ANALYSIS OF RAINFALL DATA FOR EFFECTIVE AGRICULTURAL PRODUCTION IN ADAMAWA STATE, NIGERIA

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Abstract

The paper demonstrates how analysis of climatic data particularly precipitation related parameters are very crucial in agricultural production. Daily rainfall data were collected from the archives of the Upper Benue River Basin Development Authority (UBRBDA) for 3 stations from the North, Central and Southern part of the state to ensure spatial coverage for the period 1984 – 2004. Precipitation effectiveness parameters analysed are onset, cessation, length of rainy season, seasonality index of rainfall and hydrologic ration. The result of the analysis show that the south-north onset and north-south cessation pattern does not apply to Adamawa State. Some pattern was observed with the seasonality index, while hydrologic ratio followed the normal north-south gradation. The spatial pattern of these parameter were discussed with respect to Adamawa State. The study concludes that except for the late maturing variety of rice, all the major subsistent crops cultivated in the state can be sustained using rain fed agriculture and that the southern part of the state can conveniently support double cropping without irrigation.

Introduction

Agriculture plays a central role in the lives of the people of Adamawa State. About 90% of the rural population is engaged in agriculture, which is largely subsistent and comes from numerous small farms. The small farm holdings depend on the amount of water received during the rainy season. Ati (2005) observes that, one of the two limiting factors to agricultural production next to soil fertility is insufficiency of water supply. Adebayo and Adebayo (1997) stated that, precipitation effectiveness indices are major control of crop yield in West African Savannah region. It is not only the total amount of rainfall that matters, but how effective the rain in terms of its time of occurrence, spread, intensity, frequency and availability as soil moisture.

Rainfall variability can therefore be defined as the amount by which the actual rainfall in station differs in average from its mean value either above or below. Variation in the total amount of rainfall, its duration, intensity, onset and cessation dates and number of rain-days over a period of time and/or space induces some catastrophies on man and his environment. Literature abounds on crop-climate relationship (Olaniran, 1988; Adefolalu, 1993; Adebayo, 1997; Kowal and Andrew, 1973), showing that, fluctuation in rainfall has been a major factor responsible for crop failure.

The amount of rainfall received over Adamawa State is not evenly distributed throughout the year. For even spatial coverage three stations (Mubi North, Yola North, and Ganye) representing North, Central and Southern part of the state were identified (Fig. 1). Hence, rainfall as a climatic element needs to be studied so that its characteristics such as amount, frequency, intensity and duration over space and time, as they affect agriculture in Adamawa state can be identified. The need to derive vital rainfall information covering the entire state for meaningful agricultural planning becomes the main thrust of this paper.

Study Area

Adamawa State is located at the northeastern part of Nigeria. It lies between Latitudes 7^0 and 11^0 N of the equator and between Longitude 11^0 and 14^0 E of the Greenwich meridians. It shares boundary with Taraba State in the South and West, Gombe State in its Northwest and Borno to the North. Adamawa State has an international boundary with the Cameroon Republic along its eastern border (Fig. 1). The state covers a land area of about 38,741km with a projected population of 2,347,993 people (NPC, 1991). Adamawa State is divided into 21 Local Government Areas.

Adamawa State has a typical West African Savannah climate with high temperature throughout the year because of high radiation income, which is relatively evenly distributed throughout the year. Maximum temperature in the state can reach 40^0C particularly in April while minimum can be as low as 18^0C between December and January. Mean monthly temperature in the state ranges from 26.7^0C in the south to 27.8^0C in the northeastern part of the state (Adebayo, 1991). The rate of evaporation in the state is generally high due to high insulation. Relative humidity is extremely low (20-30%) between January and March. It reaches up to 80% in August and September, due to the influence of the humid maritime air mass, which covers the whole state during this time.

The movement of Inter tropical Discontinuity (ITD) and its associated zones of rainfall during the course of the year is the major factor controlling rainfall in the state. The months of May to September constitute the wet season in the state. During this period, no place receives less than 60mm of rains (Adebayo, 1991). The mean annual rainfall in the state ranges from 700mm in the northeastern part of 1600mm in the southern part. Generally, mean annual rainfall is less than 1000mm in the central and northwestern parts of the state. On the other hand, the northeastern axis and the southern parts have over 1000mm.

