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Monthly Variation and Annual Trends of Rainfall across Major Climatic Zones in Nigeria

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***Abstract**:This study focused on analysing variability and trends in rainfall in ten meteorological stations across Nigeria namely, Port Harcourt (4.51˚N, 7.01˚E),Ikeja (6.35˚N, 3.20˚E), and Benin (6.34^0 N, 5.63^0 E) in the Rain forest, Makurdi (7.7^{0}N, 8.5^{0}E), Ilorin (8.48^0 N, 4.54^{0}E) and Enugu (6.28˚N, 7.33˚E) in Guinea savanna,Kaduna (10.5°N, 7.44°E,) and Bauchi (10.30^0 N , 10.0^{0}E) in Sudan Savanna while Sokoto (13.01˚N, 5.15˚E) Maiduguri (11.51˚N, 13.05˚E) in Sahel savanna. Monthly rainfall data for this study for the period of 31years (1985 - 2015) were obtained from the archives of the Nigerian Meteorological Agency (NIMET) Oshodi, Lagos.The Statistical Package for Social Science (SPSS) was used to determine the mean, standard deviation and coefficient of variation in all the study areas.Simple linear regression analysis and a modified non-parametric Mann-Kendall trend test were used to analyse the trends exhibited by the variable. The monthly analysis shows that period of highest rainfall falls in June or July for the locations nearest to the coast and August or September for the locations closer to the Sahara desert. The annual rates of increase /decrease in rainfall over the period of investigation 1985 - 2015 were; -0.44mm/year forPort Harcourt, 0.693mm/year for Ikeja, 1.581mm/year for Benin,0.316mm/year for Makurdi, 1.268mm/year for Ilorin, 0.754mm/year for Enugu, 0.668mm/year for Kaduna, 1.873mm/year for Bauchi, 0.294mm/year for Sokoto and 0.821mm/year for Maiduguri. Both linear regression analysis and Mann-Kendall test results show increasing rainfall trend in all the studied locations except in Port Harcourt that shows a decreasing trend. However, rainfall trends were only statistically significant in Benin, Ilorin, Bauchi and Maiduguri (at $p < 0.05$) at 95% confidence level. This study reveals that Nigeria is experiencing a rise in rainfall. The implication of this is that Nigeria is susceptible to the attendant consequences of global warming. In this regard the human population in Nigeria dependent on economic activities that are rainfall sensitive such as agriculture are vulnerable to risks. This study recommends the provision of accurate and timely weather and climate information for planning in the sectors of the economy that are rainfall sensitive such as agriculture,health, water resources management. This would prevent rainfall extremes from becoming disasters and threats to livelihood across Nigeria.*

***Keywords:** Rainfall, climate change, Trend, zone.*

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I. Introduction

Rainfall is one of the most important climatic variables that determine the spatial and temporal patterns of climate variability of a region, which also provide useful information for planning of water resources, agricultural production etc.[1-5].Climate change is one of the most important worldwide issues talked among the scientists and researchers and one of the consequences of climate change is the alteration of rainfall patterns [3]. Nigeria's population and economy are linked to climate sensitive activities including rain-fed agriculture andexcess climate anomalies, deficient and flooded rainfall years have a dramatic impact on the economy as well as on the living conditions of the inhabitants of the affected region. An understanding of current and historical trends and variation is inevitable to her future development especially in agricultural and hydrological sectors [6].The growing problem of climatic change impacts is global and the developing countries, especially Africa will be mostly affected. This is because, African economy is predominantly agrarian rain-fed, fundamentally dependent on the vagaries of weather, due to inability to cope as a result of poverty and low technological development, hence low level of cropping capabilities by the farmers [7-10]. It is projected that crop yield in Africa may fall by 10-20% by 2050 or even up to 50% due to climate change [11]. Hence, this study investigates the variability and trend of rainfall across major climatic zones in Nigeria. The knowledge of climate variability will empower the farmers to make informed decision about crop management for maximum yield.At thesame time, the critical need that all parts of the world are examined forevidence of climate change especiallyextreme events [12]will be accomplished by the study's contribution.

II. Study Areas

Nigeria lies between latitude 4^0N and 14^oN, and between longitude 2^0E and 15^0E. It has a total area of 923.77km^2 and land mass coverage of 910.77km^2.The synoptic stations chosen in this study takes into account the major climatic zones in the country. Sokoto (13.01˚N, 5.15˚E) and Maiduguri (11.51˚N, 13.05˚E) in Sahel savanna, Kaduna (10.5°N, 7.44°E,) and Bauchi (10.30^0 N , 10.0^{0}E) in Sudan Savanna , Ilorin (8.48^0 N, 4.54^{0}E),Enugu (6.28˚N, 7.33˚E) and Makurdi (7.7^{0}N, 8.5^{0}E) in Guinea savanna while Ikeja (6.35˚N, 3.20˚E),Port Harcourt (4.51˚N, 7.01˚E) and Benin (6.34^{0}N, 5.63^{0}E) in the Rain forest. The figure below shows the locations of the studied areas.

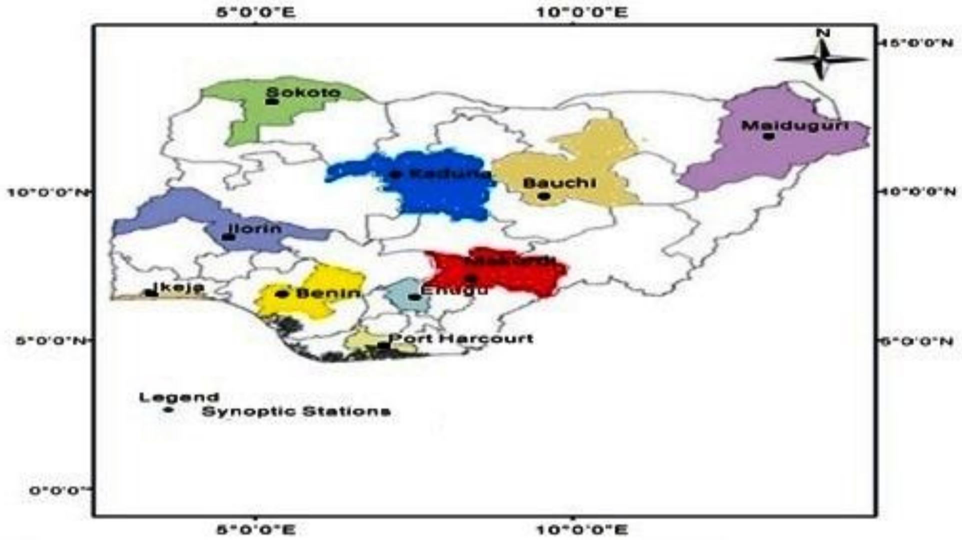

Fig.1**:** Map of Nigeria showing the synoptic stations used in this study

III. Materials and Methods

3. 1 Data Source

This study employed the use of secondary data obtained from the achieves of the Nigerian Meteorology Agency (NIMET) for a period of 31 years (1985 -2015).

