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Research Article

# Precipitation Intensity-Duration Occurrence Models Development for Designated Locations in the Southern Humid Rain Forest Zones of Nigeria

**Cordelia Chika EMEKA-CHRIS**[a] **Christopher Ikechi OBINECHE**[b*] **Bejoy Otuobi UNANKA**[b]

[a]*Department of Agricultural and Bioresources Engineering, Michael Okpara University of Agriculture, Umudike, NIGERIA*
[b] *Department of Agricultural Engineering Technology, Federal College of Land Resources Technology, P.M.B. 1518 Owerri, NIGERIA*

*(*): Corresponding author, ikechiobineche@gmail.com*

## ABSTRACT

This research work examined the tendencies and patterns in the rainfall in carefully chosen localities of Southwest and South-South Nigeria. Rainfall data from 1983-2014 in Ibadan, Lagos, Benin, Calabar, Port Harcourt and Warri were used for this study. Standard deviation, mean, coefficient of skewness, coefficient of kurtosis, coefficient of variation and standardized anomaly index were engaged to analyze the data and describe the distribution of rainfall in these stations. The data were analyzed using statistical package for social sciences, SPSS 17 and Minitab 16. The outcomes revealed that the maximum annual rainfall occurred at Warri station 4489.80 mm in the year 2008 and the minimum occurred at Benin 229.10 mm in 2005. Also, Benin has the maximum coefficient of variation of about 24.72%, while Port Harcourt has the minimum coefficient of variation of about 12.71%. Warri station was positively skewed indicating that it experienced frequent low rainfall values, while Port Harcourt was approximately symmetrical skewed. Warri has kurtosis coefficient of 4.45 which is highest among others. However, the patterns of rainfall in these areas are random or fluctuating. It is recommended that models built on the perceived decreasing rainfall, such as drainages, dams, have to be reviewed.

**RESEARCH ARTICLE**

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## INTRODUCTION

In Nigeria, the development of IDF models is still in its growing path and it is inadequate to the extent of available data (Nwaogazie *et al.*, 2019). Oyebande (1982) derived IDF model for the western region without adequate data and applied Gumbel EVT -1distribution to the maximum period of ten years records to derive rainfall IDF models. In Humid Forest Zones of Nigeria, recent studies on rainfall IDF development have been done in Southern Nigeria. Akpan and Okoro (2013), Nwaogazie and Duru (2002) developed Rainfall Intensity Frequency Models based on statistical method of least squares. Also, Okonkwo and Mbajiorgu (2010), Ologhadien and Nwaogazie (2014) developed IDF curves of extreme rainfall for South Eastern Nigeria based on generalized accumulated rainfall. Akpen *et al.* (2016) studied rainfall events for Makurdi metropolis. The IDF curves developed were in accord with IDF theory of shorter recurrence periods of 2 to 10 years. Life-threatening precipitation actions cause contamination of the water quality, ruin of properties and harm of livelihood owing to deluging. Extreme environmental events, caused by climate change have become a major factor in the variability of rainfall trends in Nigeria and the world at large. Such actions include floods, drought, rainstorms, and high winds, have severe consequences for human society.

Among all forms of precipitation, rainfall is the one which affects agriculture most (Onwualu *et al.*, 2006). As such, it is necessary to note the methods for measuring and analysing rainfall data. The amount of rainfall is expressed as depth in cm (or mm), which falls on a level surface. The principal characteristics of a storm are its intensity, duration, total amount and its frequency or recurrence interval.

The IDF relationship is a mathematical relationship among rainfall intensity *i*, duration, *d*, and the return period, *T* (equivalent to the annual frequency of exceeding referred to as "frequency"). Mathematical curve fitting is nevertheless, easily adapted to the computer, and the results can be neatly and completely described by a few parameters. Identification of homogenous regions may also be adopted in analyzing rainfall data. A standardized area is defined as a group of sites that can be described by the same statistical distribution (Raiford *et al.*, 2007). The focus of this study is to determine the precipitation intensity - duration occurrence models development for designated locations in the southern Humid Rain Forest zones of Nigeria using Gumbel distribution and to relate outcome to the standardized anomaly index.

## MATERIALS and METHODS

The study areas are in Humid Rain Forest Zones of Nigeria. Nigeria lies between Latitudes 4-14° North and Longitudes 2° 2' and 14° 30' East. It estimated land mass of 923.769 km$^2$, a North – South length of approximately 1450 km and a West-°East breadth of almost 800 km. The total land boundary is 4047 km, whereas the coastline is 853 km. The study locations include Ibadan and Lagos (West) while; in the South we have Calabar, Edo, Port-Harcourt and Warri (NFRA, 2008) are shown in Table 1.

**Table 1.** Characteristics of the meteorological stations of the study cities.

| Location | State | Coordinate | Agro-ecological zones | Data Range |
|---|---|---|---|---|
| Ibadan | Oyo | 07° 23'N, 03° 55'E | Western Moist Forest | 1983- 2014 |
| Lagos | Ikeja | 06° 27'N, 03° 23'E | Western Moist Forest | 1983- 2014 |
| Benin | Edo | 06° 10'N, 05° 37' 20"E | Central Moist Zone | 1983 - 2014 |
| Calabar | Cross River | 04° 57'N, 08° 19'E | Eastern Moist Forest | 1983 - 2014 |
| Port-Harcourt | Rivers | 4.75° N, 07°E | Eastern Moist Forest | 1983- 2014 |
| Warri | Delta | 05° 31'N, 05° 45'E | Central Moist Zone | 1983- 2014 |

National Food Reserve Agency (NFRA, 2008)

## Climate

The climate of Nigeria is tropical with variable rainy and dry season. In southeast it is hot and wet most of the year, while in the southwest it is dry. Length of rainy season decreases from south to north. In the humid rain forest zone, the rainy season lasts from March to November. The southwest has large area of forest which has been replaced by cocoa and rubber plantation.

