Journal of Environment and Earth Science www.iiste.org
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.5, No.18, 2015

Spatial Analysis of Rainfall in the Climatic Regions of Nigeria using Insitu Data

Ojo Olusola Adedayo Kayode Emmanuel Israel
Department of Physics, P.M.B. 704, Federal University of Technology, Akure

Abstract
Analysis of rainfall trends is important in studying the impart of climate change for water resources planning and management. In this paper, the daily rainfall data of thirty-two (32) years (1982 - 2013) were obtained from the Nigeria Meteorological Agency (NIMET), Oshodi, Lagos for some stations across the climatic regions of Nigeria and these stations were further divided into four climatic regions according to their weather conditions such as Sahel savannah, Derived Savannah, Guinea Savannah and coastal regions. The rainfall pattern as well as its spatial distribution with air temperature through different months and years were observed and studied. The long time average of monthly and annual amounts of rainfall was calculated and analyzed. It was observed in the years of study statistically that highest mean rainfall of 193.38mm occurred in August at Sahel region, 215.99mm and 214.87mm in September at Guinea and Derived savannah regions respectively and 310.19mm in July at Coastal regions. Meanwhile, the average annual rainfall includes 590.831mm in Sahel, 1220.941mm in Guinea Savannah, 1381mm in Derived savannah and 1532mm in Coastal. It was observed that rainfall pattern below latitude 10^0 is bi-modal in distribution having a primary peak in June-July and another secondary peak in September with little dryness in August. Finally, there is an increasing trend in rainfall amounts and frequency towards the middle of the wet season in all the regions in Nigeria.
Keywords: Spatial distribution, Climate change, Climatic regions, Rainfall and Air temperature.

1. Introduction
Rainfall is one of the key climatic variables that affects both the spatial and temp oral patterns of water availability. One of the challenges posed by climate change/climate variability is ascertainment, identification and quantification of trends in rainfall and their implications on river flows in order to assist in formulation of adaptation measures through appropriate strategies for water resources management (De Luis et al., 2010). Analysis of rainfall trends is important in studying the impacts of climate change for water resources planning and management. It has been recognized that global or continental scale observations of historical climate are less than useful for local or regional scale planning (Brekke et al., 2009). The climate of a location can be understood easily in terms of annual or seasonal averages of temperature and precipitation. The global climate has changed rapidly with the global mean temperature increasing by 0.7 *oC* within the last century (IPCC, 2007). However, the rates of change are significantly different among regions. This is primarily due to the varied types of land surfaces with different surface albedo, evapotranspiration and carb on cycle affecting the climate in different ways (Meissner et al., 2003;Snyder et al., 2004). Increasing flood risk is now being recognized as the most important sectorial threat from climate change in most parts of the region which has prompted public debate on the apparent increased frequency of extreme, and in particular, on perceived increase in rainfall intensities (Oriola, 1994). Several studies have adduced extreme rainfall to b e the ma jor cause of flo o d worldwide. Such studies include Bunting et al. (1976), Folland et al. (1986), Odekunle (2001) and Ologunorisa (2001). Other studies have identified the characteristics of extreme rainfall that are associated with flood frequency to include duration, intensity, frequency, seasonality, variability, trend and fluctuation (Olaniran, 1983; Ologunorisa, 2001). Eludoyin (2009) studied monthly rainfall distribution in Nigeria between 1985 − 1994 and 1995 – 2004 and noticed some fluctuations in most months within the decades. Ayansina and Ogunbo (2009) also investigated the seasonal rainfall variability in Guinea savannah part of Nigeria and concluded that rainfall variability continues to be on the increase as an element of climate change. The Inter-tropical Discontinuity (ITD) is the most popularly accepted medium that influence rainfall distribution in Nigeria (Adejuwon et al., 1990; Lamb, 1983; Ayoade, 1983; Ilesanmi, 1981). It is established that in the southern part of ITD, varying degrees of convective activity and precipitation takes place, whereas, little or no cloud development or precipitation occur in the northern part. The aims of this research are to describe the distributions and patterns of rainfall across four climatic regions in Nigeria such as Sahel savannah, Derived Savannah, Guinea Savannah and coastal regions on daily, monthly and annual bases.

2. Materials and Methods
Daily insitu data of rainfall and air temperature were obtained from the Nigerian Meteorological Agency (NIMET), Oshodi, Lagos, Nigeria. The thirty-two (32) years data between 1982-2013 were collected for some stations which were further divided into four climatic regions of Nigeria according to Olaniran and Summer, 2005 as shown in Figure 1.