Hills and mountains ranges, perhaps, constitute the most striking landform features in the state. In most cases, they appear as grouped hills and, generally, trading from south to north particularly along the eastern borderlands of Nigeria and the Cameroon. Prominent among them include Atlantika and Mandara mountains and Longuda-Kiri and Lamurde-Dukul hills. The state is dominated by three main drainage systems – the Benue, Yadzeram and Taraba. The mountains/hills and the major drainages systems, particularly the Benue, contribute significantly in moderating the climate of the state.

Materials and Methods

The data collected for this study was basically rainfall and potential evapotranspiration data. The rainfall data was obtained from Upper Benue River Basin Development Authority (UBRBDA), Yola. Data for one station each from Northern; central and Southern regions were collected for 21 years (1984-2004), to ensure spatial coverage of the state. Potential evaporanspiration data were obtained from the study of Adefolalu (1988). From the rainfall data, the derived precipitation effectiveness indices were computed in accordance with the following methods:

Mean, Standard Deviation and Coefficient of Variation: These were determined using simple statistical analysis. For example, mean is the summation of the distribution (X) divides by the distribution (N). Expressed as

$$\bar{X} = \frac{\sum x}{N} \qquad (1)$$

The standard deviation measures the dispersion about the mean of the variable, it is simply the square root of the variance. It is expressed as

$$\sigma = \sqrt{\frac{\sum(X-\bar{X})^2}{N}} \qquad (2)$$

While the coefficient of variation measures the percentage deviation from the mean, expressed as

$CV = \sigma / X \times 100\%$ - - - - - - - - (3)

Onset, Cessation Dates and Length of Rainy Season: Onset date of rain refers to the time a place receives an accumulated amount of rainfall sufficient for growing of crops. It doesn't actually refer to the first day rainfalls. Cessation means the termination of the effective rainy season. It is not however, the last day rain fell, but when rainfall can no longer be assured. The onset and cessation of rains are controlling factors of the calendar of agricultural activities. Length of Rainy Season (LRS) is the difference between the cessation date and onset date. Walter (1967), Griffith (1972), Ilesanmi (1972) and Adefolalu (1989), employed several statistical methods in order to determine the onset, cessation and length of rainy season. In this work, Walter (1967), method was adopted because of its accuracy and simplicity. The Walter's formula for computing the onset and cessation dates of rains is as follows:

$$\text{Days in the month} \left\{ \frac{(51 - \text{accumulated rainfall of previous months})}{\text{Total rainfall for the month}} \right\} \quad - \quad - \quad - (4)$$

Where the month in reference is that in which the accumulated total rainfall is in excess of 51mm. For the cessation dates, the formula is applied in the reverse order from December.

Seasonality Index of Rainfall

This is the sum of absolute deviations of mean monthly rainfall from the overall monthly mean divided by the mean rainfall. The rainfall seasonality index measures the spread and steadiness of rainfall during the wet season. According to Walsh and Lawler (1981), the seasonality index is computed as follows:

$SI = 1/R\sum|Xn - R/12|$, where; - - - - - - - - (5)

SI = Seasonality Index

Xn = Mean rainfall of month n

R = Mean annual rainfall.

The interpretations of the result according to Walsh and Lawler is shown in Table 1.

Hydrologic Ratio

Hydrologic ration (Λ) may be defined as the ratio of mean annual rainfall (P) to the potential evapotranspiration (PE) (Adefolalu, 1989). That is, $\Lambda = P/PE$. The value symbolizes soil moisture deficiency or surplus. This index helps in decision-making in agriculture, because it provides a guide on the best choice of the area or plot where a particular type of crop will not only thrive but will equally have high yield or reach optimum growth level.