## Data requirement and collection for the study

The rainfall depths data are vital in this research for smaller durations viz., 5, 10, 15, 20, 30, 60, 120, 180, 240, 300 and 360 minutes. Data were collected from National Root Crop Research Institute (NRCRI), Umudike and the Nigeria Meteorological Agency, (NIMET), Lagos. The length of the records used for all the stations are same 32 years (from 1983 to 2014).

## Data Analysis

### Analyzing trends of rainfall

In analyzing the required data and testing the normality of the time series data, the descriptive statistical techniques/tools were used. They include Mean yearly (Annual) rainfall for each study area, Yearly rainfall standard deviation for each study area, Standard coefficient of skewness Coefficient of variation, Standardized anomaly index (SAI) and Graphical plots.

### Mean yearly (annual) rainfall

This is a measure of central tendency. Mathematically, it is denoted as $\bar{X}$ and computed as:

$$\bar{X} = \frac{\sum_{i=1}^{n} x_i}{n} \quad (1)$$

Where:

$\bar{X}$= mean yearly rainfall

$x_i$= yearly rainfall values (mm)

n= total number of observations.

**Yearly rainfall standard deviation**

This is a measure of dispersion. The standard deviation measures the absolute dispersion for variability. The greater the standard deviation, the greater will be the magnitude of the deviation of the yearly rainfall values from the mean yearly rainfall for the periods.

A small standard deviation means a high degree of uniformity of the yearly rainfall values.

Computationally, it is denoted as σ and given by

$$\sigma=\sqrt{\frac{\sum_{i=1}^{n}(x_i-\bar{X})^2}{n-1}} \qquad (2)$$

Where:

$x_i$= annual rainfall for the year

$\bar{X}$= mean annual rainfall

n= total number of observations

σ= standard deviation

**Standard coefficient of Skewness**

To measure the co-efficient of skewness, one can make use of the Karl Pearson's co-efficient of skewness which is based upon the difference between mean and mode. The difference value is divided by the standard deviation to give the relative measure. This is obtained using the formulae:

$$\text{Coefficient of Skewness} = \frac{Mean-Mode}{Standard\ deviation} \qquad (3)$$

When, Skew > 0: Right skewed distribution that is most values are concentrated on left of the mean with extreme values to the right.

Skew < 0: Left skewed distribution that is most values are concentrated on the right of the mean, with extreme values to the left.

Skew = 0: Mean = Mode = Median; and distribution is symmetrical.

**Standard coefficient of Kurtosis**

It refers to the degree of flatness or peakness. When a distribution is normal or symmetrical, the co-efficient of kurtosis is equal to 3. When it is more than 3, it is more peaked than the normal and when it is less than 3, it is less peaked than the normal. Mathematically,

$$\text{Kurt (x)} = \frac{\mu^4}{\sigma^4} \qquad (4)$$

Where:

$\mu^4$= fourth moment of the mean

$\sigma^4$ = standard deviation

**Gumbel Theory of Distribution**

The Gumbel theory of distribution is the most widely used distribution for IDF analysis owing to its suitability for modeling maxima (Elsebaie, 2012). Frequency precipitation

$P_T$ (in mm) for each of the duration with a specified return period $T$ (in year) is given by the following equation.

$$P_T = P_{ave} + K\,S \quad (5)$$

Where $K$ is Gumbel frequency factor given by:

$$K = \frac{\sqrt{6}}{\pi}\ [0.5772 + In[In\left[\frac{T}{T-1}(8)\right]] \quad (6)$$

Where $P_{ave}$ is the average of the maximum precipitation corresponding to a specific duration.

### Log Pearson Type III

The LPT III distribution involves logarithms of the measured values. The mean and the standard deviation were determined using the logarithmically transformed data.

$$P*_T = P*_{ave} + K_T\ S \quad (7)$$

$K_T$ is the Pearson frequency factor which depends on return period ($T$) and skewness coefficient, Where $P*_T$, $P*_{ave}$ are as defined previously.

### Coefficient of variation

This is a measure of relative variation. It is used when comparing the variability of two or more than two series. That series for which the coefficient of variation is greater is said to be less consistent or less uniform or less stable. On the other hand, a series which has less coefficient of variation is more consistent and more stable.
Mathematically,

$$\text{Coefficient of variation, CV} = \frac{\sigma}{\bar{X}}\ x\ 100 \quad (8)$$

Where:
$\sigma$= yearly rainfall standard deviation
$\bar{X}$= mean annual rainfall

It is clear from above that dispersion (variation) measures the extent to which the observations vary from some central value like the mean. They served as a basis for the control of the variability in the yearly data.

It is clear from above that dispersion (variation) measures the extent to which the observations vary from some central value like the mean. They served as a basis for the control of the variability in the yearly data.