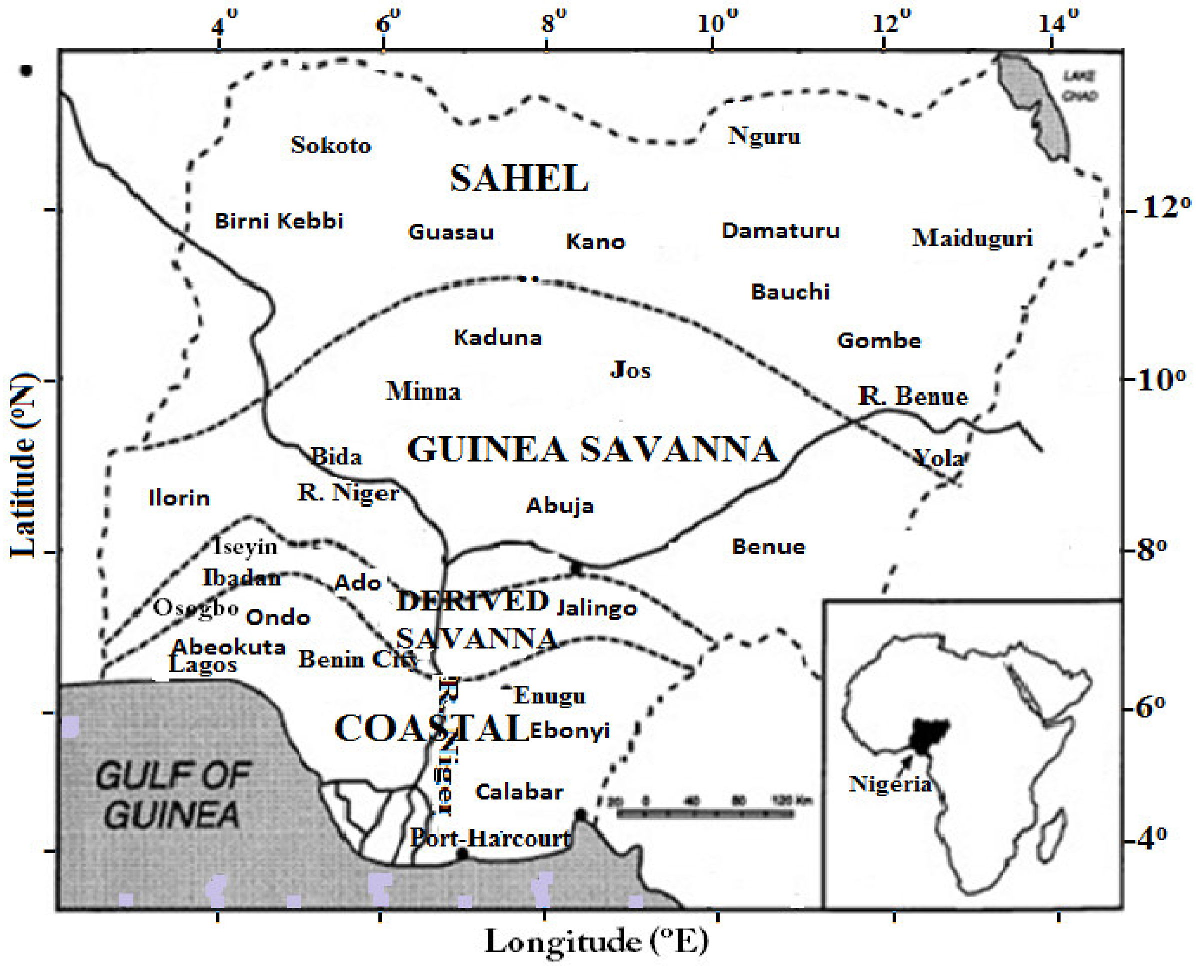

Figure 1: Map of Nigeria Showing the investigated Regions and their Stations

The long time monthly and annual averages were computed. The spatial distribution across each of the regions as well as their rainfall characteristics were observed and analyzed. The statistical parameters such as mean, mode, median, variance, standard deviation, and skewness of each of the climatic regions rainfall data are summarized in Table 1-4. The mean, median and mode give information about the centre of the distribution. The variance and standard deviation give information about the variability of the data. They also measured the spatial spread distribution of the data. The spatial spread is an indicator of how far away are the data values from the centre of the distribution. The variance (σ^2) and standard deviation (σ) were calculated using equations 1 and 2 respectively.

$$\sigma^2 = \frac{\sum_{n=1}^{n} \left(x_i - \overline{x} \right)}{n = 1} \qquad 1$$

$$\sigma = \sqrt{\frac{\sum_{n=1}^{n} \left(x_i - \overline{x} \right)}{n = 1}} \qquad 2$$

where xi and $\overline{x}$ represent the daily and monthly mean rainfall respectively, n is the total number of the observed rainfall. The coefficients of skewness and kurtosis provide information about the symmetry and length of the tail for certain types of distributions respectively. Skewness is a measure of asymmetry of the probability distribution of a variable from mean. It tells us the amount and direction of departure from horizontal symmetry. It can be positive and negative even undefined. If skewness is zero, the data are perfectly symmetrical. The following are the general rules of skewness:

- If skewness is less than -1 or greater than 1, the distribution is highly skewed.
- If skewness is between -1 and - 0.5 or between 0.5 and 1, the distribution is moderately skewed.

- If skewness is between -0.5 and 0.5, the distribution is approximately symmetric.

The expression for computing the coefficient of skewness (ξ) is as shown in equation 3 as

$$\xi = \frac{\frac{1}{n}\sum_{n=1}^{n}\left(x_i - \overline{x}\right)^3}{\left(\frac{1}{n}\sum_{n=1}^{n}\left(x_i - \overline{x}\right)^2\right)^{\frac{3}{2}}} \qquad 3$$

where *xi* and ¯*x* represent the daily and monthly mean rainfall respectively, n is the total number of the observed rainfall. Kurtosis is any measure of the peakedness of the probability distribution of a variable. It tells us the shape and the central peak is, relatively to that of a standard bell curve. It is standardized fourth population moment about its mean. The expression for computing the coefficient of kurtosis (μ) is as shown in equation 4 as

$$\mu = \frac{\frac{1}{n}\sum_{n=1}^{n}\left(x_i - \overline{x}\right)^4}{\left(\frac{1}{n}\sum_{n=1}^{n}\left(x_i - \overline{x}\right)^2\right)^{2}} - 3 \qquad 4$$

where *xi* and ¯*x* represent the daily and monthly mean rainfall respectively, n is the total number of the observed rainfall. The minus 3 in the expression is often explained as a correction to make kurtosis of normal distribution to be equal zero (the kurtosis is 3 for a normal distribution). The following are the general rules of skewness:

- If kurtosis is greater than 3, the distribution is highly leptokurtic i.e. it is sharper than normal distribution, with values concentrated around the mean and thicker tails. This signifies high probability for extreme values.
- If kurtosis is less than 3, the distribution is platykurtic i.e. it is fatter than normal distribution with a wider peak. The probability of extreme values is than for a normal distribution, and the values is wider spread around the mean.
- If kurtosis is 3, the distribution mesokurtic i.e. it is a normal distribution.

