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A TEMPORAL ANALYSIS OF RAINFALL CHARACTERISTICS ON THE JOS PLATEAU, NIGERIA

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Abstract: *Jos Plateau practices rain fed agriculture which is completely dependent on rainfall which in turn is highly variable in time and space. The timing of rainfall availability has been proven to be more important to crops than its amount and duration. It is for this reason that the present study examines some important rainfall characteristics such as annual rainfall amount, length of rainy season, seasonality index, onset and cessation dates of rainfall on the Jos Plateau using monthly rainfall data obtained from the head office of Nigerian Meteorological Services department for a period of 30 years (1988 – 2017). Appropriate statistical techniques were used in calculating each index. Major findings shows that none of the indices calculated remain stable from their mean over time. The mean annual rainfall on the Jos Plateau for the study period was found to be 1245.020 mm with a standard deviation of 139.28 mm. The mean length of raining season for the study period was found to be 173 days with a minimum occurrence of 129 rain days occurring in the year 2017, and a maximum of 203 rain days occurring in the year 2003. The same variability was observed with seasonality index, onset and cessation dates with mean values of 0.94, 14th April and 3rd October respectively. It was therefore observed that since the rainfall characteristics studied exhibited high variability, this might be the major determinant in yield variability of crops in the study area. The research therefore concludes that further studies should be planned towards establishing the relationships between the studied indices and crop yield on the Jos Plateau.*

Keywords; *Agriculture, rainfall, characteristics, variability and relationship*

INTRODUCTION

Agriculture constitute the major economic activity in Nigeria employing about 70% of the rural population and contributing about 22.86% to the GDP (Binbol and Zemba, 2007). Majority of the agricultural practices in Nigeria depends on rainfall which is characterised by high variability in amount both seasonally and annually. The seasonal variation in rainfall is known to affect the crop calendar of the area in terms of clearing the farm, planting, on farm activities and even post-harvest activities related to storage. Annual variability of rainfall on the other hand affects agriculture more in terms of frequency and intensity of fall. These in most cases exhibit negative impact on crop yield especially in the Sub Saharan Africa (SSA).

Agriculture in SSA is generally considered a climate sensitive venture and it is expected that climate change will further exacerbate this condition either positively or negatively. This is because analyses of rainfall trend in the recent past over Nigeria suggest a downward trend in most northern locations, while the southern stations demonstrate an upward trend (NiMet, 2018). The effects of rainfall variability on some studied crops have been documented (Beyers et al, 2014; Bekele et al, 2017; Sawa and Adebayo, 2018). Adebayo and Adebayo (1997) argued that it is not the amount of rainfall available to a crop that determine its final yield, but rather, it's the timing that matters. Therefore, in this era of global warming and changing climate, the present study is focussed on a temporal analysis of rainfall characteristics on the Jos Plateau. Findings in current study can then be linked to crop yield variability in the study area.

MATERIALS AND METHODS

The Study Area

Jos Plateau has geo coordinates of latitude 8^0 to 10^0N and longitude 7^0 to 11^0E. It is bounded in the north by Kaduna state, west by Nasarawa State, to the east by Bauchi state and to the south by Quan Pan, Mikang, Langtang north and Kanke local government areas (see Figure 1). The climate is characterized by two distinct seasons, wet and dry. The wet season spans a period of 6 months (May – October), while the dry season covers November to April. Mean annual rainfall total stands at about 1200mm, with a mean temperature of about 22^0C (Binbol et al, 2016).