### Standardized Anomaly index (SAI)

It is used in the analysis of rainfall variability. It is given as

$$\text{SAI (Z-scores)} = \frac{x_i - \bar{X}}{\sigma},\ i = 1, 2 \ldots 0. \quad (9)$$

Where:
$x_i$= yearly observations
$\bar{X}$= mean annual rainfall
$\sigma$ = yearly rainfall standard deviation.

**Statistical and graphical analysis**
Graphical plots were used to plot annual rainfall values and to reveal trends (variations) and patterns in rainfall over the thirty-two years period for each study area. Statistical package for social sciences (SPSS) 17 and Minitab 16 was used in the analysis. Gumbel distribution methodology was used to perform the flood probability analysis. The excel solver methods used was the Generalized Reduced Gradient (GRG Solver) which is for optimization of nonlinear equations and the Linear Programming Solver (LP Solver) for linear equations.

## RESULTS AND DISCUSSION

The result of the annual rainfall series from 1983 to 2014 is presented in the Table 2.

**Table 2.** Annual series of rainfall (mm) from 1983-2014.

| YEAR | LAGOS | IBADAN | BENIN | CALABAR | Port Harcourt | WARRI |
|---|---|---|---|---|---|---|
| 1983 | 1470.7 | 865.4 | 1657.9 | 2308.8 | 1632 | 2522.6 |
| 1984 | 1432 | 1382.2 | 1225.6 | 2508.4 | 2095.6 | 2741.4 |
| 1985 | 1986.6 | 1460.9 | 1557.7 | 2963.2 | 2395.7 | 2958.8 |
| 1986 | 1533.6 | 1297.7 | 1313.2 | 2611 | 2283.1 | 2887.1 |
| 1987 | 2048.27 | 1285.8 | 2419.2 | 2915.5 | 2261.3 | 2147.3 |
| 1988 | 2432.1 | 1408 | 2007.3 | 2814.7 | 2420.9 | 2442.6 |
| 1989 | 1821.7 | 1344.4 | 1939.8 | 2767.3 | 2160.2 | 2636.4 |
| 1990 | 2031.2 | 1279.9 | 2588.4 | 2729.1 | 2073.3 | 2567.7 |
| 1991 | 1867.8 | 1369.3 | 2439.2 | 2662.9 | 2094.4 | 2952.9 |
| 1992 | 1357.6 | 1072.7 | 2026.9 | 2896.3 | 1913.5 | 2944.5 |
| 1993 | 1837.1 | 1257.3 | 1899.1 | 2511.4 | 2359.8 | 2976.9 |
| 1994 | 1355 | 1002.7 | 2595.3 | 2904.6 | 2375.2 | 2870.7 |
| 1995 | 1977.4 | 1534.9 | 2677.9 | 3581.7 | 2523 | 3449.4 |
| 1996 | 1982.6 | 1647.9 | 2507 | 1084 | 2349.5 | 2592.1 |
| 1997 | 1699.8 | 1195.3 | 2082.8 | 3492.2 | 2329.8 | 2906.2 |
| 1998 | 953.5 | 920.6 | 2204.4 | 2802.7 | 2563.1 | 2537.3 |
| 1999 | 2068 | 1605.4 | 2164 | 3004.1 | 2498.2 | 3127.6 |
| 2000 | 1458.9 | 1240.1 | 2257.7 | 2750.2 | 1993.7 | 2879.9 |
| 2001 | 1310 | 1279.7 | 2424.3 | 3309.5 | 2123.4 | 2400.2 |
| 2002 | 1523.2 | 1447.8 | 2422.2 | 2797.7 | 2186.2 | 3307.4 |
| 2003 | 1575 | 1569.5 | 1860.1 | 2561.7 | 2349.6 | 2359.9 |
| 2004 | 2155.6 | 1327.4 | 2239.8 | 2356.1 | 1875 | 3138.5 |
| 2005 | 1746 | 1226.2 | 229.1 | 3008 | 1973.5 | 1925.8 |
| 2006 | 1364.6 | 1261.2 | 2183.9 | 2607.4 | 2975.9 | 2547.3 |
| 2007 | 1073.6 | 985.8 | 1904.6 | 1225 | 2362.2 | 2642.4 |
| 2008 | 939.2 | 1743.8 | 2727.7 | 3029.5 | 1977.4 | 4489.8 |
| 2009 | 1707.6 | 1702.2 | 2417.3 | 2586.1 | 2120.7 | 2656.1 |
| 2010 | 2086.8 | 1539.5 | 2663 | 3770 | 1998.4 | 2896.7 |
| 2011 | 2172.1 | 1639.8 | 3068.7 | 3754.6 | 2453.1 | 3179.5 |
| 2012 | 2214.3 | 1598.3 | 2568.9 | 3028.4 | 2120.7 | 3089.5 |
| 2013 | 2569.5 | 1965.4 | 2530.4 | 2810.2 | 1860.4 | 2307.6 |
| 2014 | 2450.5 | 2049.5 | 2395.3 | 2685.5 | 1636.8 | 2108.5 |

**Table 3.** Descriptive statistics of annual rainfall of study areas.

| Yearly Rainfall (mm) | No. of Years | Minimum | Maximum | Mean | Standard Deviation | Skewness Coefficient | Kurtosis | CV |
|---|---|---|---|---|---|---|---|---|
| Lagos | 32 | 939.2 | 2569.5 | 1756.31 | 416.61 | -0.10 | -0.58 | 23.72 |
| Ibadan | 32 | 865.4 | 2049.5 | 1390.83 | 276.66 | 0.30 | 0.20 | 19.89 |
| Benin | 32 | 229.1 | 3068.7 | 2162.46 | 534.52 | -1.61 | 4.13 | 24.72 |
| Calabar | 32 | 1084 | 3770.0 | 2776.18 | 558.85 | -1.14 | 3.41 | 20.13 |
| Port Harcourt | 32 | 1632 | 2975.9 | 2197.99 | 279.29 | 0.91 | 0.23 | 12.71 |
| Warri | 32 | 1925.8 | 4489.8 | 2787.21 | 464.16 | 1.31 | 4.45 | 16.65 |

*CV* = Coefficient of variation.