3. 2 Method of data analysis

Statistical Parkage for Social Science (SPSS) was used to determine the mean, standard deviation and coefficient of variabilityfor all the studied locations. Linear regression method was used to identify thetrends in the annual rainfall data. Theresults obtained were further verified by using a modified non-parametric Mann-Kendall test.Addinsoft's XLSTAT 2017 software was used for performing the statistical Mann-Kendall test.

3.2.1 Linear regression

Linear regression is one of the simplest methods to calculate the trend of data in timeseries. The equation of linear regression line is given by

$$Y = a + bX, \qquad (1)$$

where, X is the explanatory variable and Y is the independent variable. The slope line is *b*and *a* is the intercept (value of y when x=0). The slope of regression describes the trendwhether positive or negative. In this study independent variable, Y is rainfall and explanatoryvariable X is the year.

Linear regression requires the assumption of normal distribution. In this case, the nullhypothesis is that the slope of the line is zero or there is no trend in the data.In this study, Microsoft Excel was used to calculate the trend lines and statistical values of linear regression analysis .The probability value (p-value) from the analysis was tested for the significant level α=0.05.The value of R-square (R^2), or the square of the correlation coefficient from theregression analysis was used to show how strong the correlation and relationship between thevariable X and Y. The value is a fraction between 0.0 - 1.0.

R^2 value of 1.0 means that thecorrelation becomes strong and all points lie on a straight line. On the other hand, R^2value of 0.0mean that there is no any correlation and no linear relationship between X andY.

3.2.2 Mann-Kendall Test

The Mann-Kendall test, is a non-parametric approach, it has been widely used fordetection of trend in different fields of research including hydrology and climatology(Ampitiyawatta and Guo, 2009). It is used for identifying trends in time series data. Eachdata value is compared to all subsequent data values. The initial value, S, is assumed to be0 (no trend). If a data value from a later time period is higher than a data value from anearlier time period, S is incremented by 1. If the data value from later time period is lowerthan a data value from an earlier time period, S is decremented by 1. The net result of allsuch increments and decrements yield the final value of S.

Mann Kendall statistic (S) is given by:

$$S = \sum_{k=1}^{n-1}\sum_{j=k+1}^{n} Sgn\left(x_j - x_k\right) \qquad (2)$$

where: $sgn\left(x_j - x_k\right) = \begin{cases} 1 \; if x_j - x_k > 0 \\ 0 \; if x_j - x_k = 0 \\ -1 \; if x_j - x_k < 0 \end{cases}$

The S statistic, in cases where the sample size n is larger than 10, is approximately normallydistributed with the mean equal to 0. The variance statistic is given as:

$$\text{VAR (S)} = \frac{1}{18}\left[n(n-1)(2n+5) - \sum_{p=1}^{q} t_p\left(t_p - 1\right)(2t_p + 5)\right] \qquad (3)$$

where t is the extent of any given ties. Then the test statistic, Zis given below:

$$Z = \begin{cases} \frac{S-1}{\sqrt{VAR\ (S)}} if S > 0 \\ 0 \; if S = 0 \\ \frac{S+1}{\sqrt{VAR\ (S)}} if S < 0 \end{cases} \qquad (4)$$

Z here follows a standard normal distribution. A positive and negative value of Z indicates an upward trend and downward trend respectively. A significance level α was also utilised for testing either an upward or downward monotone trend (a two tailed test). If Z appears greater than $Z_{\alpha/2}$ where α depicts the significance level, then the trend will be considered as significant. Generally, Z values are 1.645, 1.960 and 2.576 for significance level of 10%, 5% and 1% respectively.

The advantages of using this test is that, it is a non parametric test and does not require the data to be normally distributed, suiting perfectly to the present study. Also, the test has low sensitivity to abrupt breaks due to inhomogeneous time series [13].