Result and Discussions

Mean Annual/Monthly Rainfall

The mean annual and monthly rainfall is shown in Tables 2 and 3 respectively. It can be observed that, the southern region experiences higher rainfall than the north and central areas. Mean annual rainfall values here range from 68.34mm in 1984, which happens to be lower than that of north and central, to 109.67mm in 1985. The central region records lesser rainfall in all the years in consideration except 1984, when it reads even higher than that of south. The movement of Inter Tropical Discontinuity (ITD) and its associated zones of rainfall during the course of the year, seems to be the major factor controlling rainfall in the state. The ITD moves from south in March until around August when it is at its northerly position (about 20^0N). The rate of the movement of ITD is about 160km per month and its retreat, around September, towards south is 320km.

The mean monthly rainfall records (Table 3) indicate that, the months of May to September constitute the wet season in the state. During this period, no place receives less than 60mm of rainfalls. Very little amounts fall, sometimes, in the months of January and February but no area experience rainfall in December. Rainfall values steadily from May for all the stations. The northern region, being close to the zone of maximum rainfall receives relatively higher amounts compared with the central region. Higher amount of rainfall in this region is also due to the effect of orographic lifting. Monthly rainfall in September, increases in a north-south pattern. The amounts range from 150mm in the north to 350mm in the south. The relatively high amount in the south and low amount in the north during this month could be attributed to the gradient of the ITD, which dips in a south-north direction. Generally, August and September are the wettest months and the incidence of flood and erosion are experienced in the state mostly during this period. There is a sharp drop in rainfall in October. This diminution of rainfall is due to the fast rate of the retreat of ITD.

Onset, Cessation and Length of Rainy Season

The spatial distribution of onset, cessation and length of rainy season are shown in Table 4. Onset dates vary from 12th March in the southern axis to 18th April, resulting to an average date of 11th April. For the northern part of the state, the onset dates of rains stretch from March 27th to May 9th. Just like the onset dates, cessation dates are less varied between the central and northern areas, despite the fact that the annual and monthly averages in the north are higher. The only slight variation in cessation dates in the state is between the south and other parts, which can be attributed to the fast southward retreat of ITD. The length of rainy season ranges from 145 days in the north to 280 days in the southern part of the state. The northern axis has a mean length of rainy season of 165 days; central has 151 days and south has 205 days. The difference in the amount of rainfall between north and central is attributed to the variation in rain days. North has more rain days per month than the central, which can be related to orographic influence. A variation in the lengths of rainy season explains why there are differences in total annual rain values for the areas. The state can be divided into two zones based on the onset and cessation dates of rains.

(i) The southern zone, where onset date commences in late March to early April and effective rainfall ceases in late October and sometimes in November.

(ii) The northern, including the central, zone where normal planting date starts in late April and sometimes in early May.

Rainfall Seasonality

The spatial variation of rainfall seasonality in Adamawa State is shown in Table 5. The seasonality is lowest in the south, high in the north and highest in the central parts of the state. On Walsh and Lawler scale (Table 1), the state fall into two rainfall regimes. These are purely seasonal regime with 7-8 months of rains. This exists in the southern part of the state. The second regime is the markedly seasonal regime with 5-6 months of rains. This covers the central and northern parts of the state. The implication of the above regime is that only the southern part of the state could conveniently support double cropping without irrigation. In addition, crops requiring a long wet season, particularly trees and root crops can conveniently be cultivated in the same area.

Hydrologic Ratio

The pattern of hydrologic ratio in the state indicates that three zones exist (Table 6). The first is the hydro-neutral zone, which is found in the southern part of the state. In this zone, there is no soil moisture deficit and hence supplementary irrigation is not required to make crops reach optimum yields. The second zone (0.6-0.9) covers the central part of the state. In this zone, rainfed agriculture for short variety crops is also possible without supplementary irrigation. The presence of River Benue and the soil type of this region might be a contributing factor in improving soil moisture surplus. The third zone is the northern zone with a mean hydrologic ratio of 0.56, a value slightly above the second zone. This zone can also support short variety crops. However, high water requirement plants cannot thrive well in this zone.

Conclusion

Climatic information on precipitation effectiveness indices in Adamawa State has been presented. This information are very important because they serve as baseline data for grassroot agricultural planning in the state. It is expected that, farmers, water and agricultural agencies will make use of these information, alongside with advances in agricultural technology to produce higher crop yields and sustainable water development that may guarantee food security of the state in particular and the action in general. The research concludes that, the rainfall characteristics analysed for the state can support the rainfed cultivation of the four major subsistent crops cultivated in the state. These are Guinea corn, maize, rice and groundnuts, virtually all except the late maturing variety of rice can be produce in the state.