From Table 3, the results show that Warri recorded the highest mean minimum and maximum values of annual rainfall; Ibadan has the lowest mean and maximum annual rainfall while Benin recorded the least minimum annual rainfall. Lagos has annual rainfall values fairly symmetrical with skewness coefficient of -0.10. The annual rainfall values here are light tailed distribution with kurtosis of -0.58 and are said to experience platykurtic distribution. The coefficient of variation for the annual rainfall for Lagos is obtained as 23.72%, indicating variability in annual rainfall distribution. Ibadan has an annual rainfall distribution fairly symmetrical, with skewness coefficient of 0.3; the kurtosis value of 0.20, which is greater than zero and so the rainfall values have leptokurtic distribution with heavier tails and a coefficient of variation of 19.89%. Benin has a rainfall distribution highly skewed with a skewness coefficient of -1.16, while the kurtosis value is 4.13, its distribution has heavier tails and it is a leptokurtic distribution and a coefficient of variation of 24.72%, which indicates more variability. Calabar is negatively skewed with skewness coefficient of -1.14 indicating that the rainfall values are highly skewed and frequently high. The kurtosis coefficient and coefficient of variation for Calabar are high with values as 3.41 and 20.13%; Calabar experiences leptokurtic distribution with kurtosis of 3.41, which is greater than zero. Port Harcourt is moderately skewed with skewness coefficient of 0.91, signifying that rainfall values are neither low nor high. The kurtosis coefficient for Port Harcourt is 0.23, showing that it has a normal distribution, which is also known as mesokurtic distribution. There is less variability in annual rainfall values with coefficient of variation of 12%, which is the lowest among the six stations examined. Warri has positively skewed rainfall distribution, with skewness coefficient of 1.31. Its kurtosis value is 4.45. This shows that Warri experiences leptokurtic distribution.

**Results of the Standardized Anomaly Index for the six states**

The result of the standardized anomaly index for Lagos is shown in Figure 1.

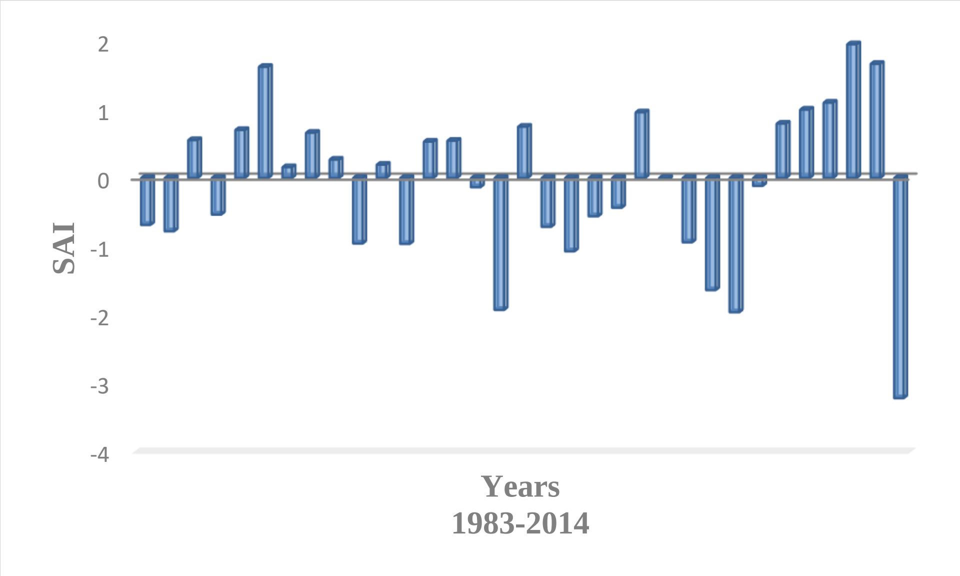


**Figure 1.** Standardized anomaly index for annual total rainfall at Lagos.

Lagos experienced a positive annual rainfall anomaly index above average from 1983 to 1997, with 6 respite years of negative anomaly index below long-term average. However, from 1998 there was a negative annual anomaly index below average with 2 respite years of positive anomaly index above long-term average until 2009. After 2009, there was positive departure, with long positive anomaly index above average up to 2014. In 1988, highest positive annual rainfall anomaly index above average was recorded, while the lowest negative rainfall anomaly index below average was recorded in 2008.