IV. Results and Discussion

4.0Analysis of Monthly Rainfall Data

4.1.1 Descriptive statistics of monthly rainfall in zone 1

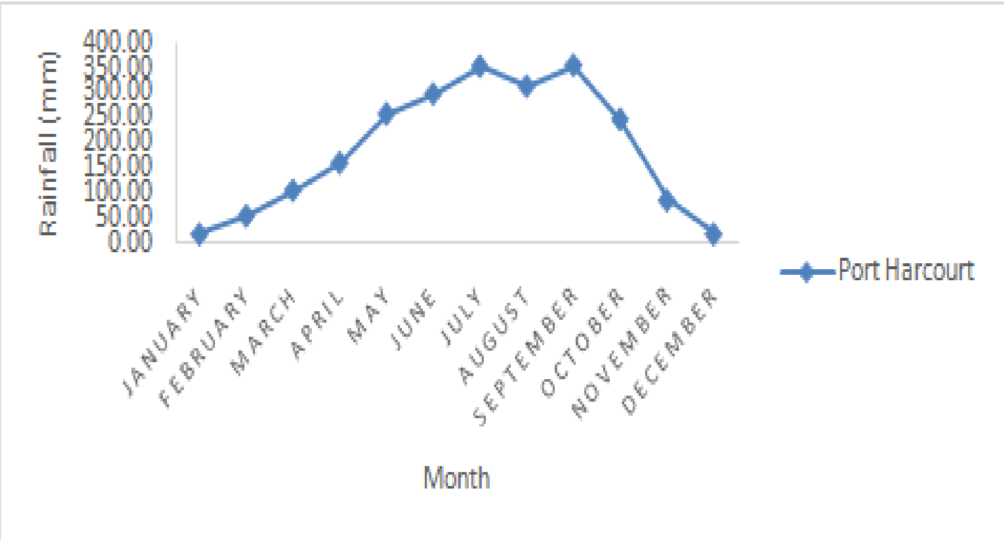

Figure 2 : Monthly Variation of Rainfall for Port Harcourt

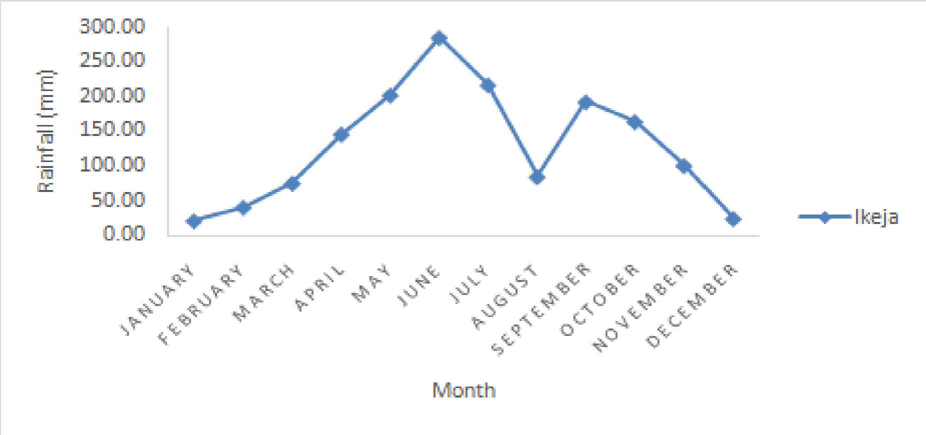

Figure 3: Monthly Variation of Rainfall for Ikeja

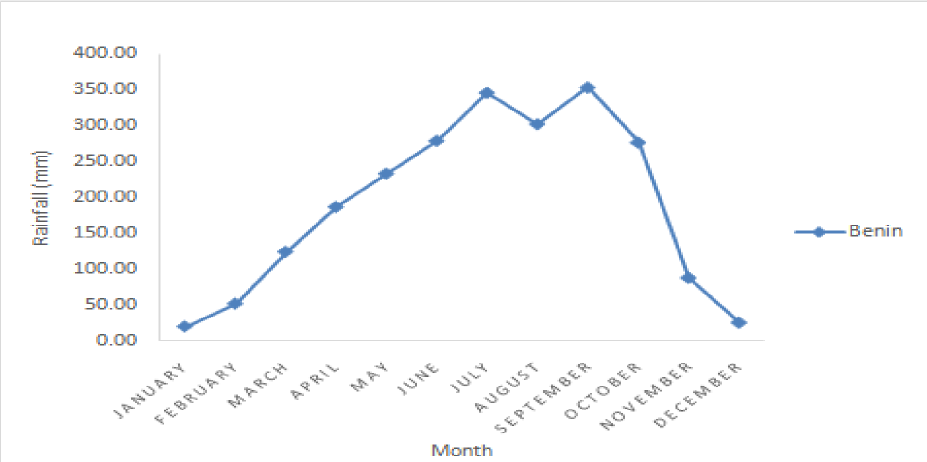

Figure 4: Monthly Variation of Rainfall for Benin

Mean monthly rainfall throughout the period under investigation in zone 1 ranged between 19.78mm-354.44mm. The coefficient of variation in this zone ranged from 0.26-1.89;the highest occurring in the month of Dec/January while the lowest occurred between May, July and October. Rainfall in this zone is double peaked as shown in Fig.2, 3 and 4

4.1.2 Descriptive statistics of monthly rainfall in zone 2

The graph in figure 5 shows the plots of monthly rainfall in Makurdi.

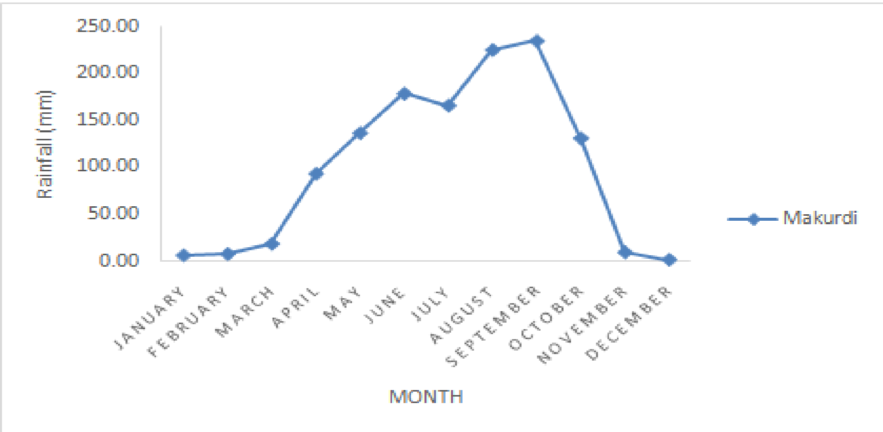

Figure 5: Monthly Variation of Rainfall for Makurdi

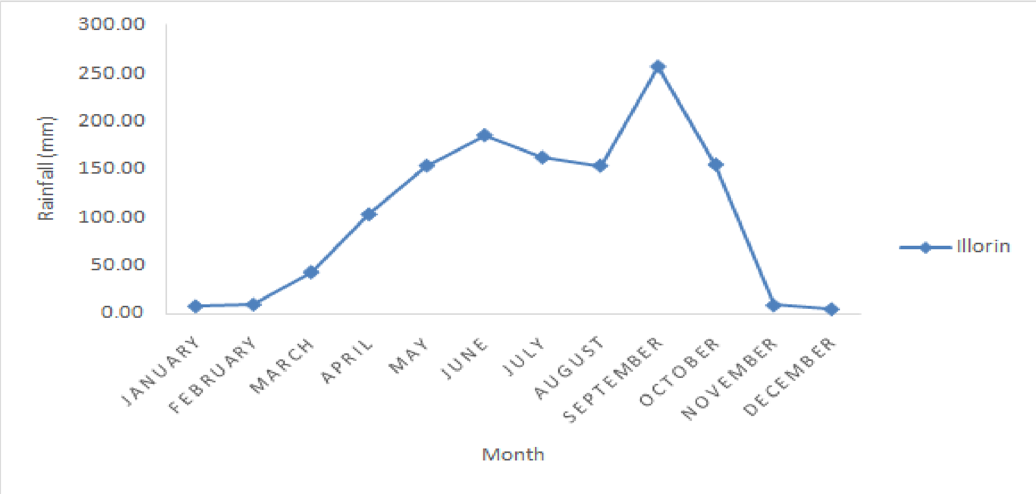

Figure 6: Monthly Variation of Rainfall for Ilorin

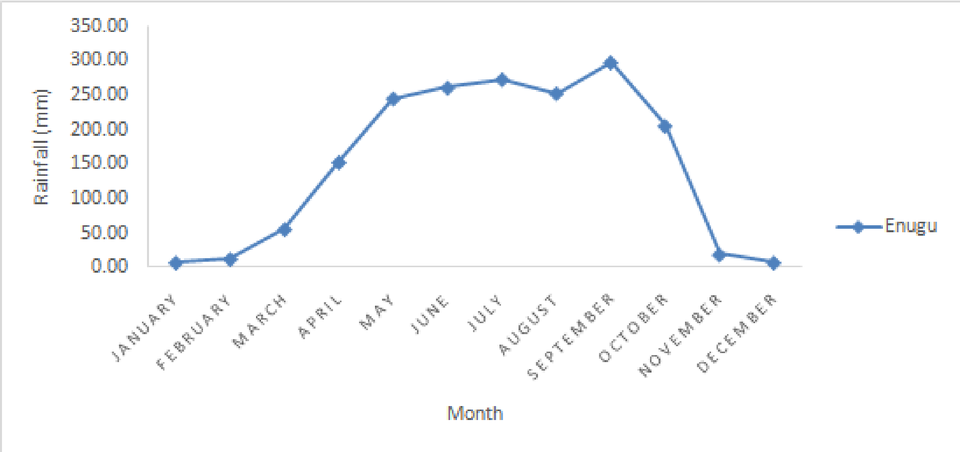

Figure 7: Monthly Variation of Rainfall for Enugu

The mean monthly rainfall in this zone throughout the period under study ranged between 0.82mm – 296.55mm. The Coefficient of variation in this zone ranged between 0.25 – 3.40;the highest was recorded in the month Dec/Jan while the lowest was recorded between June to July. Rainfall in this zone is double peaked as shown in Fig.5, 6 and 7