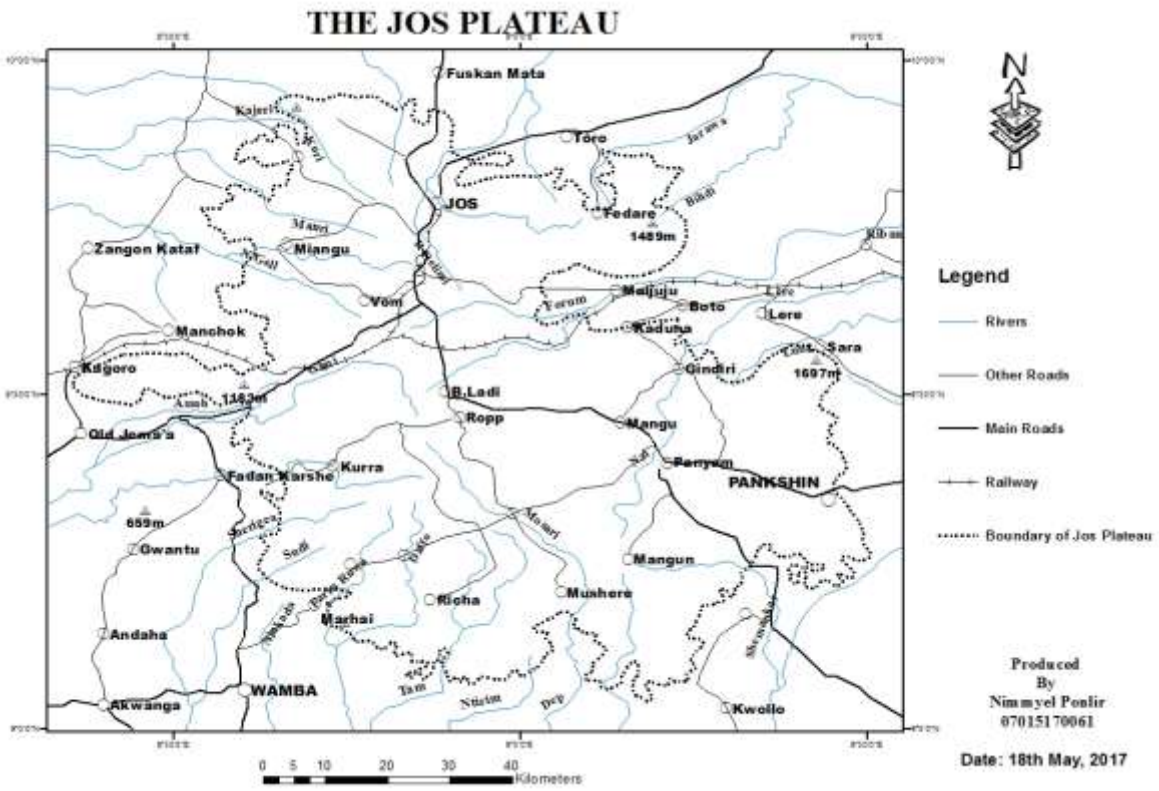

Figure 1, Outline Map of the Jos Plateau

Data Collection

The research made use of secondary data in the form of monthly rainfall data collected from the Head office of Nigerian Meteorological Agency (NIMET). The data collection spans a period of 30 years (1988 to 2017). The data exist in the form of daily rainfall record from which monthly and annual values were derived. According to Nigeria Meteorological Organization, a rain day is a period where moisture collected exceed 0.25mm, below that it is recorded as Trace "TR".

Data Analysis

The rainfall data collected was subjected to descriptive statistics of mean, standard deviation and coefficient of variation. The mean monthly and annual rainfall is the summation of all rainfall values occurring within the study period, divided by the number of years or months as the case maybe. This is expressed as

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

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

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

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

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

The major rainfall characteristics considered for this study are; Annual rainfall amount, Onset and Cessation of rainfall, Hydrologic Growing Season (HGS) or Length of Raining Season (LRS), Seasonality Index and Hydrologic Ratio.

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 rain falls. Cessation means the termination of the effective rainy season. It does not mean 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), Adefolalu (1989) and (Binbol *et.,al*, 2016) employed several statistical methods in order to determine the onset,

cessation and length of rainy season. In this present 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:

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

Where the month in reference is that in which the accumulated total rainfall is in excess of 51mm. The formula adopted the use of 51mm of rainfall because of the high evaporative tendency in the tropics. 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 annual 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:

$$SI = \frac{1}{R}\sum\left[X_n - \frac{R}{12}\right] \quad (5)$$

where; SI = Seasonality Index
Xn = Mean rainfall of month n
R = Mean annual rainfall.