**The result of the standardized anomaly index for Ibadan**

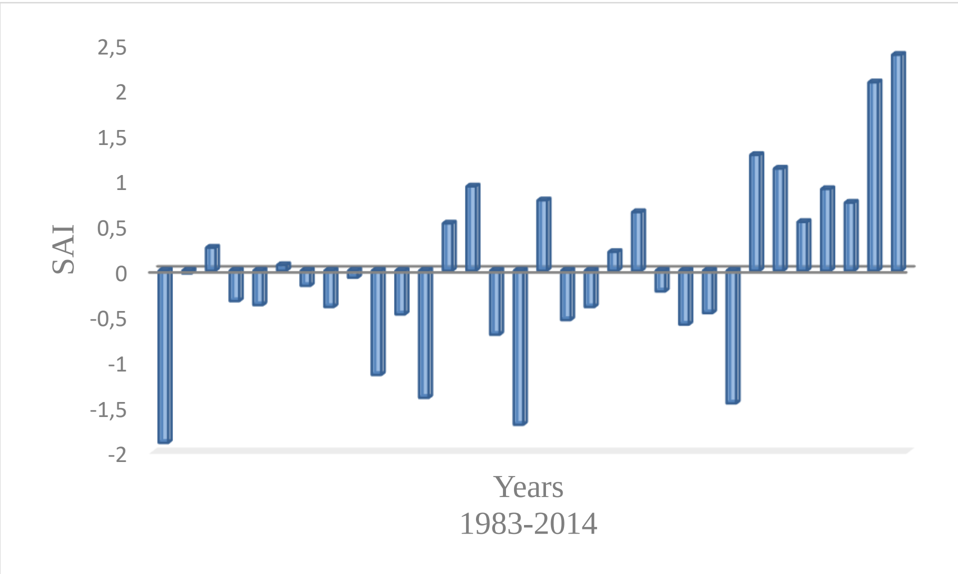


**Figure 2.** Standardized anomaly index for annual total rainfall at Ibadan.

Below long-term averages annual rainfall persisted during the period spanning 1983 to 2007, with 8 respites of positive anomaly index average years. Then there was strong positive departure above averages from 2008 until 2014 indicating period of high rainfall. Ibadan experienced highest rainfall anomaly index above average in 2014 and lowest negative rainfall anomaly index below average in 1983.

**The result of the standardized anomaly index for Benin**

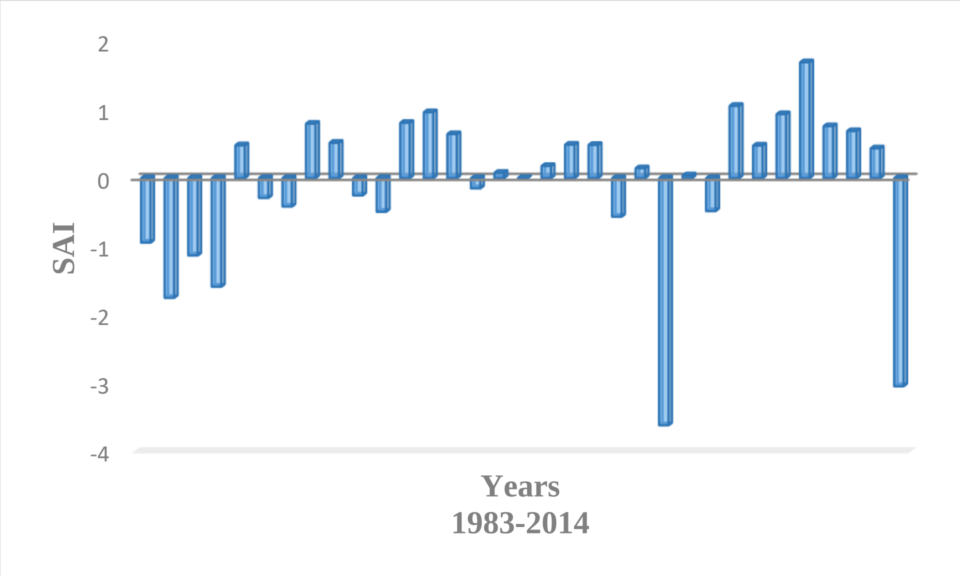


**Figure 3.** Standardized anomaly index for annual total rainfall at Benin.

Benin was marked with below long-term average between 1983 and 1986 indicating period of low annual rainfall. After 1986, there was above long-term averages of annual rainfall during the period spanning 1987 to 2014, with 9 respites of negative anomaly index below average.

**The result of the standardized anomaly index for Calabar**

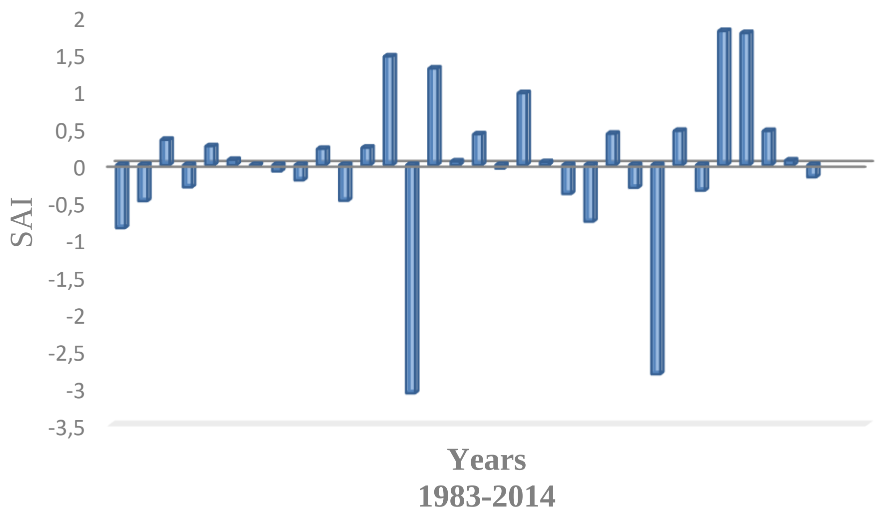


**Figure 4.** Standardized anomaly index for annual total rainfall at Calabar.

Below long-term averages of annual rainfall persisted during the period spanning 1983 -1995 with 5 respites of positive anomaly index above average indicating period of low rainfall years at Calabar. After 1995, there was alternate positive anomaly index above average and negative rainfall anomaly index below average until 2014.