4.1.3 Descriptive statistics of monthly rainfall in Zone 3

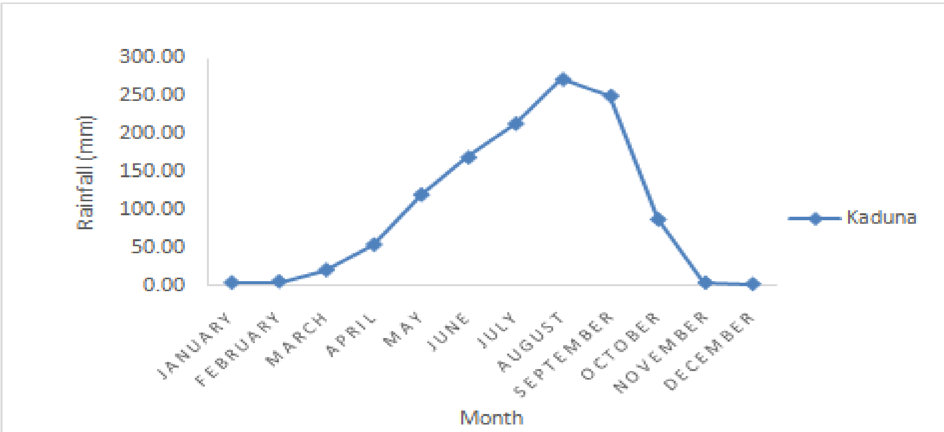

Figure 8: Monthly Variation Of Rainfall For Kaduna

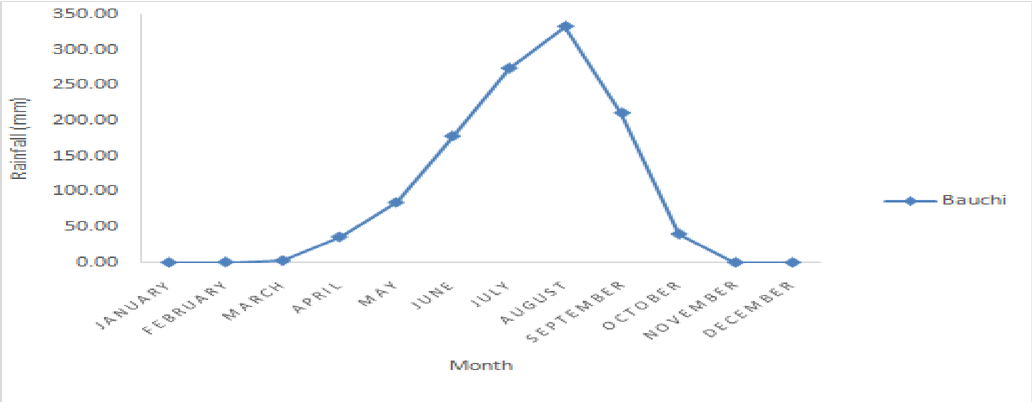

Figure 9: Monthly Variation of Rainfall for Bauchi

Mean monthly rainfall in this zone throughout the period under investigation ranged between 0.04mm – 332.49mm. The highest rainfall in this zone is usually in the month of August. Coefficient of variation in this zone ranged between 0.31 – 5.75;the highest occurring in the month of November while the lowest occurred in the month of August. There was little or no rain in the month of November to February in this zone.

4.1.4 Descriptive Statistics of Monthly Rainfall in Zone 4

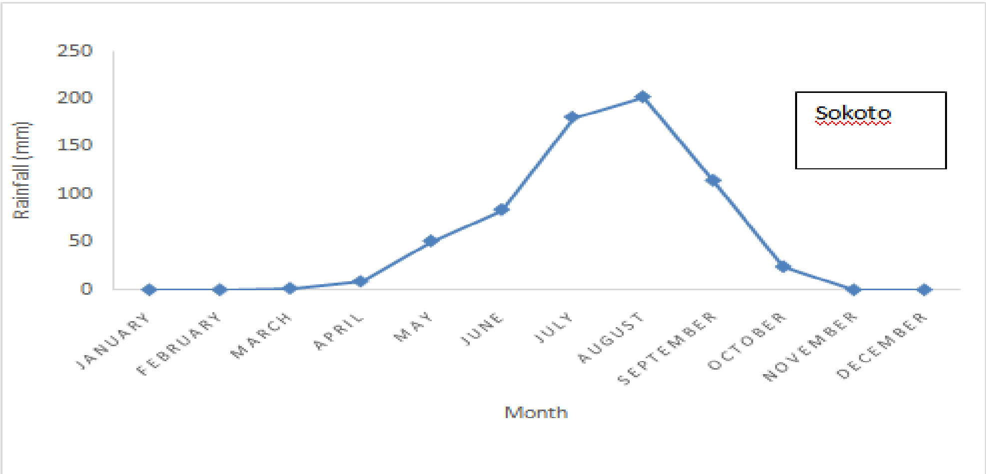

Figure 10: Monthly Variation of Rainfall for Sokoto

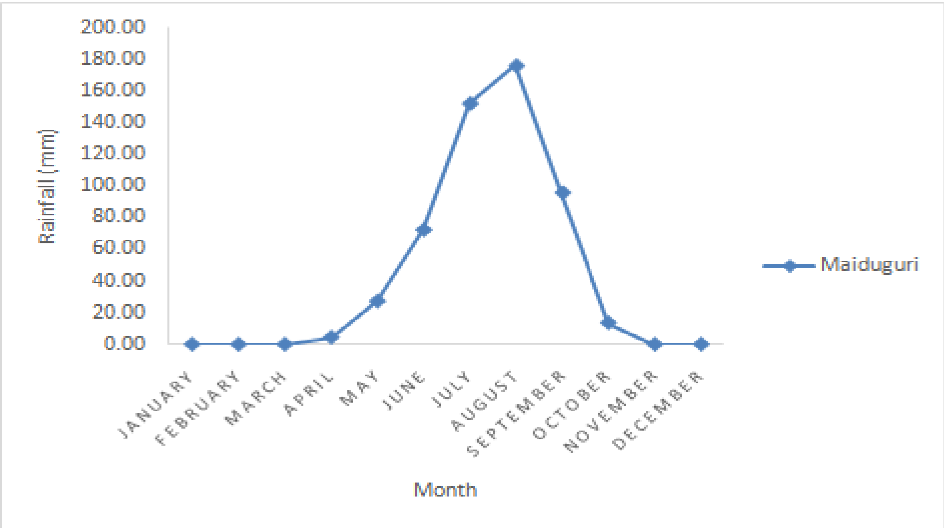

Figure 11: Monthly Variation of Rainfall for Maiduguri

Mean monthly rainfall in this zone throughout the period under investigation ranged between 0.09mm – 201.50mm. The Coefficient of variation ranged between 0.29 – 5.56; the highest was recorded in the month of January/ December while the lowest was recorded in the month of August. Rainfall pattern in this zone is mono-modal with a peak period in the month of August. There was little or no rainfall between themonths of October to February.