3. Results and Discussions

3.1 Statistical Parameters of Rainfall

Table 1: Statistical parameters of the Rainfall data for the Sahel Region

Month	Min.	Max.	Mean	Median	σ^2	σ	Ξ	μ
Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
Feb	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
Mar	0.00	9.00	0.39	0.00	2.72	1.65	5.101	29.967
Apr	0.00	24.40	4.75	2.35	49.38	7.03	1.793	2.362
May	0.00	109.20	28.92	16.90	1902.73	30.94	1.422	1.082
Jun	21.50	197.90	82.25	82.85	957.02	43.62	0.675	0.384
Jul	33.20	283.00	165.12	170.10	3489.07	59.068	-0.237	0.338
Aug	41.20	438.90	193.38	183.30	5142.58	71.71	1.113	3.755
Sep	26.20	243.90	112.15	96.50	3825.64	61.85	0.874	-0.155
Oct	0.00	90.50	15.78	9.50	461.18	21.48	2.086	4.625
Nov	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
Dec	0.00	3.90	0.21	0.00	0.67	0.82	4.030	15.999

Table 2: Statistical parameters of the Rainfall data for the Guinea Savannah Region

Month	Min.	Max.	Mean	Median	σ^2	σ	Ξ	μ
Jan	0.00	74.20	11.92	0.40	457.54	21.39	1.988	2.865
Feb	0.00	84.40	16.31	6.40	403.98	20.10	1.659	3.471
Mar	9.40	170.30	61.10	48.10	1880.14	43.36	1.099	0.673
Apr	43.60	192.00	111.65	110.90	1991.72	44.63	0.222	-1.038
May	49.00	458.50	165.31	157.10	5600.58	74.84	1.975	6.913
Jun	52.00	328.60	178.91	168.55	4232.12	65.05	0.407	-0.358
Jul	28.70	276.20	147.59	140.60	4390.26	66.26	0.091	-1.088
Aug	46.50	308.00	146.89	141.70	4395.23	66.30	0.619	0.082
Sep	116.00	298.90	215.99	216.30	1968.56	44.37	0.204	0.009
Oct	40.90	370.30	169.56	153.90	7400.41	86.03	0.625	-0.498
Nov	0.00	132.40	21.32	4.10	1068.68	32.69	2.195	4.841
Dec	0.00	42.10	4.98	0.00	97.24	9.86	2.549	6.731

Table 3: Statistical parameters of the Rainfall data for the Derived Savannah Region

Month	Min.	Max.	Mean	Median	σ^2	Σ	Ξ	μ
Jan	0.00	24.60	4.32	0.10	57.80	7.60	1.581	4.114
Feb	0.00	121.10	41.86	35.00	1187.63	34.46	0.474	2.111
Mar	0.40	175.00	85.95	91.90	2336.08	48.33	-0.028	1.733
Apr	46.90	220.30	132.01	136.75	2123.63	46.08	0.141	2.158
May	35.40	353.60	166.99	150.80	4520.69	67.24	0.542	3.213
Jun	72.40	383.00	206.48	196.60	5508.64	74.22	0.339	2.374
Jul	47.20	338.70	193.98	199.30	6811.60	82.53	0.039	1.089
Aug	36.00	296.50	148.77	142.60	3811.25	61.74	0.451	2.660
Sep	57.00	415.30	214.87	204.20	5732.34	75.71	0.497	3.625
Oct	43.00	345.00	188.93	203.30	6658.32	14.66	-0.094	2.002
Nov	0.00	171.70	27.90	10.75	1730.40	41.60	1.855	5.954
Dec	0.00	48.30	9.31	2.00	189.21	13.76	1.437	3.758

Table 4: Statistical parameters of the Rainfall data for the Coastal Region

Month	Min.	Max.	Mean	Median	σ^2	Σ	Ξ	μ
Jan	0.00	67.10	17.03	7.50	454.81	21.33	1.136	0.043
Feb	0.00	97.60	35.79	30.95	939.75	30.66	0.561	-0.847
Mar	0.00	194.50	69.94	62.80	2923.48	54.07	0.932	0.095
Apr	38.70	402.50	141.27	116.40	7931.79	89.06	1.821	3.251
May	55.00	316.40	197.09	212.60	5334.30	73.04	-0.311	-0.995
Jun	117.60	530.50	310.19	291.25	15467.98	124.37	0.090	-1.196
Jul	33.00	442.50	209.35	189.20	13620.73	116.71	0.600	-0.630
Aug	6.20	372.80	81.38	70.30	4334.57	65.84	3.059	12.748
Sep	81.00	310.40	206.09	207.20	3732.57	61.09	-0.178	-0.681
Oct	53.50	384.40	162.67	159.10	4107.24	64.09	1.267	3.580
Nov	0.00	202.70	90.23	81.35	3098.53	55.66	0.258	-0.866
Dec	0.00	99.40	22.83	18.90	666.94	25.83	1.402	1.851

Table 1 showed the statistical analysis of rainfall in the Sahel regions. There following observations could be deduced from Table 1. There was no record of rainfall in the three months (January, February and November) and zero value of minimum rainfall in eight months in the region. There were moderate amount of rainfall in the remaining months with highest value of 438.90 mm and highest mean value of 193.38mm in August in the zone. Rainfall is highly skewed in five months (March, April, August, October and December) and moderately skewed in two months (September and June). Kurtosis analyses also indicated that the distribution of rainfall in four months (March, August, October and December) in the zone were leptokurtic, five months (April, May, June, July and September) were Platykurtic and three months (January, February and November) were symmetric.