**The result of the standardized anomaly index for Port Harcourt**

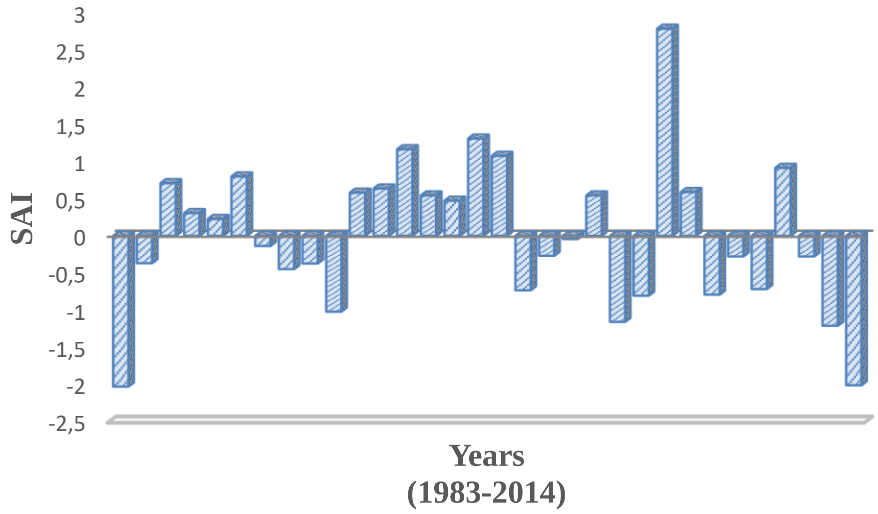


**Figure 5.** Standardized anomaly index for annual total rainfall at Port-Harcourt.

Port Harcourt was marked with below average annual rainfall from 1983 to 1984; followed by alternate high and low rainy years from 1985 to 1992. After 1992, there was above long-term average between 1993 and 1999, followed by alternate high and low rainy years until 2014. Port Harcourt experienced the highest positive rainfall anomaly index in 2006 and lowest negative rainfall anomaly index in 1983.
The result of the standardized anomaly index for Warri.

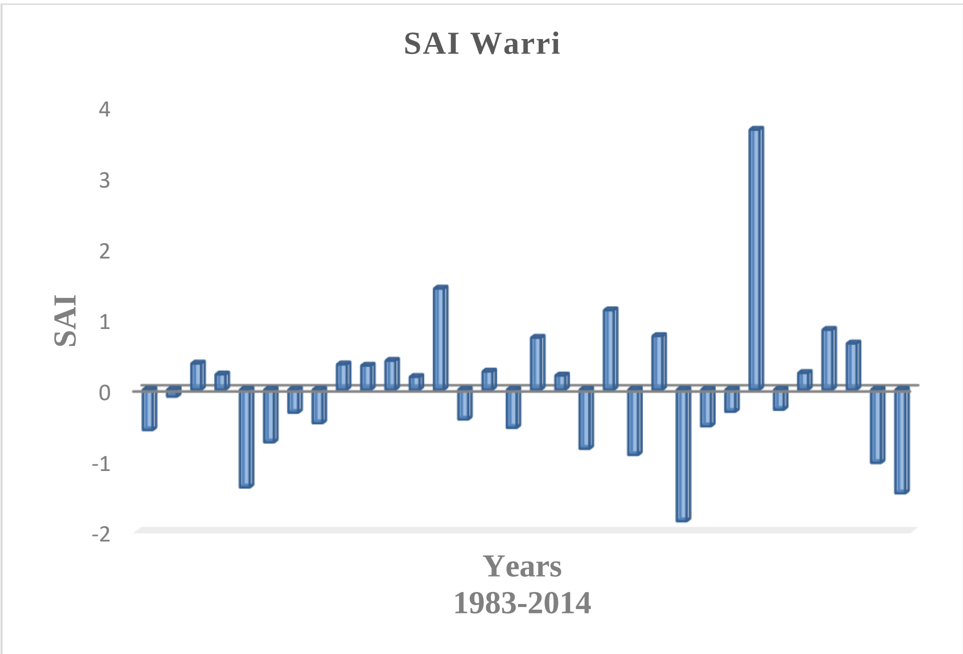


**Figure 6.** Standardized anomaly index for annual total rainfall at Warri.

Warri experienced below long-term averages annual rainfall during the period spanning 1983 to 1990 with 2 respites of positive anomaly index above average years. From 1991, there was positive departure above average until 1995. From 1996, Warri experienced alternate negative anomaly index below average and positive anomaly index above average until 2014.