4.2 Analysis of Annual Rainfall Data

4.2.1 Analysis of annual rainfall data in zone 1

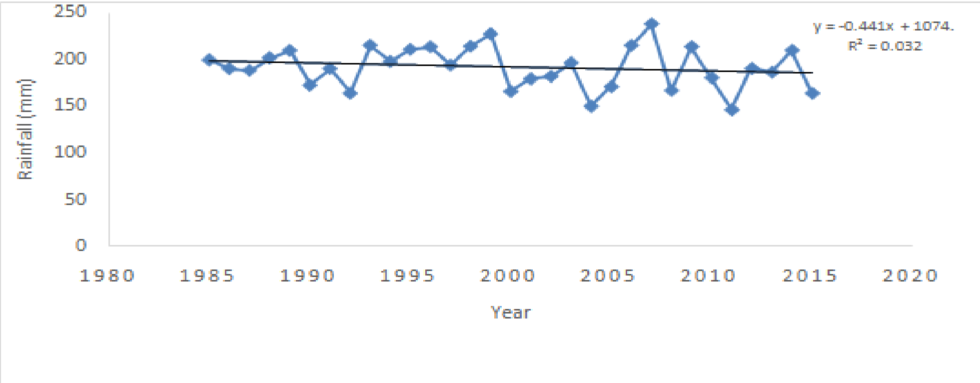

Figure 12: Time series graph of Mean Yearly Rainfall for Port Harcourt

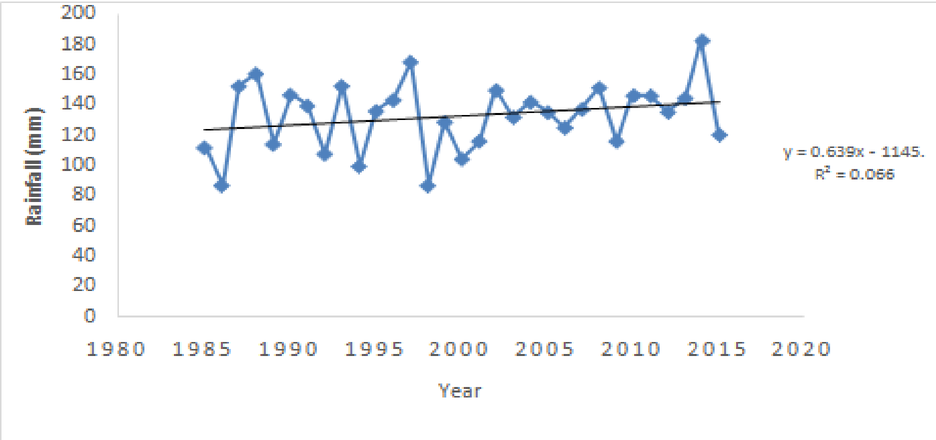

Figure 13: Time series graph of Mean Yearly Rainfall for Ikeja

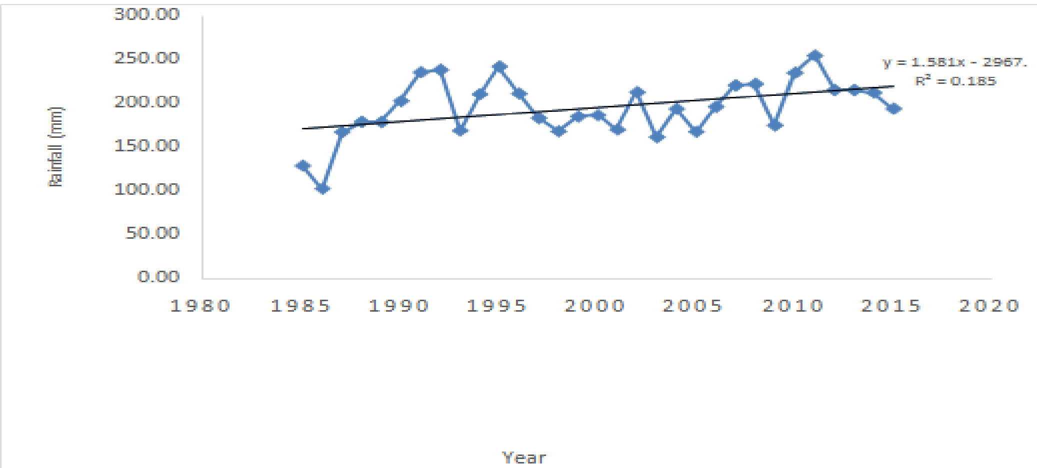

Figure 14: Time series graph of Mean Yearly Rainfall for Benin

The trend line in Fig. 12 shows that annual rainfall in Port Harcourt is decreasing at the rate of 0.44mm/year with R^2 value of 0.03 which is statistically insignificant at 5% level of significance as shown in tables1a and 1b. The wettest year in this location as shown in fig. 12 throughout the period under study was recorded in the year 2007 with annual mean value of 227.24mm while the lowest value was recorded in the year 2011 with annual mean value of 146.53mm.The trend line in fig.13 shows that annual rainfall in Ikeja is increasing at the rate of 0.639mm/year with R^2 value of 0.066 which is statistically insignificant at 5% level of significance as shown in tables1a and 1b. The wettest year in this location as shown in fig. 13 throughout the period under study was recorded in the year 2014 with annual mean value of 182.33mm while the driest year was recorded in the year 1998 with annual mean value of 86.61mm.The trend line in fig. 14 shows that annual rainfall in Benin is increasing at the rate of 1.58mm/year with R^2 value of 0.185 which is statistically insignificant at 5% level of significance as shown in tables1a and 1b. The wettest year in this location as shown in fig. 14 throughout the period under study was recorded in the year 2011 with annual mean value of 355.30mm while the driest year was recorded in the year 1986 with annual mean value of 242.58mm

