	07.29	745	21
Ibadan	SW	Derived Savannah	07.26	03.54	745	50
Ikeja	SW	Forest	06.35	03.20	125	37
Jos	NC	Guinea Savannah	09.52	08.54	4230	50
Kano	NW	Sudan Savannah	12.02	08.32	1549	37
Maiduguri	NE	Sahel	11.51	13.05	1162	50
Minna	NC	Guinea Savannah	09.37	06.32	848	50
Nguru	NE	Sahel	12.51	10.28	1100	50
Ogoja	SE	Forest	06.39	08.42	750	22
Port-Harcourt	SS	Forest	04.51	07.01	64	20
Sokoto	NW	Sahel	13.01	05.16	1150	50

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Table 2: Soyabean yields and rainfall distribution during 1995 and 1996 cropping period at Fasola farm, south West Nigeria.

Parameter	**1 9**	**9 5**	**1 9**	**9 6**
	Amount	**Number of Rain days**	**Amount**	**Number of Rain days**
Total Precipitation(mm)	1089	64	635	49
Biomass yield(kgha^{-1})	3964		1474	
Grain yield (kgha^{-1})	1801		591	

Source: Extracted from Modupe (1998)

Table 3: Available Precipitation for maize: early and late growing seasons in Ibadan, 1986 (90 day period).

Early	Number	Of	Rain	Days	Total Precipitation(mm)
	March 16-31	April 1-30	May 1-31	June 1-14	
	3	7	6	13	448.1

Late	Number	of	Rain	Days	Total Precipitation (mm)
	May 20-31	June 1-30	July 1-31	August 1-17	
	2	13	9	2	550.0

Table 4: Grain yield of maize in Ibadan, 1986(tons/ha).

Variety	Growing	Season
	Early	Late
4.5	7.3	4.0
8321-18	7.4	5.5
8428-19	7.5	4.2
8321-21	6.9	4.3
8505-10	6.8	4.4
8605-16	6.9	5.1
Gusau	6.6	4.3
8425-8	7.2	4.7
8329-15	6.3	5.0
8334-11	7.1	5.0
8605-18	7.4	4.0
8425-10	6.8	4.3
8605-17	6.9	4.2
TZ5R-Y	5.9	3.5

Source: Extracted from IITA Maize Research Program, Annual Report, 1986

Table 5: Summary of rainfall variation in twelve selected locations in Nigeria.

Location	Peak month of Rainfall	Onset month of rainfall	Cessation month of rainfall
Calabar	July	May	October
Enugu	July, Sept.*	April	October
Ibadan	June, Sept.*	April	October
Ikeja	June*, Sept.	April	October
Jos	July	May	September
Kano	August	June	September
Maiduguri	August	June	September
Minna	August	May	October
Nguru	August	June	September
Ogoja	September	May	October
Port-Harcourt	July*, Sept.	May	October
Sokoto	August	May	October

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Table 6: Percentages of the year considered having suitable amount of Rainfall.

Location	Average (mm)	99% confidence limits(mm)	% years with suitable amount of rainfall
Calabar	2865.2	± 146.7	85.0
Enugu	1702.2	± 172.5	76.0
Ibadan	1275.9	± 103.7	68.0
Ikeja	1487.9	± 152.1	75.5
Jos	1293.2	± 63.6	72.0
Kano	836.0	± 143.2	70.3
Maiduguri	594.7	± 55.6	68.0
Minna	1233.1	± 61.6	68.0
Nguru	473.3	± 47.0	68.0
Ogoja	1827.1	± 159.5	63.6
Port-Harcourt	2338.6	± 251.4	80.0
Sokoto	643.2	± 49.9	66.0

Table 7: Slopes of Linear Trends of Precipitation and Temperature.

Station	Precipitation Slope	Temperature Slope
Ogoja	6.9	0.064
Calabar	4.9	0.001
Port-Harcourt	14.0	-0.0112
Enugu	16.1	-
Ibadan	0.7	0.032
Ikeja	-3.4	0.056
Jos	-6.9	0.059
Minna	-1	0.009
Maiduguri	-3.2	-0.002
Nguru	-5.3	-0.341
Sokoto	-2.3	-0.007
Kano	16	-

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