Hydrologic Ratio

This is defined as the ratio of mean annual rainfall (P) to the potential eveapotranspiration (PE). Therefore, HR = P/PE (6)

The value symbolizes the degree of wetness or dryness of a place. This index helps in decision making in agriculture because it provides a guide on the best choise of the area where a particular type of crop will not only thrive, but will equally have high yield or reach optimum growth level. The ratio is always expressed as fraction between 0 to 1. Something. So the higher the value, the more the soil moisture.

RESULTS AND DISCUSSION

Annual Variation of Rainfall on the Jos Plateau

Table 1 presents a descriptive statistics of variables under investigation. Out of 30 years rainfall analysed, the lowest annual amount recorded was 814.7 mm in the year 1995, while the highest amount of annual rainfall of 1582.7mm was recorded in the year 2001. Average rainfall for the entire period is put at 1245.020 mm with a standard deviation of 139.28 mm. This means that the variability of rainfall in Jos is not too pronounced and it is within acceptable standard.

However, in order to establish the annual pattern of variability of annual rainfall, Microsoft excel was used to plot the 30 years annual rainfall data. The result is presented on Figure 2. A regression trend line was fitted on the plot and findings shows that in spite of the variable nature of rainfall on the Jos plateau, rainfall seems to be on the increased. This is demonstrated by the regression equation generated Y= 2.4669X + 1206.6, the correlation coefficient shows that rainfall (X) generally increased from the mean annual of 1206.6 mm with about 2.5mm annually. The coefficient of determination (r^2) confirms the increased in the mean of annual rainfall by about 2.4%. This finding confirmed Oruonye *et.al,* (2014) where they discovered that annual rainfall is on the increase in a similar study conducted in Gassol Taraba state. It however, contradicted the report of Ayanlade *et.al,* (2010) where they found out that rainfall is very high in most part of northern Nigeria guinea savannah (e.g Yola, Minna and Kaduna) except Jos which has a unique pattern.

Table 1: Descriptive Statistics for variables under study

	N	Minimum	Maximum	Mean	Std Deviation
Ann. RF	30	814.7	1582.7	1245.020	139.2816
LRS	30	129	203	173.17	18.934
S. Index	30	.082	1.10	.9447	.07500
Onset	30	70	138	103.77	14.383
Cessation	30	232	294	273.27	13.539