**Results on trend plots of annual rainfall for the six selected locations**

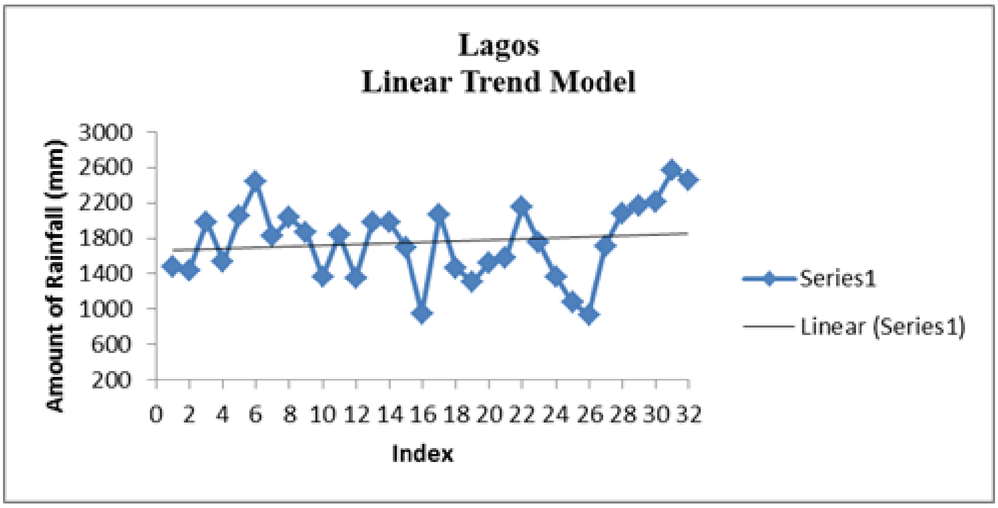


**Figure 7.** Trend plot of annual rainfall in Lagos.

From the graph the linear trend line is positive, indicating a progressive increase in the annual rainfall during the period of study in the region.

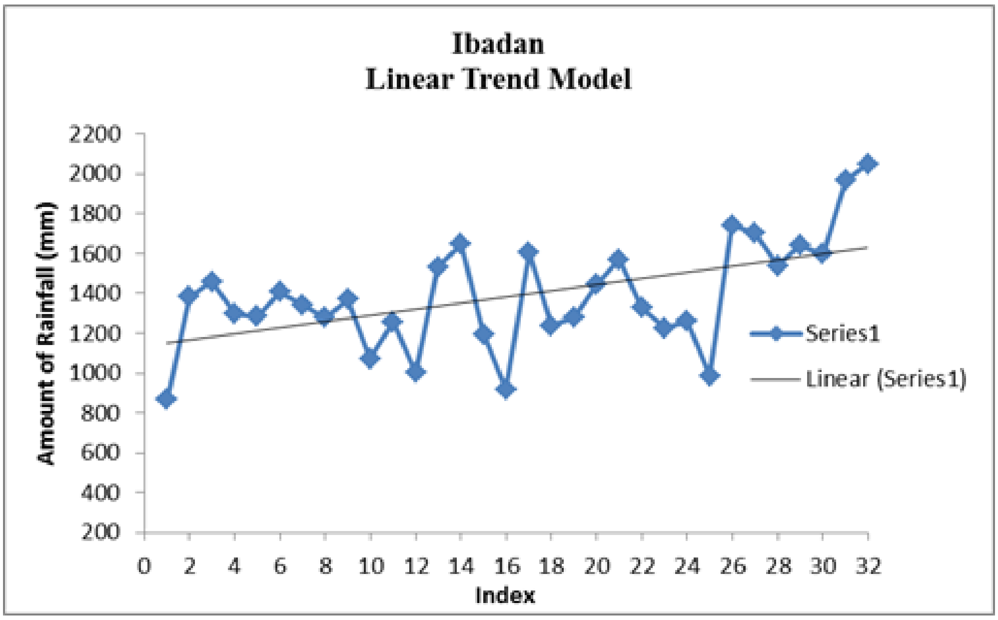


**Figure 8.** Trend plot of annual rainfall in Ibadan.

From the graph, the trend in rainfall shows a decrease in rainfall as indicated by the decreasing linear trend line. This means that rainfall amount decreases as the years went by.

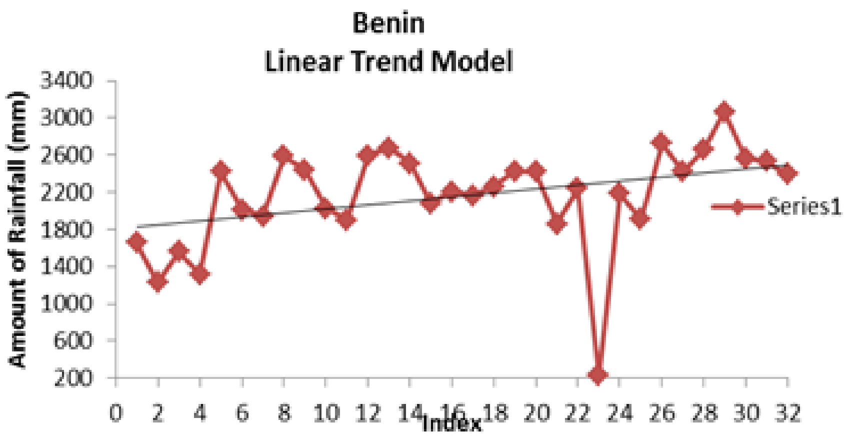


**Figure 9.** Trend plot of annual rainfall in Benin.

From the graph the linear trend line is positive, indicating a progressive increase in the annual rainfall during the period of study in the study area.