4.2.2 Analysis of annual rainfall data in zone 2

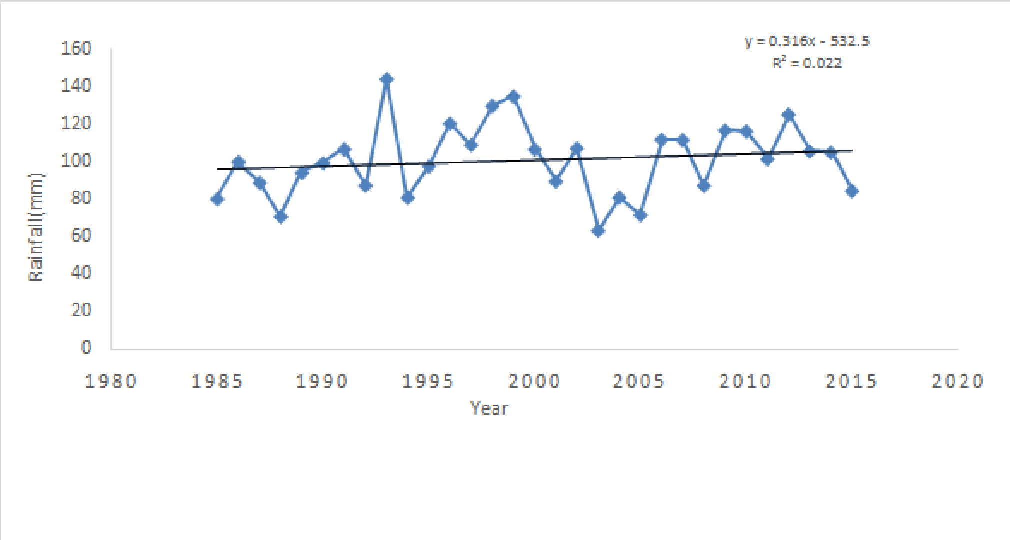

Figure 15: Time series graph of Mean Yearly Rainfall for Makurdi

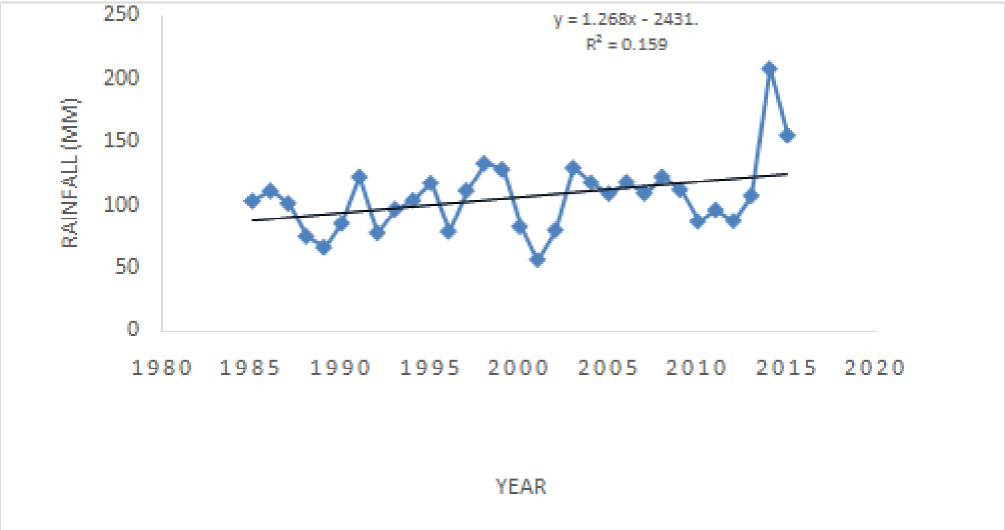

Figure 16: Time series graph of Mean Yearly Rainfall Ilorin

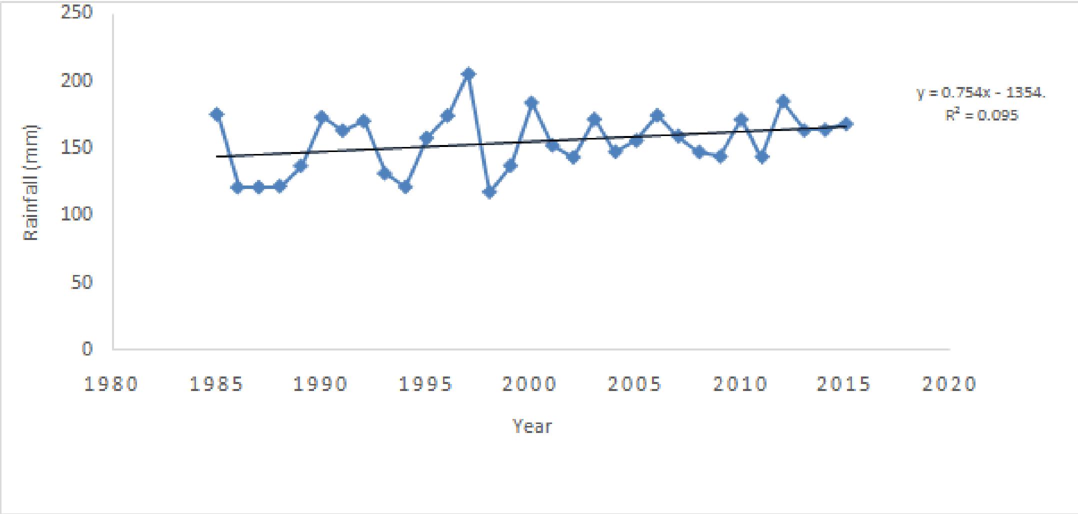

Figure 17: Time series graph of Mean Yearly Rainfall for Enugu

The trend line in Fig. 15 shows that annual rainfall in Makurdi is increasing at the rate of 0.316mm/year with R^2 value of 0.022 which is statistically insignificant at 5% level of significance as shown in tables 1a and 1b. The wettest year in this location as shown in fig. 15 throughout the period under study was recorded in the year 1993 with annual mean value of 144.09mm while the driest year was recorded in the year 1986 with annual mean value of 63.46mm.The trend line in Fig.16 shows that annual rainfall in Ilorin is increasing at the rate of 1.27mm/year with R^2 value of 0.160 which is statistically significant at 5% level of significance as shown in tables1a and 1b. The wettest year in this location as shown in Fig.16 throughout the period under study was recorded in the year 2014 with annual mean value of 208.41mm while the driest year was recorded in the year 2001 with annual mean value of 56.09mm.The trend line in Fig.17shows that rainfall in Enugu is increasing at the rate of 0.75mm/year with R^2 value of 0.095 which is statistically significant at 5% level of significance as shown in tables1a and 1b. The wettest year in this location as shown in Fig.17 throughout the period under study was recorded in the year 1997 with annual mean value of 205.78mm while the driest year was recorded in the year 1998 with annual mean value of 117.41mm.