Source: Authors computation using SPSS Software

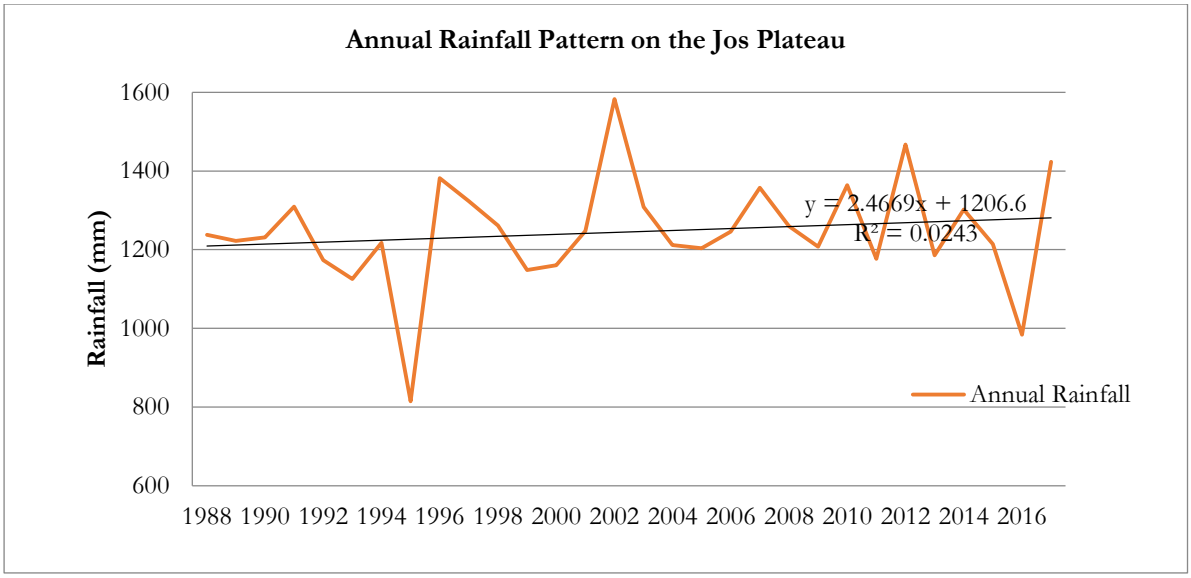

Figure 2. Annual Rainfall Pattern on the Jos Plateau

Rainfall Characteristic on the Jos plateau

Annual Rainfall has been described in details in the previous section. The descriptive statistics for the analysed rainfall characteristics is presented on Table 1.

Seasonal Variation of Rainfall on the Jos Plateau

Analysis of seasonal pattern of rainfall on the Jos Plateau shows that on the average, rainfall tend to increase from January to August. Thereafter, rainfall starts to decrease to a lowest value of 0.21mm in the month of December. Though most of the rainfall on the Jos plateau is orographic in nature, its seasonal pattern is controlled by the movement of the Inter Tropical Discontinuity (ITD). By August it is expected that the ITD should be at its Northern-most position of 22^0 N of the equator. By then all Northern locations will experience highest down pour as shown in the single maxima graph in Figure 3. It is worthy to note that when northern stations are enjoying maximum rainfall in August, southern stations will record a slight break because the ITD has moved far up north. The ITD retreats at twice the speed of its ascend Binbol (2007).

Length of Rainy Season (LRS)

The length of rainy season sometimes refers to as hydrologic growing season is the number of days between onset and cessation of rain in a particular location within the rainy season. It is calculated by counting the number of days between onset and cessation dates of rainfall in the location. The mean length of raining season for the study period was found to be 173 days with a minimum occurrence of 129 rain days occurring in the year 2017, and a maximum of 203 rain days occurring in the year 2003. Analysis of the study period shows a high variability on annual basis of length of rainy season (LRS) see table 2. It is however studied to enable farmers streamline their crop calendar with respect to rain-fed agriculture, further analysis of length of raining season within the study period shows a steady decrease from 182 days in the year 1998 to a low of 150 days in the year 1995, thereafter it started increasing gradually from 168 days in the year 1996 to a peak time high of 203 days in the year 2003. This finding clearly shows

that the variability associated with climate change is also leaving its finger prints on rainfall associated parameters. This might not be a healthy development for crop calendar and rain fed agriculture generally.