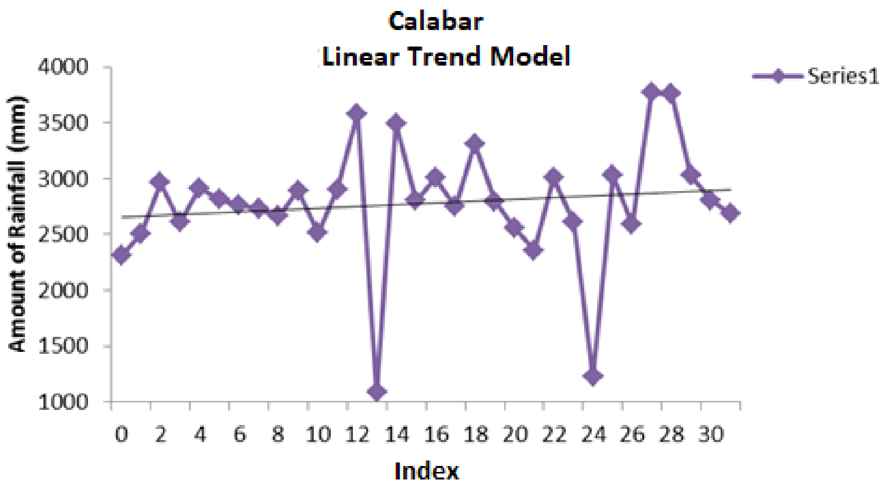


**Figure 10.** Trend plot of annual rainfall in Calabar.

The graph the linear trend line is positive, indicating a progressive increase in the annual rainfall during the period of study in the study area.

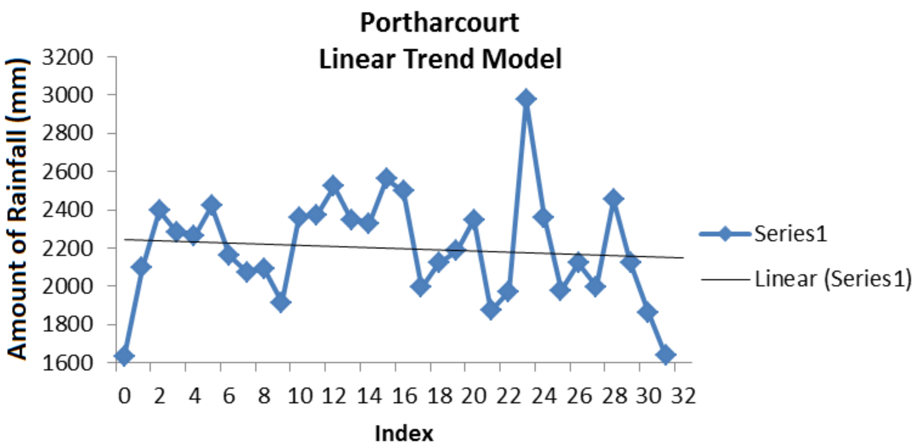


**Figure 11.** Trend plot of annual rainfall in Port Harcourt.

From the graph, the trend in rainfall shows a decrease in rainfall as indicated by the decreasing linear trend line. This means that rainfall amount decreases as the years went by.

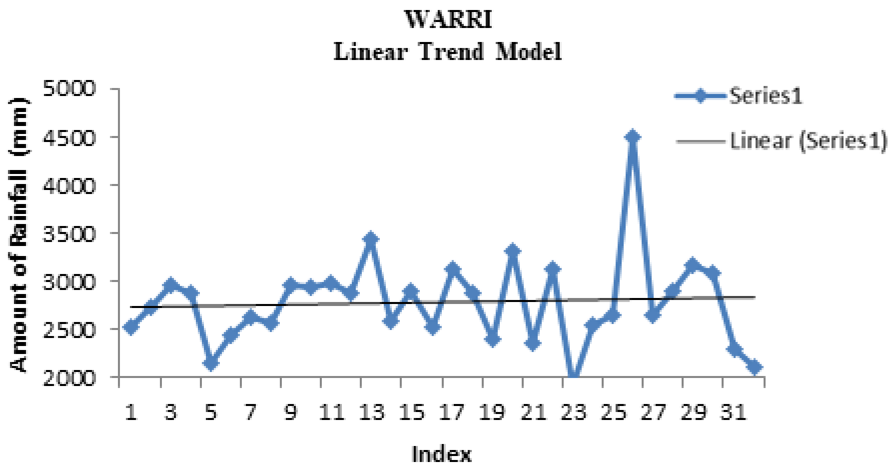


**Figure 12.** Trend plot of annual rainfall in Warri.

It is evident that the year 2005 recorded the lowest annual rainfall of 1925.8, while the year 2008 recorded the highest rainfall of 4489.80 mm.

**Results of Rainfall Intensity Duration Frequency Models and their parameter values**

The parameter values used in deriving the Gumbel and Log Pearson Type 111 models, including the models for each region are shown in Table 4.

**Table 4:** Parameters values used in deriving models for rainfall intensity at different locations.

| S/No. | Location | Distribution | Parameters | | | | