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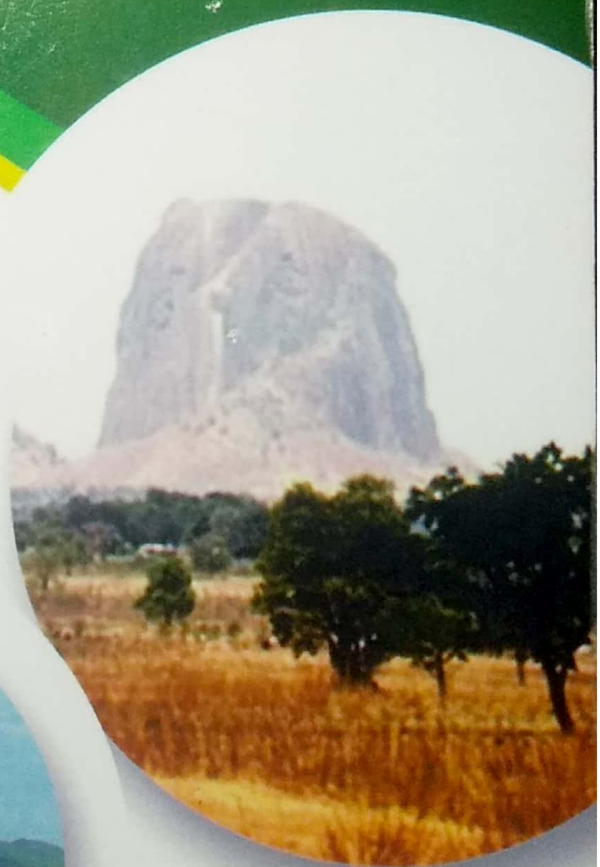

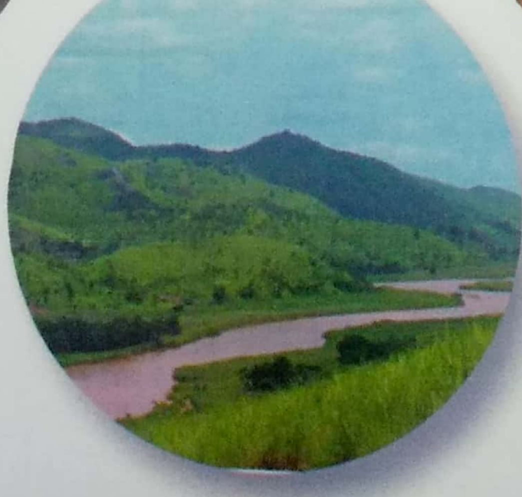

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Aims and Scope

Nigerian Journal of Tropical Geography is the Journal of the Department of Geography of the Nasarawa State University, Keffi (NSUK). Readership and authorship is mainly from academics and professionals of geography and environmental sciences and technology and their students or those with interest and involvement in environmental issues both in Nigeria and globally. We accept manuscripts from a wide range of topics including every aspect of geography, and environmental resources management which include air quality and pollution, waste management, land contamination and restoration, every facet of the water cycle management holistic environmental conservation with biodiversity and environmental law. The journal is widely read by academics and professionals, consultancies, Government agencies, regulators, NGOs, the water and environment and the land and urban development sectors. Multimedia information and knowledge exchange and dissemination will be initiated and actively encouraged and promoted by the Journal. This issue Vol. 7, No. 1, 2016 will consist at least 150 pages regularly featuring In-depth peer-reviewed papers; Shorter "articles from the "field"; "Crossfire"-a debate on topical issue argued out between experts/specialists; Book reviews-views on which books are really worth reading; "From our correspondent" – a regular letter from a geographical and environmental professional dealing, in a balanced, objective and evidence-based manner, with contemporary "controversial issues"; and Webwatch-theme-relevant websites to visit..

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CONTENTS

Effects of Rainfall Variability on Crop Production Planning in Bida Basin, Nigeria

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Abstract
Availability of moisture for all land based activities (Agricultural and Hydrological) is dependent on spatial and temporal steadiness of rainfall during any rainy season. Failure rates in terms of crop yield and moisture harvest may be disastrous due more to lack of cognizance of the basic characteristics of rainfall such as Onset and Cessation dates and the Length of Rainy Season. These collectively results in both short and long term anomalies in rainfall amount received over a geographical area. The effect of rainfall variability on crop production planning over the Bida Basin was investigated to assess farmers adoption and adaptation strategies to the variability in rainfall. Rainfall data for 40 years (1969 - 2009) were utilised. Both descriptive and inferential statistics were used in the analysis. The results indicate that rainfall pattern is in form of alternate wet and dry years and characterised by strong seasonality. This is reflected in the farmers' response interms crop production planning and also served as useful indicator for estimating extreme rainfall events such as drought and floods. It is therefore recommended that continuous monitoring and careful assessment of moisture requirement be carried out and incorporated into planning process for maximum crop yield.