References

Adebayo, A. A. (1997). The agroclimatology of rice production in Adamawa State. Ph.D. Thesis, Department of Geography, Federal University of Technology, Minna.

Adebayo, A. A. and Adebayo, E. F. (1997). Forecasting the yield of upland rice in Adamawa State, Nigeria on the basis of agroclimatic factors. *Malaysian Journal of Tropical Geography 28(2).* 97 – 101.

Adebayo, A. A. (1999). *Climate II: Rainfall.* In Adebayo and Tukur (Eds.), Adamawa State in Maps. Paraclete Publishers, Yola.

Adefolalu, D. O. (1993). Rainfall climatology and agricultural extension services. WMO Training Lecture Series 93:3.

Adefolalu, D. O. (1989). Precipitation, evapotranspiration and the ecological zones in Nigeria. *Theor Appl. Climatology, 39,* 81 – 89.

Ati, O. F. (2005). Variation and trends in rainfall and its onset series for Kano. Paper presented at the 47th Annual Conference of the Nigerian Geographical Association, Port-Harcourt. 14th – 17th August, 205.

Griffith, O. O. (1972). Nigeria. In Lansberg (Ed.), *World Survey of Climatology.* Elvesier Pub. 10:167-186.

Ilesanmi, O. O. (1972). An empirical formulation of the onset, advance and retreat of rainfall in Nigeria. *Jour. of Trop. Geog. 34:* 17-24.

Kowal, J. and Andrews, D. J. (1973). Pattern of water availability and water requirement for grain sorghum production at Samaru, Nigeria. *Samaru Research Bulletin, 188,* 89-100.

Olaniran, O. J. (1988). Climate and the planning of agricultural land use in Nigeria: The NRBDA area as a case study. *J. Agr. Met. 43(4):* 285-294.

Walsh, P. R. D. and Lawler, D. M. (1981). Rainfall seasonality: Description, spatial, pattern and change through time. *Weather,* Vol. 36 No. 7, pp. 201-208.

Walter, M. W. (1967). The length of rainy season in Nigeria. *Nigerian Geog. Jour. 10;* 123-128.

Table 1: Classification of Rainfall Regimes According to Walsh and Lawler (1981)

SI Class Limit	Rainfall regime
≤ 0.19	Very equable
0.20 – 0.39	Equable but with a definite wetter season
0.40 – 0.59	Rather seasonal with a shorter, drier season
0.60 – 0.79	Seasonal
0.80 – 0.99	Markedly seasonal with long drier season
1.00 – 1.19	Most rain in three months or less
≥ 1.20	Extreme, almost all rains in 1 to 2 months

Table 2: Mean Annual Rainfall Distribution

Region	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
North	81.5	89.1	85.8	83.7	91.1	92.3	79.1	82.3	91.2	92.4	87.5
Central	80.9	80.9	75.1	71.6	96.3	91.6	68.7	71.8	80.8	81.0	77.1
South	68.3	109.7	95.6	82.3	98.9	97.7	84.5	87.6	95.6	97.8	92.9

Region	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
North	100.5	94.6	91.9	95.7	101.2	88.7	86.9	65.2	87.1	91.9
Central	90.1	84.2	81.5	83.2	92.8	78.1	76.1	54.7	76.9	81.5
South	105.9	100.0	97.3	101.1	108.6	94.1	92.1	70.5	92.7	99.3

Table 3: Mean Monthly Rainfall Distribution

Region	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
North	0.0	0.0	0.74	18.2	108.0	130.0	269.5	295.7	218.8	66.6	1.38	0.0
Central	0.18	0.0	0.36	40.8	121.7	134.6	190.2	281.4	184.6	183.9	1.41	0.0
South	1.75	0.42	13.9	43.5	140.2	189.4	201.2	227.5	225.9	82.1	0.92	0.0

Table 4: Average Onset and Cessation Dates and Length of Rainy Season

Region	Onset	Cessation	Length of Rainy Season
North	18th April	15th October	165 days
Central	20th April	13th October	151 days
South	1st April	28th October	205 days