Table 2 showed the statistical analysis of rainfall in the Guinea Savannah regions. There following observations could be deduced from Table 2. There was zero value of minimum rainfall in four month (January, February, March, November and December) in the region. There were moderate amount of rainfall in the remaining months with highest value of 458.50 mm in May and highest mean value of 215.99 mm in September in the zone. Rainfall is highly skewed in six months (January, February, March, May, November and December) and moderately skewed in six months (April, June, August, September and October). Kurtosis analyses also indicated that the distribution of rainfall in four months (February, May, November and December) in the zone were leptokurtic, eight months (January, March, April, June, July , August, September and October) were Platykurtic.

Table 3 showed the statistical analysis of rainfall in the Derived Savannah regions. There following observations could be deduced from Table 3. There was zero value of minimum rainfall in four months (January, February, November and December) in the region. There were moderate amount of rainfall in the remaining months with highest value of 415.30 mm and highest mean value of 214.87 mm in September in the zone. Rainfall is highly skewed in three months (January, November and December) and moderately skewed in nine months (February – October). Kurtosis analyses also indicated that the distribution of rainfall in five months (January, April, September, November and December) in the zone were leptokurtic, seven months (February, March, April, June, July , August and October) were Platykurtic.

Table 4 showed the statistical analysis of rainfall in Coastal region. There following observations could be deduced from Table 4. There was zero value of minimum rainfall in eight months in the region of rainfall in the five months (January, February, November and December) in the region. There were slightly heavy amount of rainfall in the remaining months with highest value of 530.50 mm and highest mean value of 310.19 mm in June in the zone. Rainfall is highly skewed in four months (January, April, August and December) and moderately skewed in six months (February, March, May, June, September and October). Kurtosis analyses also indicated that the distribution of rainfall in three months (April, August and October) in the zone were leptokurtic, nine months (January, February, March, May, June, July , September, November and December) were Platykurtic.

3.2 Daily and Monthly Distribution of Rainfall

In the Sahelian region, the highest amount of rainfall was observed in August. There was about six months of dryness without rainfall. This may due to prolong increasing evapotranspiration, drought and desertification prevalence in the zone as it was observed by Adefolalu (1986) and Odjugo and Ikhuoria (2003). There was a peak rainfall in August in contrast to the usual depression in rainfall associated with the month in the other zones in Nigeria. This may due to the presence of inter-tropical discontinuity (ITD) of the northern monsoon which drives African Easterly Jet (AEJ) from the other regions of the country and causes a temporary dryness in those zones. The rainfall pattern has modal distribution with single peak (see Figure 2 and 3). In the Guinea Savannah region, there was a slightly oscillating pattern of rainfall with bi-modal distribution. The primary peak in rainfall was observed in June-July and the secondary peak was observed in September-October but the primary peak is less than the secondary peak is as shown in Figure 2 and 3. This may due to the seasonal distribution of rainfall in the region which follows the direction of the inter-tropical discontinuity (ITD), a great determinant of most rainfall attributes in the region and varies almost proportionally with the distance from the coast in line with the observation of Ilesanmi (1981). There was a deep between primary and secondary peaks in August as a result of African-easternly Jet and over lain of the area by the Continental Tropical (cT) air mass as it was also observed by Ilesanmi (1981), Ayoade and Akintola (1982) and Omotosho (2007).