Keywords: Rainfall Variability, Crop Production, Hydrologic Ratio, Moisture, Basin.

1.0 Introduction

Studies on climate variability in West Africa show a significant decrease in both the amount of annual rainfall and the duration of the rainy season. Carbonnel and Hubert (1992) detect a 19-year climate variation for the period 1970–89. L'Hôte and Mahé (1996) compare the rainfall average during the period 1951–69 with the period 1970–89 and determine a southward movement of isohyets in the range of 150–250 kilometers, depending on the Basin climate zone. Furthermore, analysis of monthly rainfall data for the whole region by Le Barbe and Lebel (1997) shows that the dry period is characterized by a decrease in the number of rainy events, but the mean storm rainfall varies little. A deficit of 10 percent to 30 percent in rainfall generally leads to a deficit of 20 percent to 60 percent in river discharges, confirming that rainfall in the Basin varies considerably but river discharges vary still more.

Although alternating wet and dry years have always been observed in tropical rainfall data (Oguntoyinbo, 1978), the declining precipitation effectiveness due to anomalous rainfall patterns since 1972–1973 drought suggests that a dangerous trend in mean conditions is taking place (Adefolalu, 1986). This phenomenon has been attributed to the complex interplay of surface temperature anomalies over the tropical Atlantic Ocean and the attendant latitudinal shifts of circulation system during dry years and human error in permitting the population of both people and livestock to increase to critical levels in many parts of West Africa during wet years (Hastenrath, 1990).

This seasonality of West African rainfall as a function of the migratory monsoon as stated by Adefolalu, (1990) results in contrasting summer rainfall patterns. As such, variability in rainfall over different time periods influences crop production planning on monthly, seasonal and annual basis. The highly variable nature of crop production practices in the study area is no doubt related to this decline in rainfall amounts. The specific objective of this paper is to assess the effectiveness of rainfall variability on crop production planning in the Bida Basin, Nigeria.

2.0 THE STUDY AREA

The study area is the Bida Basin, Nigeria with areal extent of about 7,540 km^2 covering parts of Gbako, Katcha and Bida Local Government Areas of Niger State, Nigeria. It is located between latitude 09° 5' N and longitude 06° 15'E (Figure 1). The general climate of the study area is the Tropical Monsoon type (Am) characterised by alternate wet and dry season, with rainfall occurring in the rainy season months of May to October. Temperatures are relatively high throughout the year hovering between 27°C and 35°C.

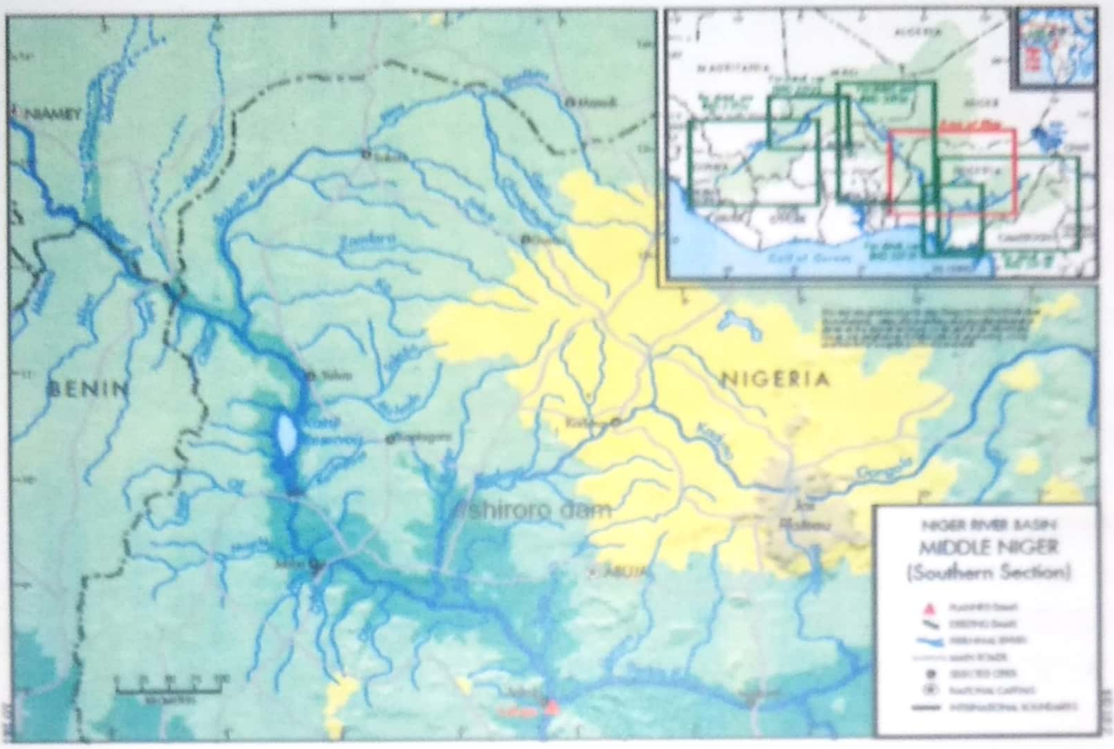

Figure 1: The Niger River Basin (Middle Niger – Southern Section)
(Adapted from Inger Anderson et al., 2005)

3.0 MATERIALS AND METHODS

Secondary data were used in this study. Monthly and annual rainfall data for the study area for 30 years (1980-2009) were obtained from the Nigerian Meteorological Service. Both descriptive and inferential statistical methods were used in data analysis and interpretation. The descriptive methods include mean, frequency analysis and graphs.

The calculated mean was done using the formula:

$$X = \frac{\sum^{x} \alpha}{N} \quad \ldots\ldots\ldots (1)$$

Where X is the observed parameter, Σ is the summation symbol and N is the number of observations.

Correlation coefficients of the main meteorological variable (Rainfall) were computed to determine the strength of the relationship between the variables. The standard deviation (SD) is the most common measure of variability and it is expressed as:

$$SD = \sum_{i=1}^{x} \left(\frac{x - \bar{x}}{n-1} \right) \quad \ldots\ldots\ldots (2)$$

$$SD = \sum_{i=1}^{n} \left(\frac{x - \bar{x}}{n-1} \right) \quad \text{.......................} (2)$$

Where:

SD = Standard Deviation

$\bar{X}$ = The value of the observed parameter and

$$CV = \frac{SD}{\bar{X}-} x \frac{100}{1} \quad \text{.......................} (3)$$

Where:

X = the daily, monthly or annual variables for a given period.

N = number of cases being considered in the variable.

$\sum$ = span of all the values of variable X e.g reservoir inflow.

In order to standardize the SD for data series, it is divided by the mean value to produce CV Coefficient of variation is a useful measure for comparative purposes where an annual series is normally distributed and where mean totals are not low (Gregory, 1969).

After, the regression analyses of the correlated variables were done to develop regression model. The regression model can be described by the equation that follows: Y – a x + b ....(4)

Where, X = time (year), a = slope coefficients and b = least square estimates of the intercept. Both the correlation and regression analysis were computed using Microsoft Excel Software Application and the Statistical Package for Social Sciences (SPSS) Version 16.0 for Windows.

3.1 Estimating the Hydrologic Ratio

Defined as the ratio of mean annual rainfall to the Potential Evapotranspiration (PE), the hydrological ratio, symbolized by λ is the degree of wetness or dryness of a place obtained as ratio of mean annual rainfall to P.E. Critical values of λ based on normal and extreme *PE* amounts were used to define the various ecological zones in Nigeria (Adefolalu, D.O. 1998).

According to Duckham (1974), this index helps with decision making in agriculture because it can provide a guide on the best choice of area where a particular type of crop will not only thrive, but will equally have high yield or reach optimum growth level. From a global investigation by Duckham and Masefield (1970) and Duckham (1974) on plant response to changes of climatic conditions and hence available precipitation, it was found that in the hydro-neutral zone, where λ = 1.0, optimum crop yields exists, not only because *PE* is equal to mean annual precipitation (*P*), but also because the effective actual evapotranspiration is high. For semi-arid zones, *PE* increasingly exceeds *P* while actual evapotranspiration decreases. In such areas crop yield will decrease. Thus, the fertility of soil notwithstanding, without moisture, such a soil is useless and plant-life is nil. As an indicator of the amount of moisture available to plants in a particular physical environment, λ is therefore, an equally important parameter in relation to natural resources evaluation.

4.0 RESULTS AND DISCUSSION

Table 1 depicts the rainfall statistics for Bida Basin. Rainfall hovers between 64 mm in April to highest monthly value of 226 mm in September. Variability in rainfall is extremely high in the dry season months of November to March with variations in the range of 92 percent in March to about 184 percent in November. The peak of the wet season months of July, August and September have low variability. Values range between 25 percent and 30 percent. This can be explained by the constancy of rainfall in days during these months.

Figure 2 illustrates the monthly distribution of rainfall over the Basin. Rainfall starts in March/April and progressively increases reaching its peak in August/September and thereafter decline until its cessation in late October.

Table 2 features the extreme values of annual rainfall distribution statistics in the Study Area. For the 40 year study period (1969 - 2009), the highest mean amount of rainfall recorded in the month of April is about 152 mm, accounting for about 239 percent of the annual mean. The lowest mean rainfall recorded in April within the same period is 8.1 mm, accounting for about 13 percent of the annual mean. The months of July, August and September usually characterised by heavy rainfall recorded 284 mm for July, 332 mm for August and 346 mm for September respectively. The corresponding percentages of the mean monthly rainfall to annual mean are 137 percent for July, 146 percent for August and 157 percent for September. The lowest mean values ranges between 54 percent and 70 percent of the total mean for the months of July, August and September.