Table 5: Hydrologic Ratio Values

Region	Mean Values
North	0.45
Central	0.75
South	1.10

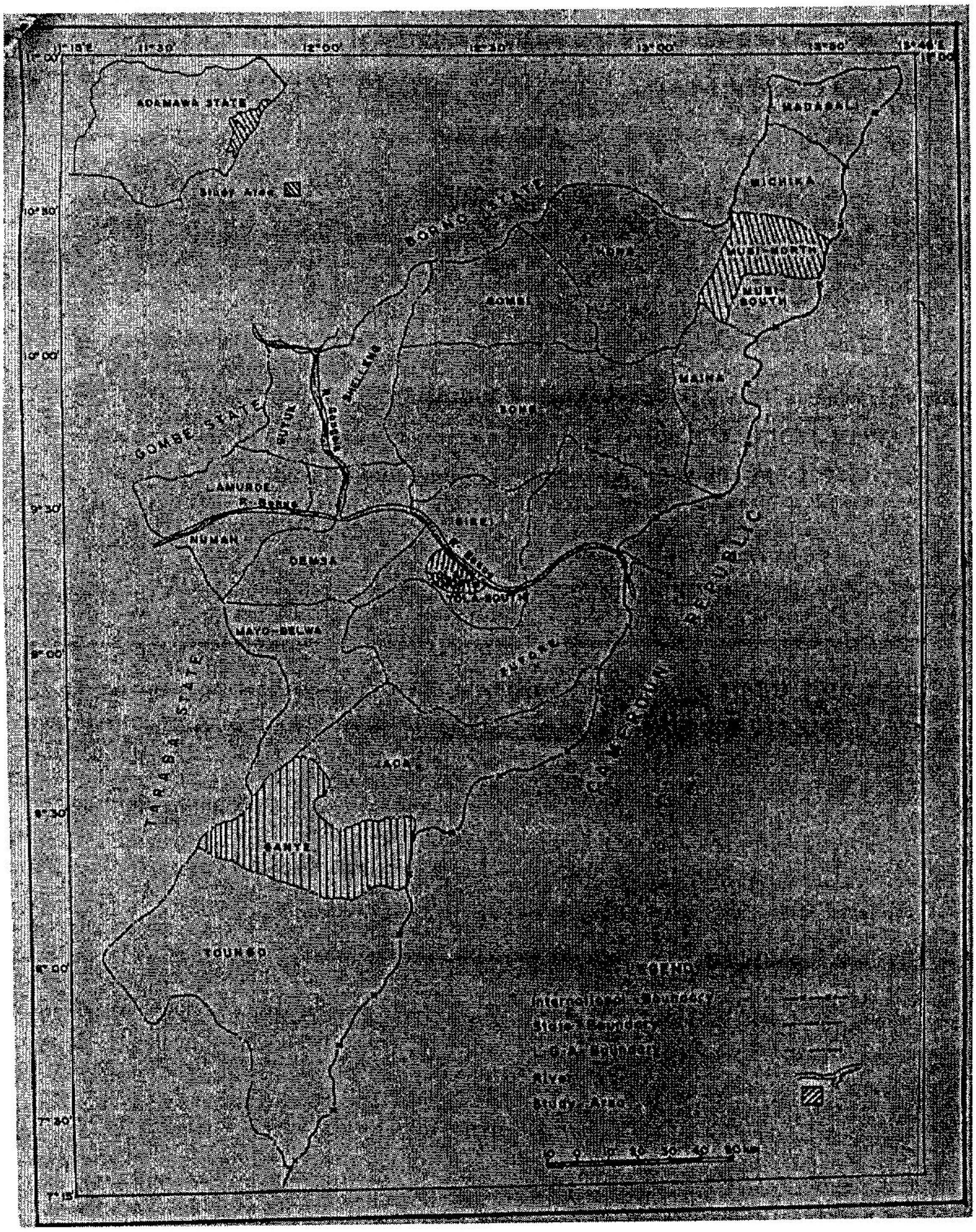

Fig. 1: Map of Adamawa State Showing Local Government and Study Area.