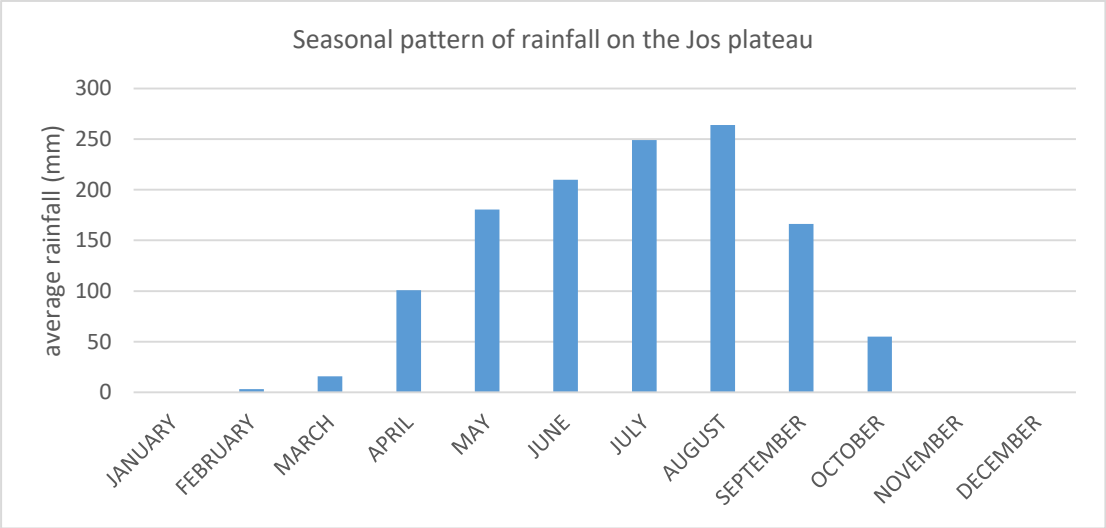

Figure 3, Seasonal Pattern of Rainfall on the Jos Plateau

Table 2: SUMMARY OF RAINFALL CHARACTERISTICS ON THE JOS PLATEAU

Years	Annual rainfall	Length of Rain days	Seasonality Index (SI)	Onset Dates	Cessation Dates
1988	123.7	182	0.85	5th April (93 days)	2nd Oct (275)
1989	1222	176	0.91	15th April (103 days)	6th Oct (279)
1990	1230.9	147	0.91	1st May (121 days)	25th Sept (268)
1991	1309.4	155	0.89	5th April (95 days)	28th Sept (271)
1992	1173.1	173	0.92	18th April (108 days)	8th (281)
1993	1125.5	172	0.82	9th April (93 days)	28th Sept (271)
1994	1217.3	170	0.95	17th April (107 days)	4th Oct (275)
1995	814.7	150	0.96	24th April (104 days)	21st Sept (264)
1996	1382	168	0.88	17th March (93 days)	1st Sept (244)
1997	1323.2	187	0.85	3rd April (93 days)	7th Oct. (280)
1998	1261.3	172	0.99	15th April (105 days)	4th Oct. (277)
1999	1148.2	177	0.99	27th April (117 days)	21st Oct.(294)
2000	1160	188	0.88	23rd April (113 days)	28th Sept (271)
2001	1247.4	194	1.0	15th April (105 days)	26th Sept (269)
2002	1582.7	187	1.1	7th April (99 days)	13th Sept (256)
2003	1308.4	203	0.94	8th April (98 days)	28th Sept (271)
2004	1211.7	163	0.99	11th March (70 days)	20th Aug/ (231)
2005	1203.9	186	0.92	17th April (107 days)	20th Oct (273)
2006	1245.7	187	0.93	7th March (97 days)	8th Oct (271)
2007	1357.2	162	0.99	11th April (101 days)	20th Sept (263)
2008	1259.8	175	0.89	22nd April (112 days)	4th Oct (287)
2009	1207.4	199	0.85	17th April (107 days)	23rd Oct (293)
2010	1364	194	0.86	1st April (91 days)	12th Oct (285)
2011	1176.8	185	0.98	1st April (91 days)	3rd Oct (276)
2012	1467.2	165	0.99	22nd April (112 days)	4th Oct (277)
2013	1185.9	187	0.90	9th April (99 days)	13th Oct (286)
2014	1302	187	1.1	11th April (94 days)	8th Oct (281)
2015	1214.3	136	1.0	9th May (129 days)	22nd Sept (265)
2016	983.7	139	1.1	5th May (125 days)	21st Sept (271)
2017	1423..2	129	1.0	18th May (138 days)	24th Sept (267)