Figure 3 shows the trend in annual rainfall over the Study Area. The 1970s and 1980s witnessed downturn in rainfall amount. The year 1990s and

2000s witnessed rise in rainfall amount. The rate of increase in rainfall is about 24 percent. This also corresponds to rate of decrease in rainfall previous two decades (1969 - 1989).

Figure 4 illustrates the Onset dates of rains in the Study Area which is between April 10 and May 15. The cessation dates of rains, falls within October 25 and 30 (See Figure 5). The length of rainy season in days is between 161 and 200 days in the Basin (See Figure 6).

Table 1: Annual Rainfall Statistics for the Bida Basin

	Mean monthly Rainfall											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Rainfall (mm)	0	1	14.9	63.6	135.8	166.4	219.8	206.3	226.9	12.6	4.3	0
% of Annual Rainfall	0	1	1.2	5.4	11.6	14.4	18.8	17.7	19.4	10.8	0.3	0
Std. Dev. (mm)	0	1.3	22.4	40.6	47.8	77.5	68.0	51.8	61.4	36.8	7.9	0
Coeff of var. (%)	0	162.5	92.0	58.9	35.2	46.5	30.9	25.1	27.0	29.2	183.7	0

Source: Suleiman (2013)

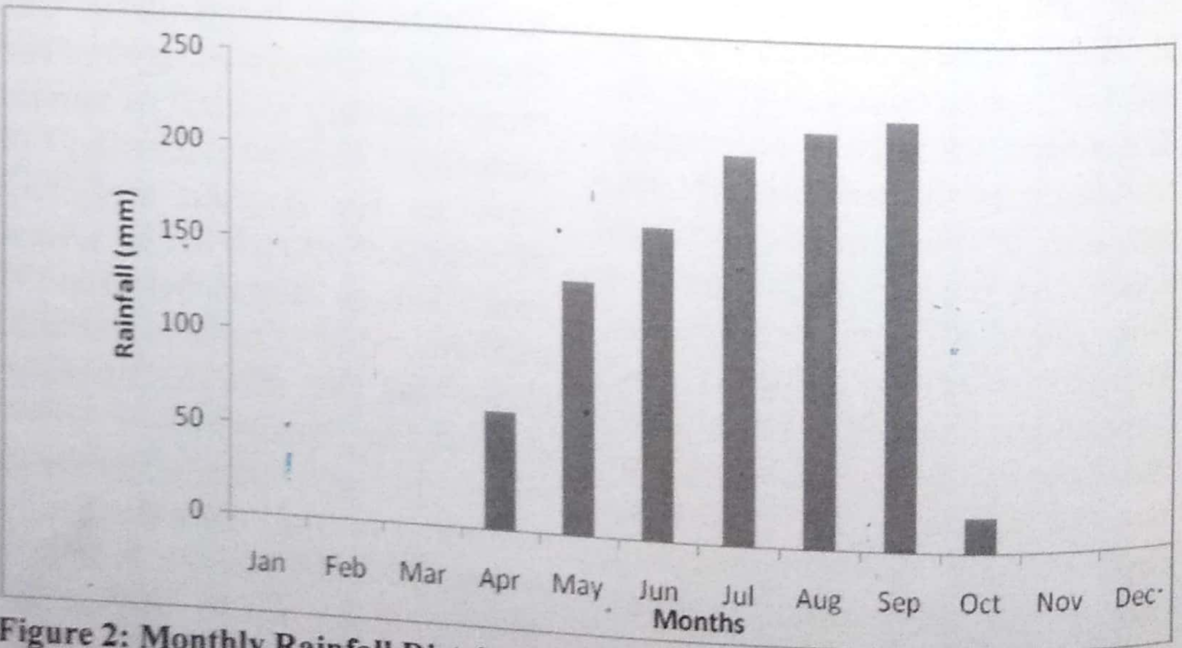

Figure 2: Monthly Rainfall Distribution at the Bida Basin.

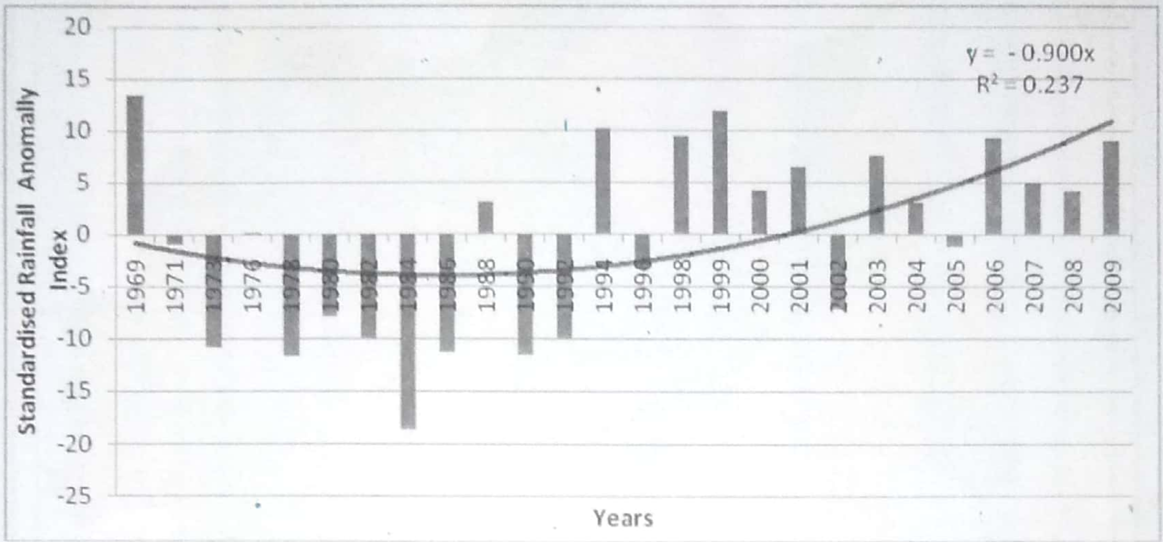

Figure 3: Trend of Annual Rainfall over the Bida Basin (1969 - 2009)

Table 2: Extreme Values of Seasonal Rainfall Statistics over the Bida Basin (1970-2009)

Month	Mean Rainfall (mm)	Highest Rainfall (mm)	% of Mean	Lowest Rainfall (mm)	% Mean
April	63.6	151.8	238.6	8.1	12.7
May	135.8	192.3	141.6	77.4	56.9
June	166.4	335.5	201.6	43.7	26.2
July	206.3	284.3	137.8	151.9	69.1
August	219.8	331.8	146.2	145.4	70.4
Sept.	226.9	346.3	157.2	124.6	54.9
Oct.	19.4	174.9	901.5	70.2	361.8
Rainy Season	**1165.7**	**1816.9**	**115.2**	**621.3**	**652.0**
Annual	**1329.0**	**1294.5**	**144.7**	**982.7**	**66.3**

Source: Suleiman (2013)