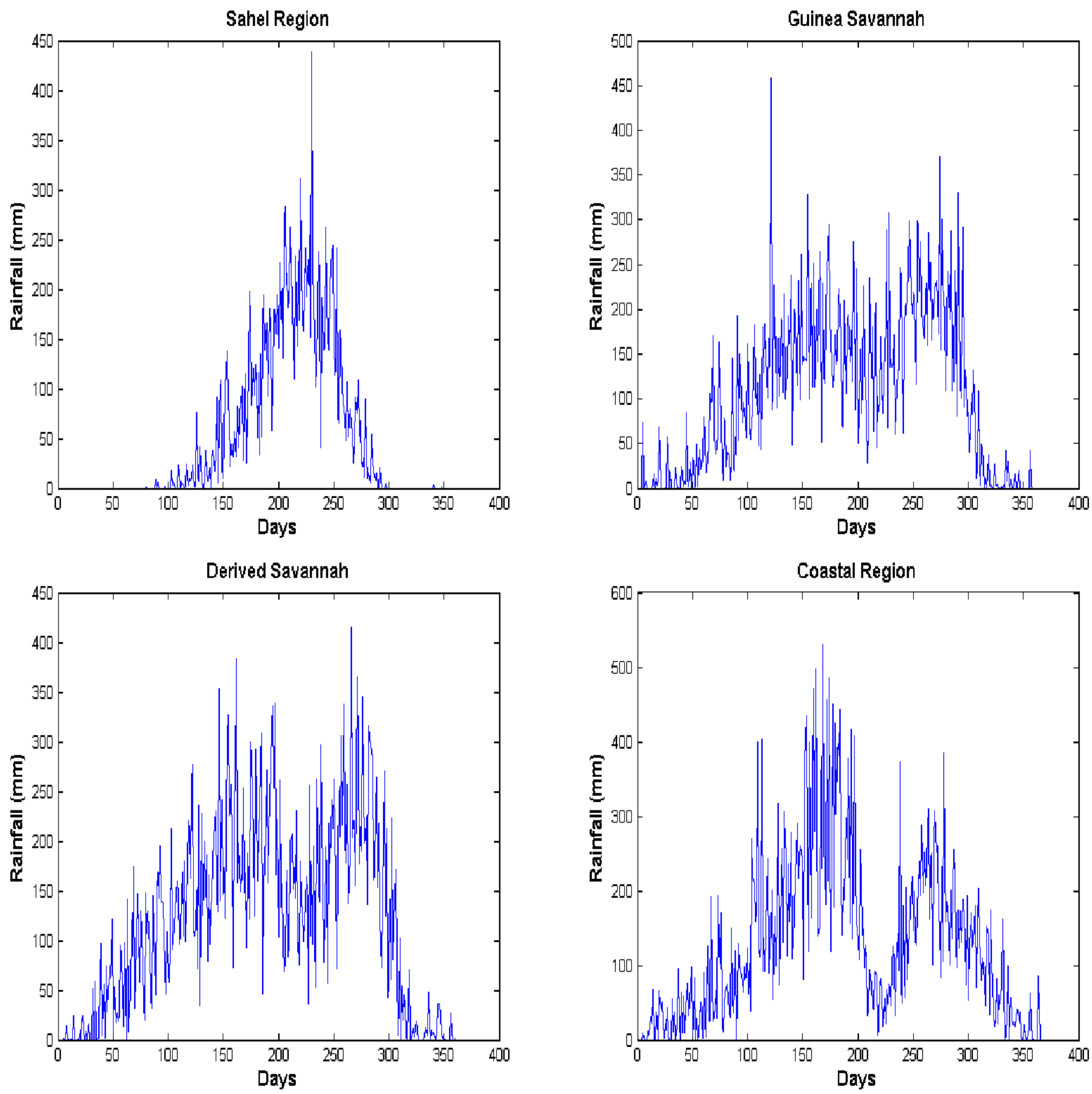

Figure 2: The Daily Variations of Rainfall across Climatic Regions in Nigeria.

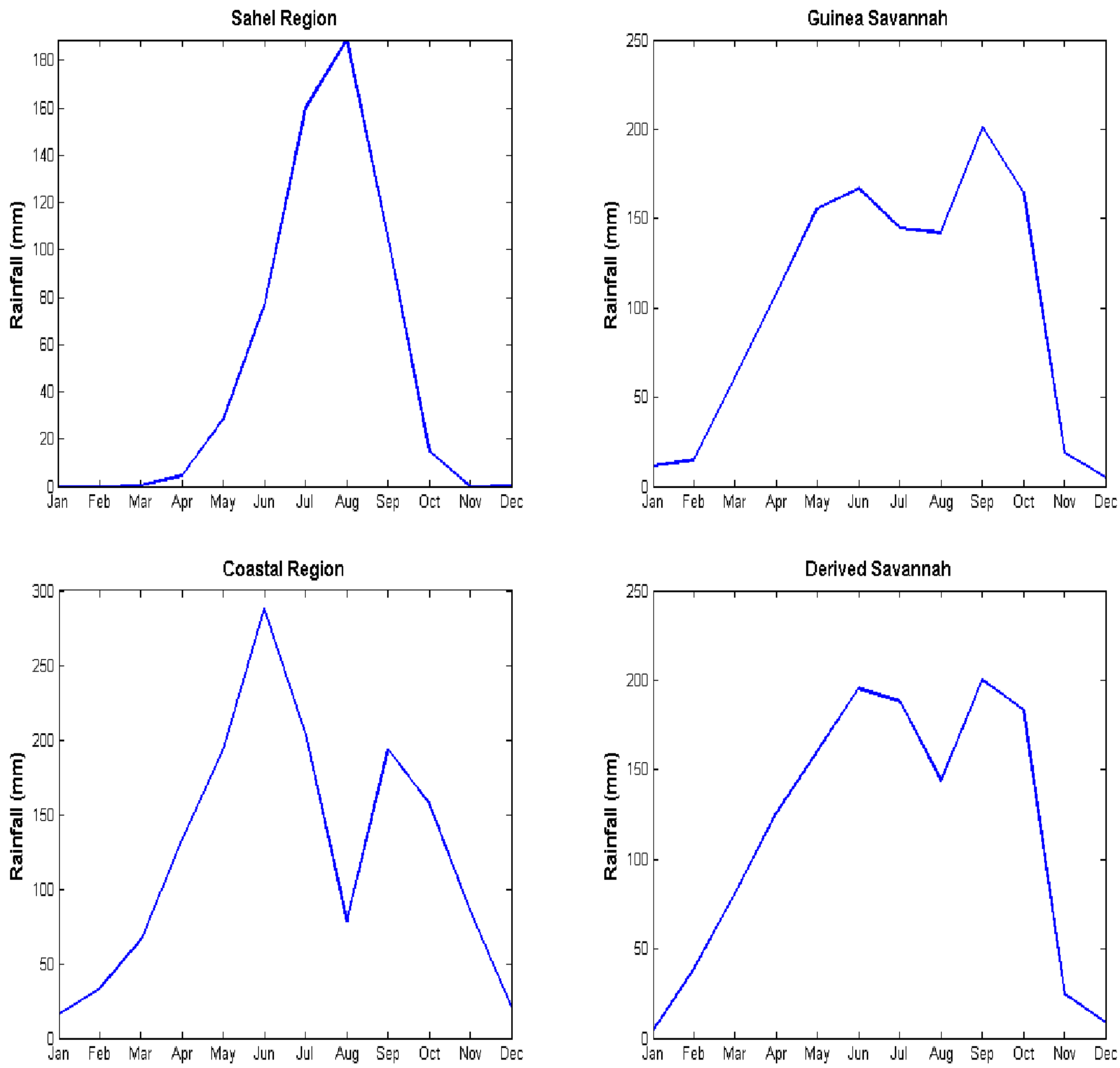

Figure 3: The Monthly Variations of Rainfall across Climatic Regions in Nigeria.