Source: Author's Computation

Seasonality Index of Rainfall on the Jos plateau

Rainfall seasonality index (S.I) measures the spread and steadiness of rainfall during the wet season. It uses the sum of absolute deviations of mean monthly rainfall from the overall monthly rainfall mean divided by the mean rainfall for the year, in order to calculate the seasonality index on the Jos Plateau the average value of all monthly rainfall for the study period was used. Finding shows that mean seasonality index for Jos Plateau is 0.94. Which can be interpreted as the rainfall on the Jos Plateau is markedly seasonal with a long dry season of about 6months according to Walsh and Lawler (1981) classification. Analysis for the study period also shows a high degree of variability (see Table 2). The lowest seasonality index was recorded in 1993 with a value of 0.82 while the highest seasonality index recorded on the Jos Plateau is 1.10 occurring in the year 2002. Observation on the deviation of the seasonality index for the study period shows that most of the years confirm to Walsh and Lawler (1981) classification for Jos which is within the range of 0.80 to 0.99. Exceptional years with high seasonality index are 2001, 2002 and 2014 to 2017. The high seasonality index recorded from 2014 through 2017 is a clear indicator of the effect of climate change on rainfall characteristics on the Jos Plateau.

Onset Dates of Rainfall on the Jos plateau

The result of the analysis for onset dates on the Jos Plateau is presented on Table 2. Results presented in Table 2 show that onset dates for Jos Plateau base on the mean average rainfall for the study period is put at 14th April. Further analysis for the study period again reveals a high variability on the onset dates. The earliest onset date recorded in the study period occurred in the year 2004 with rains commencing on the 11th of March, that is, 70 days from the first of January, in like manner 2017 recorded the late onset for the study period with rains establishing itself by the 18th May, which is 138 days from 1st January. This observed variability in the onset dates again can only be linked to climate change phenomena. The implication here is that the beginning of growing season is delayed in some cases while in other situations; it gives a false start to the planting season. The onset date calculated is not link to any particular crop, rather it is an index signifying that given the high evaporation in the tropics, any crop planted after that date has a very high chance of survival. The crop will not be affected by the possibility of moisture deficiency in the soil that might lead to wilting.

Cessation Dates of Rainfall on the Jos Plateau

The cessation date of rain in any location is simply the termination of the effective rainy season. It is not however, the last day rain is expected to fall, but rather when rainfall can no longer be assured. The cessation date of rains is one of the controlling factors of the calendar of agricultural activities. Analysis of cessation dates for the Jos plateau base on the mean average rainfall for the study period indicates that by the 3rd of October rainfall can no longer be guaranteed on the Jos plateau. Further analysis of Table 2 reveals that the earliest cessation dates recorded during the entire study period occurred in the year 2004 with rain ending on the 20th August, which is 231 days from the first day of January. In the same vein, 1999 recorded the late cessation of rain for the entire study period with rains ending on the 21st October that is 294 days from 1st January. In effect, except farmers change to early maturing crop varieties, streamline their farming calendars with the changing rainfall regime or have access to irrigation water, the secular changes in rainfall frequency for the country pose serious threat to maturity of annual crops and consequently to food security for the nation. Hence, the volatility of agricultural output due to rainfall fluctuation can mean a large burden for the low-income farming households (John and Pedroesin, 2017).

CONCLUSION

The need to examine the trends in rainfall characteristic on the Jos Plateau cannot be overemphasised; this is in view of the fact that rainfall on the Plateau has been variable both annually and seasonally. This observed variability in the rainfall characteristic seems to exhibit a two way effect on crop cultivation on the Plateau. Important rainfall characteristics such as annual rainfall, length of rainy season, seasonality index and the onset and cessation

dates of rainfall were examined over a period of 30 years (1988 to 2017). All studied rainfall characteristics exhibited a high degree of variability in line with the rainfall pattern. This variability was linked to the possible impact of climate change experienced all over the country and not only on the Plateau. The research also noted that these variability in rainfall characteristics is capable of exerting negative effects on the yield of crops. The research therefore concludes that it is needful to initiate further studies to capture the effects of rainfall characteristics on crop yield on the Jos Plateau.

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