4.2.3 Analysis of annual rainfall data in zone 3

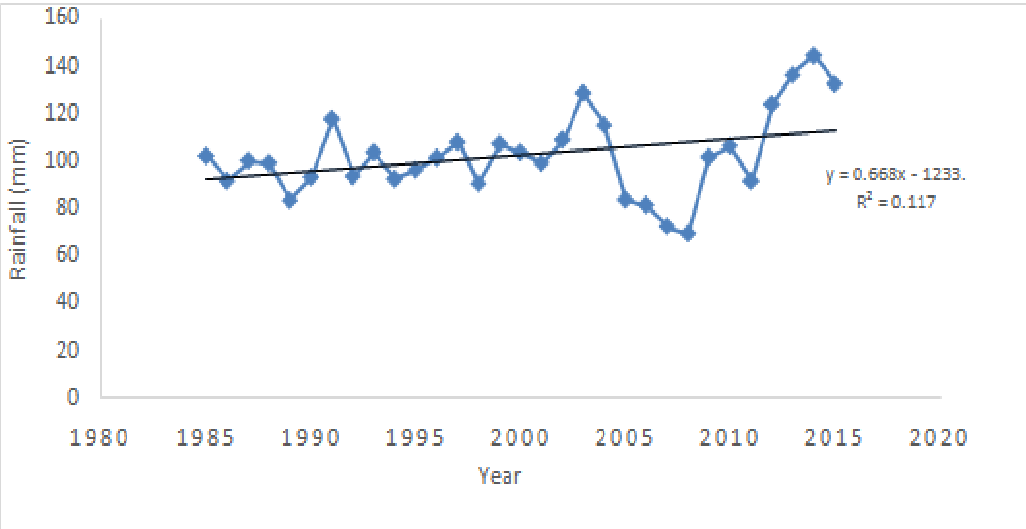

Figure 18: Time series graph of Mean Yearly Rainfall for Kaduna

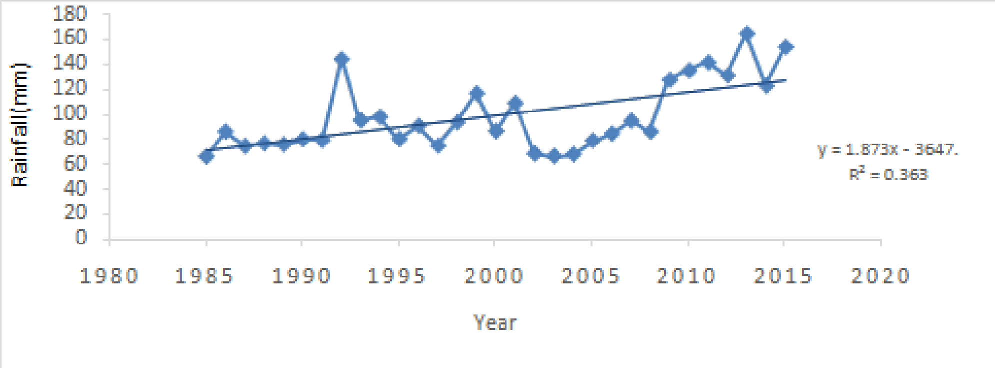

Figure 19: Time series graph of Mean Yearly Rainfall for Bauchi

The trend line in Fig.18 shows that annual rainfall in Kaduna is increasing at the rate of 0.67mm/year with R^2 value of 0.117 which is statistically insignificant at 5% level of significance as shown in tables 1a and 1b. The wettest year in this location as shown in fig.18 throughout the period under study was recorded in the year 2014 with annual mean value of 144.54mm while the driest year was recorded in the year 2008 with annual mean value of69.03mm.The trend line in Fig.19 shows that annual rainfall in Bauchi is increasing at the rate of 1.87mm/year with R^2 value of 0.36 which is statistically significant at 5% level of significance as shown in tables1a and 1b. The wettest year in this location as shown in Fig.19 throughout the period under study was recorded in the year 2013 with annual mean value of 164.74mm while the driest year was recorded in the year 1985 with annual mean value of 65.96mm

Analysis of annual rainfall data in zone 4

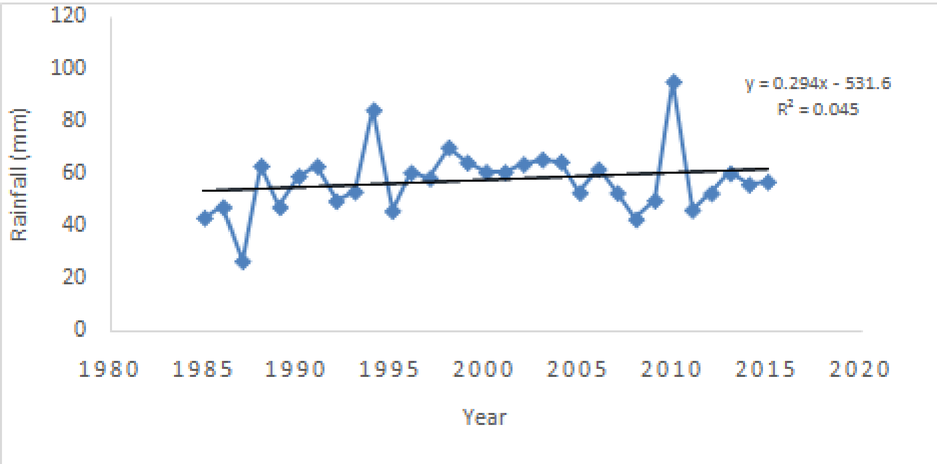

Figure 20: Time series graph of Mean Yearly Rainfall for Sokoto

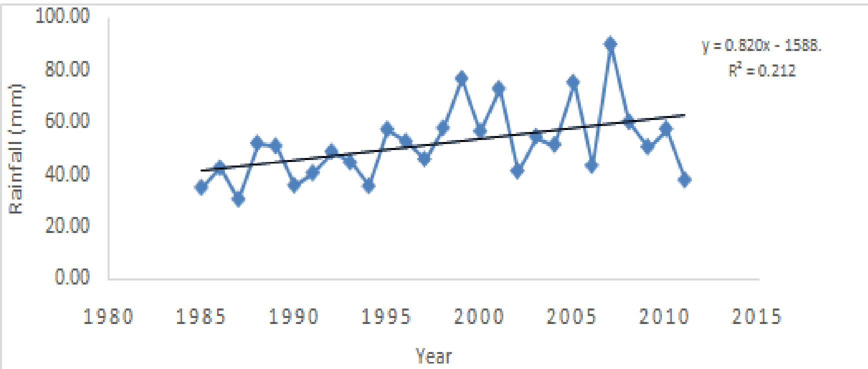

Figure 21: Time series graph of Mean Yearly Rainfall for Maiduguri

The trend line in Fig. 20 shows that annual rainfall in Sokoto is increasing at the rate of 0.295mm/year with R^2 value of 0.046 which is statistically insignificant at 5% level of significance as shown in tables 1a and 1b. The wettest year in this location as shown in fig. 20 throughout the period under study was recorded in the year 2010 with annual mean value of 95.56mm while the driest year was recorded in the year 1987 with annual mean value of 27.04mm.The trend line in Fig. 21 shows that annual rainfall in Maiduguri is increasing at the rate of 0.821mm/year with R^2 value of 0.0213 which is statistically significant at 5% level of significance as shown in table 1a and 1b. The wettest year in this location as shown in Fig. 21 throughout the period under study was recorded in the year 2007 with annual mean value of 89.78mm while the driest year was recorded in the year 1987 with annual mean value of 30.53mm.

4.6 Summary of Regression Statistics and Mann-Kendall Test Result

Table 1a: Summary of Regression Statistic Results for Annual Rainfall

Location	Regression Equation	R- Square	P-Value	Trend	Statistical significant
Port Harcourt	y = -0.441x+1074	0.032	0.24	Decreasing	No
Ikeja	y = 0.639x-1145	0.066	0.25	Increasing	No
Benin	y = 1.581x-2967	0.185	0.02	Increasing	Yes
Makurdi	y = 0.316x-532.5	0.022	0.42	Increasing	No
Ilorin	y = 1.268x-2431	0.159	0.03	Increasing	Yes
Enugu	y = 0.754x-1354	0.095	0.04	Increasing	Yes
Kaduna	y = 0.668x-1233	0.117	0.07	Increasing	No
Bauchi	y = 1.873x-3647	0.363	3.35E-04	Increasing	Yes
Sokoto	y = 0.294x -531.6	0.045	0.24	Increasing	No
Maiduguri	y = 0.821x -1588.3	0.212	0.02	Increasing	Yes

Table 1b: Summary of Mann-Kendall Statistic Results for Annual Rainfall

Location	Range	Kendall tau	MK Statistic (S)	Z–Value	P-Value	Sen's Slope	Trend	Statistical Significance
Port Harcourt	31	-0.10	-45.00	-0.75	0.778	-0.35	Decreasing	No
Ikeja	31	0.11	53.00	0.88	0.180	0.58	Increasing	No
Benin	31	0.29	135.00	2.70	0.020	1.53	Increasing	Yes
Makurdi	31	0.13	61.00	1.02	0.150	0.47	Increasing	No
Ilorin	31	0.24	111.00	2.78	0.002	0.77	Increasing	Yes
Enugu	31	0.21	97	2.55	0.005	0.92	Increasing	Yes
Kaduna	31	0.20	95.00	1.23	0.110	0.62	Increasing	No
Bauchi	31	0.42	193	2.45	0.007	1.96	Increasing	Yes
Sokoto	31	0.10	61.00	1.02	0.222	0.17	Increasing	No
Maiduguri	27	0.34	119.00	2.46	0.007	0.75	Increasing	Yes