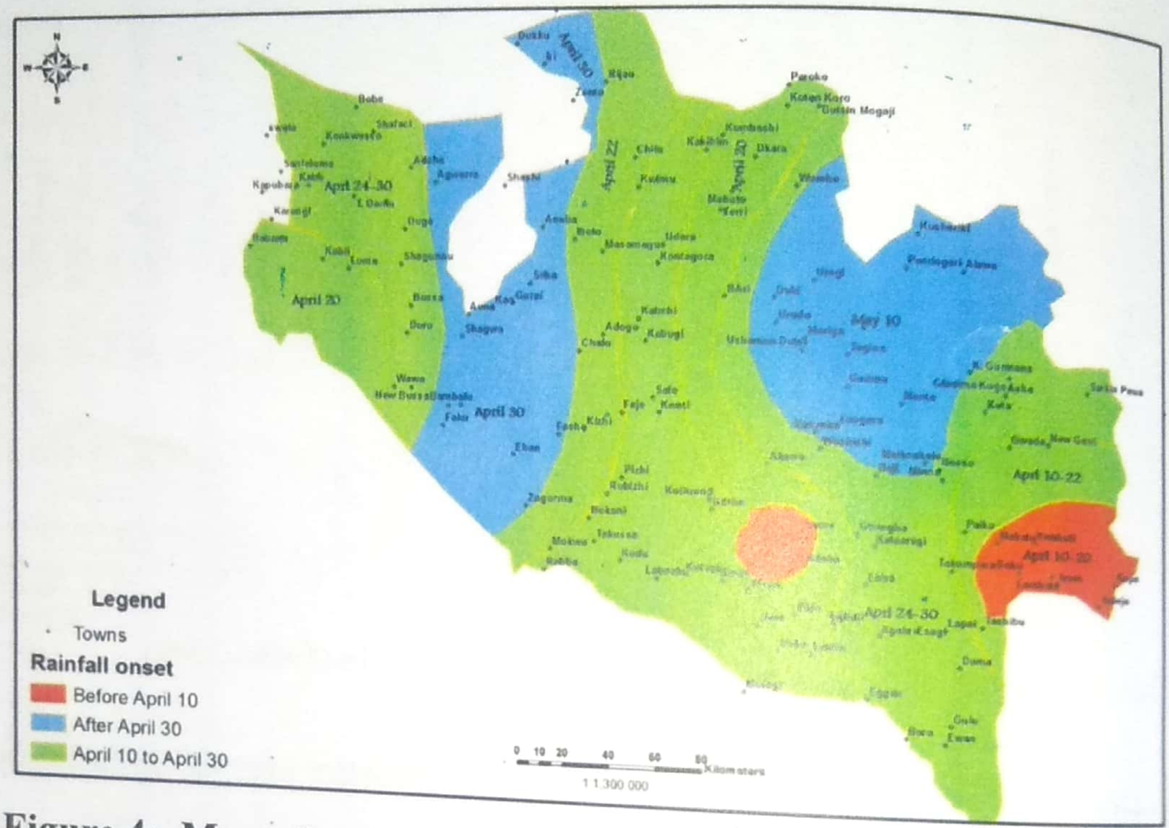

Figure 4: Mean Onset of Rains over Niger State.

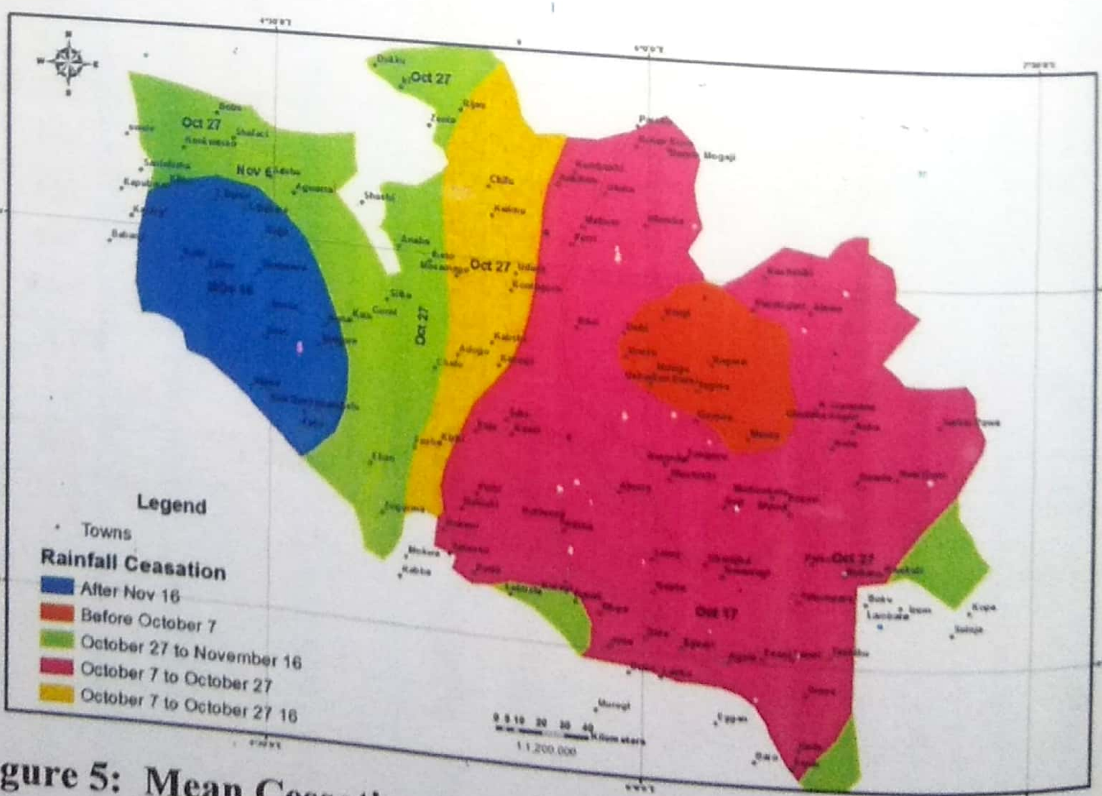

Figure 5: Mean Cessation Dates of Rains over Niger State.