In the Derived Savannah region, there were notable primary and secondary peaks which were almost of equal height in June-July and September respectively. A fairly oscillating pattern of rainfall with bi-modal distribution was observed in the region. There was also a little dryness in August between the two peaks. It was also observed that there was decrease in the amount of rainfall in the zone as compared with coastal zone. This decreases may be attributed to variation in local factors such as orography, boundary layer forcing and build up as was also observed by Akinsanola and Ogunjobi (2014).In the Coastal region, there was a prominent oscillating pattern of rainfall with a conspicuous bi-modal distribution. The primary peak observed in between June and July is higher than the secondary peak in September. There was a usual deep between the peaks in August (see Figure 2 and 3). This may also due to the African-easterly Jet and over lain of the area by the Continental Tropical (cT) air mass as it was also observed by Ilesanmi (1981), Ayoade and Akintola (1982) and Omotosho (2007). The Increase in rainfall in this region may partly be responsible for the increase in flood event devastating the coastal cities as observed by Ikhile (2007) and Nwafor (2007).

3.3 Annual Distribution of Rainfall with Air Temperature

Figure 4 shows the distributions of rainfall with air temperature in the four climatic regions of Nigeria over thirty-two years (1982-2013). The following observations were made from the figures: There was highest rainfall in 1998 in all the regions. This may due to the prevalence of inter-tropical discontinuity and the tropical maritime (mT) air mass overlain all areas of the regions in this particular year as it was also observed by Ayoade (1983), Ilesanmi (1981), Lamb (1983) and Adejuwon et al. (1990). The annual peak amount of rainfall in the regions observed in 1998 include 1250 mm in Sahel, 2200 mm in Derived savannah, 2300 mm in Guinea Savannah and

2700 mm in coastal regions. There was also oscillating patterns of rainfall in all the regions. The least amount of rainfall was observed in 1982 in the Sahel and in 1983 in the Derived savannah, Guinea Savannah and Coastal regions.

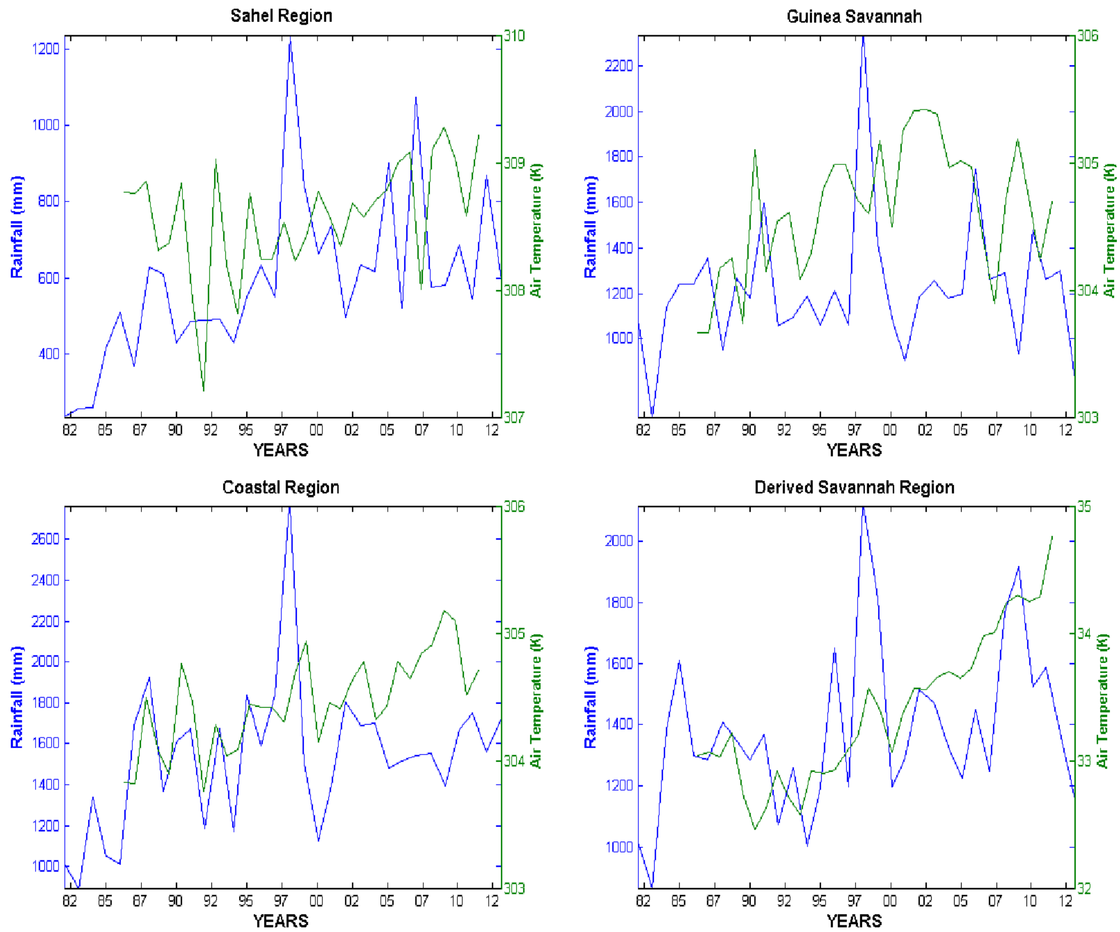

Figure 4: The Annual Variations of Rainfall with temperature across Climatic Regions in Nigeria.

Furthermore, there was consistent observable depression in the amount of rainfall in every half decade yearly interval in all the regions. There was a progression of almost three years interval of increase in the amount of rainfall in all the regions. The increase trends in the amount of rainfall were observed along the thirty-two years across the regions but the intensity of rainfall varies from one region to the other. Finally, in comparison with the air temperature, there was increase in the amount of rainfall as the temperature decreases in the Sahel, Guinea savannah and Derived savannah regions. However, rainfall and air temperature follow the same pattern in the Coastal region. This attest to the fact that increases in air temperature dictates the amount of rainfall received in the coastal cities. This may due to the dependence of rainfall in the region on sea surface temperatures of Atlantic Ocean from the Gulf of Guinea, southward up to the Benguella current region of Southern Atlantic Ocean, land/sea thermal and surface location of ITD as also observed by Adedokun (1978), Rasmusson (1985) and Burroughs (1992).

3.4 Spatial Distribution of Rainfall in Nigeria

Figure 5 shows the contour map describing the spatial distribution of rainfall along the lines of latitude and longitude based on the investigated stations across the four climatic regions in Nigeria. It was observed that rainfall in the lower latitude almost doubled that of the higher latitude across the regions in Nigeria. This is in line with the work of Nicholson (1994) who rep orted that rainfall in West Africa generally decreases with latitude with essential zonal isohyets. The intensity of rainfall increases with increase in latitude and longitude. The intensity of rainfall is highest in the Coastal region along the longitudes between 50 and 120 with latitudes between 50 and 70 i.e in Port-Harcourt, Calabar and Enugu. There was also cases of high rainfall around the confluence cities (see Figure 5).

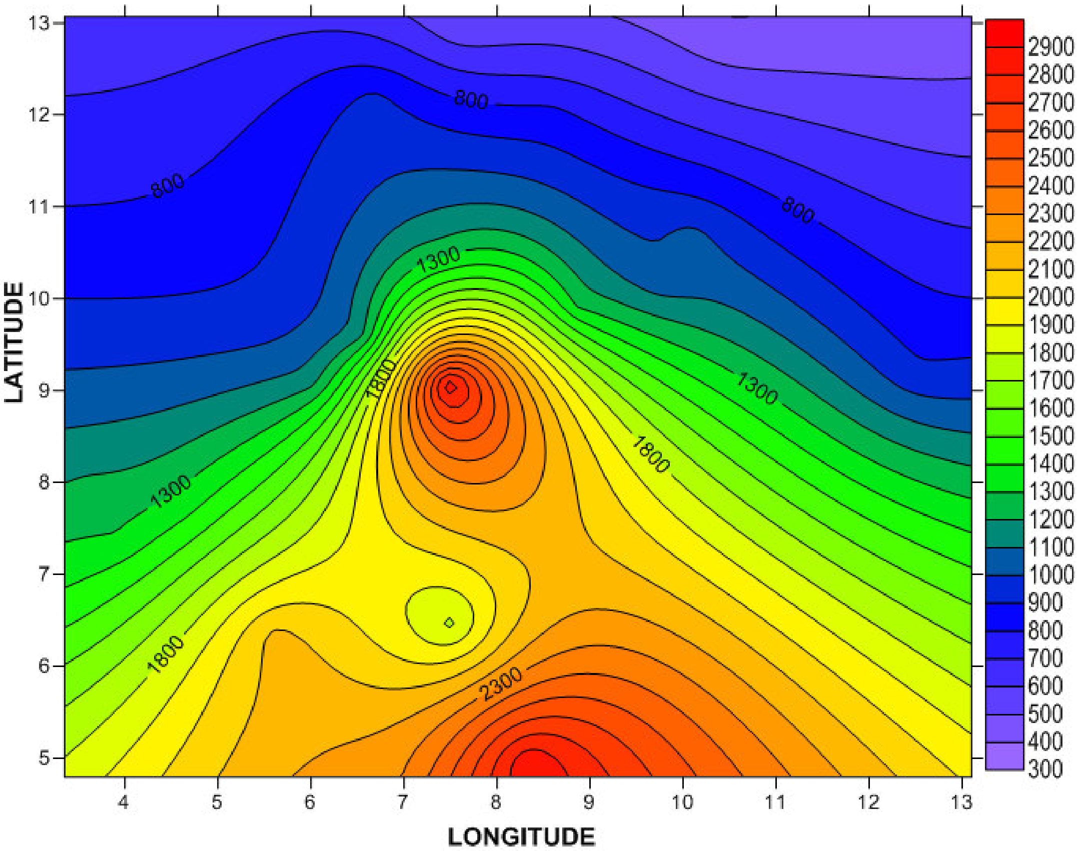

Figure 5: Spatial Distribution of Rainfall in Nigeria

This is expected because they are in riverine areas. The least rainfall intensity was observed in the North-eastern part of Nigeria. This is expected because rainfall in North-eastern Nigeria is controlled by the West African Monsoon which makes the air mass to dominate the region in response to a low pressure belt developing in North Africa with a parallel high pressure belt existing off the Gulf of Guinea. This in turn affects the rainfall producing phenomena such as ITD, ITF and Tropical continental air mass as it was also observed by Lamb (1983).

4. Conclusion

The spatial analysis of rainfall over four climatic regions has been studied extensively. It has been observed that rainfall pattern below latitude 100 is bi-modal distribution having a primary peak in June-July and another secondary peak in September with little dryness in August identified to be a result of Africa Eastern Jets and Tropical continental air mass of the West African Monsoon. It was also observed statistically that the highest mean rainfall occurred in August at Sahel region, in September at Guinea and Derived savannah regions and in July at Coastal regions. Finally, there was an increasing trend in rainfall amounts and frequency towards the middle of the wet season in all the regions in Nigeria. These results can be used by stakeholders with interests in rain-fed agricultural schemes especially in decision making for the timing of planting of crops, selecting the appropriate variety of crops to plant and in irrigation and water management schemes.

References

Adedokun, J. (1978). West Africa Precipitation and Dominant Atmospheric Mechanism. Arch Met. Geoph. Biokl, Seria, 27(A):289–310.

Adefolalu, D. (1986). Rainfall Trends in Nigeria. Theoretical and Applied Climatology, 37:205–219.

Adejuwon, J., Balogun, E., and Adejuwon, S. (1990). On the Annual and Seasonal Pattern of Rainfall Fluctuations in Sub-Saharan West Africa. International Journal of Climatol- ogy, 10:810–848.

Akinsanola, A. and Ogunjobi, K. (2014). Analysis of Rainfall and Temperature Variability over Nigeria. Global Journal Inc., USA, 14(3):1–18.

Ayansina, A. and Ogunbo, S. (2009). GIS Approach in Assessing Seasonal Rainfall Vari- ability in Guinea Savanna Part of Nigeria.page 16. 7th FIG Regional Conference, Vietnam.

Ayoade, J. (1983).Introduction to Climatology for the Tropics. John Wisley, pages 125–139.

Ayoade, J. and Akintola, F. (1982). A Note on Some Characteristics of Rain Storms in Ibadan. Weather,

37(2):56–58.
Brekke, L., Kiang, J., Olsen, J., Pulwarty, R., Turnipseed, D., Weeb, R., and White, K. (2009). Climate Change and Water Resources Management: A Federal Perspective. U.S Geological Survey Circular, 1331:65.
Bunting, A. H., Dennett, M. D., Eliston, J., and Milford, J. R. (1976). Rainfall Trends in the West Africa Sahel. Q.J.R. Meteorological Society, 102:56–64.
Burroughs, W. (1992). Weather Cycles: Real or Imaginary. Cambridge: University Press. De Luis, M., Brunetti, M., Gonzlez-Hidalgo, J., Longares, L., and Martin-Vide, J. (2010). Change in
Seasonal precipitation in the Iberian Peninsula during 1946-2005. Global Planet. Change, 74:139–144.
Eludoyin, O. (2009). Monthly Variation in the 1985-1994 and 1995-2004 Rainfall
Distribution over five selected Synoptic Stations in Western Nigeria. Nigeria Journal of Meteorology and Climate Science, 7:11–22.
Folland, C. K., Palmer, T. N., and Parker, D. E. (1986). Sahel Rainfall and Worldwide Sea
Temperatures 1901-85: Observational, Modelling and Simulation Studies. Nature, 320:602–607.
Ikhile, C. (2007). Impacts of Climate Variability and Change on the Hydrology and Water Resources of the Benin-Owena River Basin. Unpublished Ph.D Thesis, Department of Geography and Regional Planning, University of Benin, Benin City, Nigeria.
Ilesanmi, O. (1981). Aspect of the Precipitation Climatology of the July-August Rainfall Minimum of Southern Nigeria. Urban and Regional Planning Problems in Nigeria. University of Ile-Ife, Nigeria. Geographical Associations Regional Planning Committee.
IPCC (2007). Climate Change and WorldFood Security: A New Assessment. Global Environmental Change, 9:S51–S67.
Lamb, P. (1983). Sub-Saharan Rainfall Update for 1982 Continuous Drought. Journal of Climatology, 3:419–422.
Meissner, K., Weaver, A., Matthews, H., and Cox, P. (2003). The Role of Land Surface Dynamics in Glacial Inception: A Study with the UVic Earth System Model. Clim Dyn., 21:515537.
Nicholson, S. (1994). Recent Rainfall Fluctuations in Africa and their Relationship to Past Conditions
over the Continent. Holocene, 4:121–131.
Nwafor, J. (2007). Global Climate Change: The Driver of Multiple Causes of Flood Inten- sity in Sub-Saharan Africa. pages 12–14. International Conference on Climate Change and Economic Sustainability held at Nnamdi Azikiwe University, Enugu, Nigeria.
Odekunle, T. (2001). The Magnitude Frequency Characteristic of Rainfall in Ondo, Southwestern, Nigeria. Ife Research Publications in Geography, 8:36–41.
Odjugo, P. and Ikhuoria, A. (2003). The impact of climate change and anthropogenic factors on desertification in the semi-arid region of Nigeria. Global Journal of Environmental Science, 2(2):118–126.
Olaniran, O. (1983). Flood Generating Mechanism at Ilorin, Nigeria. GeoJournal, 7.3:271– 277.
Ologunorisa, E. (2001). An Assessment of Flood Risk in the Niger Delta, Nigeria. Unpublished Ph.D Thesis, Department of Geography and Environmental Management, University of Port -Harcourt, Port Harcourt.
Omotosho, J. (2007). Pre-rainy Season Moisture Build-up and Storm Precipitation Deliv- ery in the West Africa Sahel. International Journal of Climatology, 28:937–946.
Oriola, E. (1994). Strategies for Combating Urban Flooding in a Developing Nation: A Case Study of Ondo, Nigeria. The Environmentalist, 4:57–62.
Rasmusson, E. (1985). El Nino and Variations in Climate. American Scientist, 73:168–177.
Snyder, P., Delire, C., and Foley, J. (2004). Evaluating the Influence of Different Vegetation iomes on the GlobalClimate. Clim Dyn., 23:279–302.

The IISTE is a pioneer in the Open-Access hosting service and academic event management. The aim of the firm is Accelerating Global Knowledge Sharing.

More information about the firm can be found on the homepage:
http://www.iiste.org

CALL FOR JOURNAL PAPERS

There are more than 30 peer-reviewed academic journals hosted under the hosting platform.

Prospective authors of journals can find the submission instruction on the following page: http://www.iiste.org/journals/ All the journals articles are available online to the readers all over the world without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. Paper version of the journals is also available upon request of readers and authors.

MORE RESOURCES

Book publication information: http://www.iiste.org/book/

Academic conference: http://www.iiste.org/conference/upcoming-conferences-call-for-paper/

IISTE Knowledge Sharing Partners

EBSCO, Index Copernicus, Ulrich's Periodicals Directory, JournalTOCS, PKP Open Archives Harvester, Bielefeld Academic Search Engine, Elektronische Zeitschriftenbibliothek EZB, Open J-Gate, OCLC WorldCat, Universe Digtial Library , NewJour, Google Scholar