V. Discusssion

5.1 Variability and Trend of Rainfall

5.1.1 Variability and trend of rainfall in zone 1 (Rain forest)

Rainfall in this zone exhibit double maxima with a peak period in June-July and September (Fig.2, 3 and 4). It is also observed in this zone that there is a short dry season experienced in the month of August and is commonly referered to as the “August break’’. The double maxima phenomenon exhibited in this zone is a characteristic of rainfall in the southern Nigeria [14]. This is also similar to the observation made by [15]that rainfall pattern below latitude 10^0N is bimodal having a primary peak in June-July, and another secondary peak in September with little dry season in August as a result of absence of the Africa Easterly Jet. Rainfall in this zone is virtually throughout the year. The reason for this could be that these stations are located along the coast and are also at lower latitude compared to other stations in this study [16]. The annual variation in rainfall over Ikeja, Port Harcourt and Benin is displayed in Fig. 12, 13 and 14. There is a year to year variation in rainfall, which is evident in the graphs. The result in Fig.12, 13 and 14 is similar to the findings of [17] who analysed rainfall data between 1911 and 1980 from twenty-eight synoptic weather stations across Nigeria and concluded that why some locations in the coastal areas will witness more flooding others may experience drought. The increasing rainfall in the coastal cities may be partly responsible for the increase in flood events devastating the coastal cities of Warri, Lagos, Port Harcourt and Calabar as earlier observed by [18-21].

5.1.2 Variability and trend of rainfall in zone 2 (Guinea Savanna)

The characteristics of rainfall in this zone are similar to thoseof zone 1 especially the southern Guinea savannah (Fig.5, 6and 7). This is probably due to the fact Guinea savanna region receives rainfall from tropical air mass (mT) which originates from the Atlantic Ocean. The moist *mT* is overlain by the tropical continental air mass (*cT*) which blows from the Sahara Desert with the zone of convergence of the two air masses at the surface being a zone of moisture discontinuity known as the Inter Tropical Discontinuity (ITD)[22]. This study reveals that the onset and cessation period of rainfall in this zone fall between the month of April and October respectively. This implies that reliable growing seasons in this zone extend between April to October. Therefore, crops planted in this zone between late August and early September may be vulnerable to critical dry spells that may adversely affect both plant germination and establishment. Fig. 15, 16 and 17 show that rainfall trend in this zone is increasing. This observation is likely to have resulted in flooding events in the recent past in the zones (e.g Makurdi flood of2012) and could result to more cases of flooding in the coming years which could lead to loss of lives and property. The result obtained for this zone is consistent with the findings of [23-24] that found an increasing trend in annual rainfall in this zone as an evidence of climate change.

5.1.3 Variability and trend of rainfall in zone 3 (Sudan Savanna)

Rainfall in this zone as shown in Fig.8 and 9 exhibited mono-modal pattern. Double peak period in rainfall which is visible in tropical Rainforest and Guinea savanna is absent in this zone. The onset and cessation period of rainfall in this zone is between May to October which could be regarded as the length of growing season in this zone. The amount and distribution of rainfall during the length of growing season or wet season (May – October) is most important to farmers because most small-scale farmers that constitute the bulk of farming population in this zone practice rain-fed farming because of inability to afford huge financial investments that irrigation system required [25]. Despite the fact that farmers contend that the onset of rains is becoming more uncertain with a tendency towards delayed onset as earlier observed by [26-27] the data used for this study shows that there is no serious delay or shift in the onset of rains in this zone. This zone demonstrated significant positive trends in annual rainfall as shown in Fig.18 and 19through both the parametric and non-parametric tests at the 5% level of significance. It is highly probable that rainfall in this zone is likely to be on the increase in the coming years resulting in positive agricultural yields.This observation could also result to more cases of flooding in the coming years as buttressed by [28] who concluded that the increasing cases of flooding in the Sudano-Sahelian ecological zone is as a result of variation in above average rainfall between 1991 and 2009 in the region. This result is in agreement with that of [29] who demonstrated that rainfall in the Sudano-Sahelian zone has moved to wetter episodes, though it is clearly in contrast with the findings of [30]that indicated an average downward trend in annual rainfall over the Sudano - Sahelian zone including Maiduguri and Kaduna between 1950-2012.

5.1.4 Variability and trend of rainfall in zone 4 (Sahel Savanna)

The rainfall pattern in this zone is similar to that of sudan sanvanna having a peak period in the month of August. The rainfall onset and cessation period in this zone is between the month of May to September as shown in Fig.10 and 11. The rain begin to be stable in the month of June which indicates that the acceptable duration of rainy season in this zone covers the months of June to September which could be regarded as the length of growing season in this zone. The lower mean rainfall in the months of September and October in this zone during the 1985-2015 periods affirms the decline of rainfall frequencies and early rainfall cessation in the sahelian parts of the country as earlier observed by [27]. This, coupled with delayed rainfall onset, could lead to the shortening of the growing season in this zone. Delayed onset of the rainy season and early cessation of the rains has earlier be noted by [31-33] to be associated with most drought events that happened in this region. Fig. 20 and 21 shows that lower than normal mean annual rainfall were recorded between 1985-1987 which coincide with the years of severe drought episode in this region as earlier observed by Fabeku and Okogbue (2014). Fig. 20 and 21 also reveal that the mean value of annual rainfall in this zone within the period under investigation is less than 100mm which could be the reason as to why there has been gradual loss of Lake Chad in this region as high rainfall contributes to rise in water level.The positive trend noticed in Fig. 20 and 21 is an indication that annual rainfall in this region is gradually increasing which is contrast to earlier findings of [30] who reported a declining trend in annual rainfall in this zone between (1950 – 2012). This increase in rainfall could result to high agricultural yield in coming years.

VI. Conclusion

This study reveals that Nigeria is experiencing a rise in rainfall. The Sudano -Sahelian region of the country which was earlier observed by previous researchers to be experiencing declining rainfall trend is now witnessing a wetter condition. Policy makers can take advantage of this increasingrainfalltrend in the Sudano – Sahelian region by creating more dams so as to store rain water during the raining season for agricultural purposes.This would greatly reduce population drift from this region to the guinea savannah and rainforest which will in turn reduce social effects like incessant clashes between Fulaniherdsmenand crop farmers in the middle belt.The negative trend of annual rainfall observed in Port Harcourt could be an evidence of Southward creeping desert. This study, therefore, offers remarkable insights and new perspective for policy makers and planners in helping them take proactive measures in the context of climate change. Timely measures and institutional changes can certainly help in reducing the irreparable damages that can be caused by climate change, since the trends in 31 years rainfall data do not deny climate change is occurring.

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