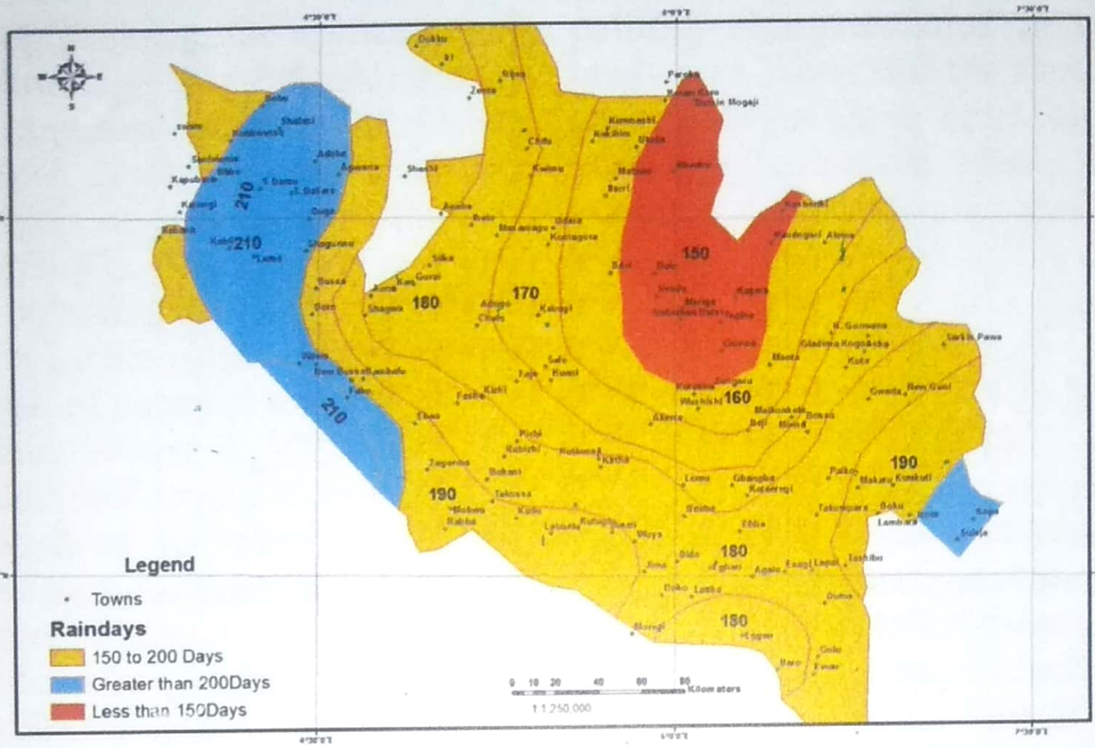

Figure 6: Length of Rainy Season in Days over Niger State.

Information on annual and monthly rainfall variation is desirable for planning, operation and management of water resource projects as this gives an insight into crop production planning purposes. The rainfall pattern over the Basin is generally in the form of alternating wet and dry years. Figure 3 indicate 19 years of increased rainfall (1969, 1970, 1971, 1977, 1976, 1988 1994, 1995, 1996, 1997, 1998, 1999, 2001, 2003, 2004, 2006, 2007, 2008 and 2009) and 21 years (1972, 1973, 1974, 1975, 1978, 1979, 1980, 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1989, 1990, 1991, 1992, 1993, 2002 and 2005) of marked decrease in rainfall below the 1165 mm annual mean computed for the Basin. This pattern of rainfall buttresses the fact that annual rainfall over the basin is highly variable not only on seasonal but also on annual basis.

Rainfall in the Basin is characterized by strong seasonality. The basin records seven months of rainfall beginning from April to October. The period November to March is dry. The amount of rainfall within the wet season also varies from year to year. The seasonal rainfall ranges between 800 mm and 1500 mm which is more than enough for most purposes. But rain does not fall everyday. The longer the time interval in-between days of rain, the worse will its effect be on crop performance.

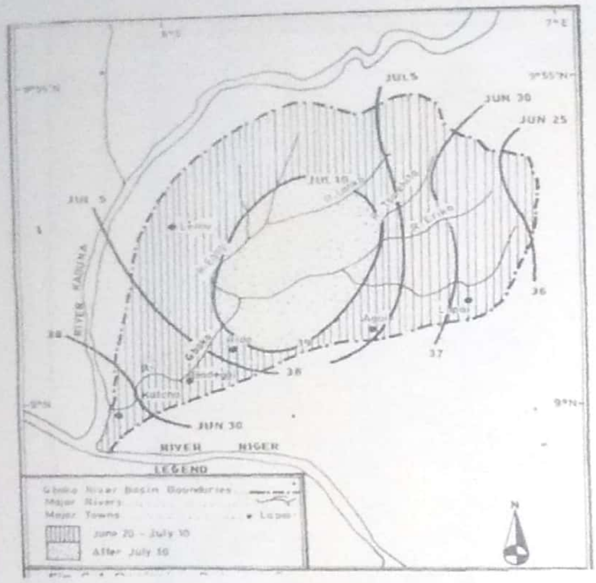

Figure 7: Beginning Dates of Breaks in the Rainy Season

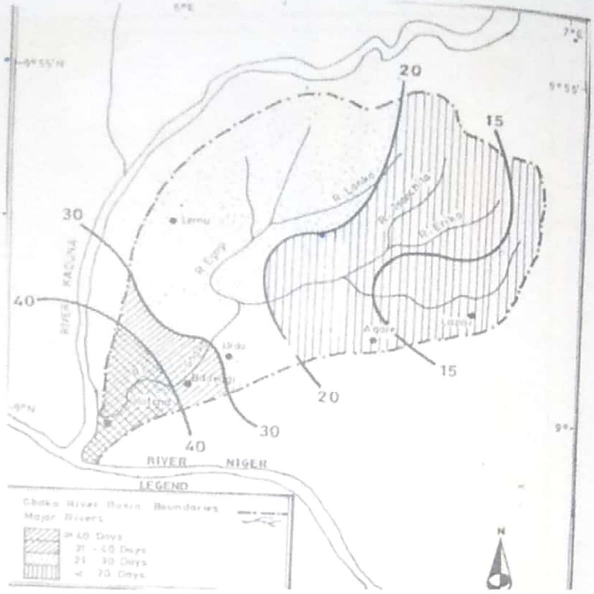

Figure 8: Length of Breaks in Days

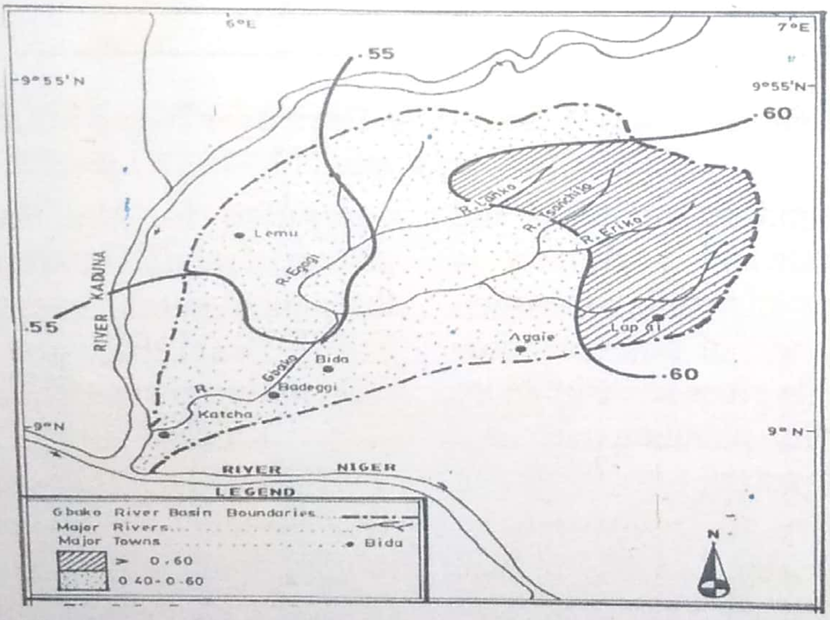

Figure 9: The Degree of Dryness/Wetness (The Hydrologic Ratio) in the Bida Basin

Figure 7 and 8 illustrate the beginning dates of breaks in the rainy season (BRS) and length of such breaks respectively in the Basin. These suggest that for effective planning, the period June 20 to July 10 must be carefully appraised. This 20-day period marks the onset of such breaks in the Bída Basin. The duration of such breaks ranges between 30 – 40 days in Bida Gbako, Agaie and Katcha Local Government Areas; the territorial extent of the research domain is to be found within the aforementioned Local Government Areas (LGAs).

In any meaningful assessment of moisture needs for crop planning, the application of knowledge of hydrologic ratio (λ) is important. A value of λ = 1.0 is called Hydro-Neutral condition which, under normal situation implies no deficit in soil moisture (100% field capacity), Areas with λ = 1.0 are called Hydro-Neutral zone of potential maximum crop yield. Where λ is below 0.40, additional source of water will be required to supplement soil moisture to ensure λ = 1.0 at all times. Figure 9 illustrates the λ ratio values for the Study Area. It is discernible that highest value of 0.60 or more is restricted to the extreme Southern fringes of Agaie, Katcha and Lapai LGAs to the Southeast of the Basin. As such, it is not possible to expect maximum crop yield in the Study Area under rain-fed agriculture and also for water harvest in times of greatest demand (dry season).

As such, the following features of rainfall and crop production are to be noted for planning and extension services to farmers.

(i) When to start planting

(ii) How long is the length of rainy season within in the study area.

(iii) What variety crop to plant and

(iv) Where to plant particular kind of crop.

Figures 3, 4 and 5 depicts the of rainfall characteristics in the study area shows that the start of the rain for the entire River Basin from April 10 to May 15 and the length of rainy season is between 161 – 200 days.

5.0 CONCLUSION AND RECOMMENDATIONS

One major characteristic of rainfall in this basin is its strong seasonality; alternating between wet and dry periods and these has implications for crop production planning in the basin. This is so because rainfall identified as the determinant of the rain-fed crop production practiced in the basin to the virtual exclusion of all other factors, is equally variable. The period of maximum crop yield in the basin usually will coincide with periods of substantial moisture availability.

It is recommended that for effective crop production planning in the Basin, continuous appraisal of the characteristic feature of rainfall be carefully made and results utilized for farmers' education and extension services, proper harnessing of annual and perennial rivers is also suggested to augment shortfall in rainfall and introduction of crop varieties that can suit the climatic setting be cultivated.

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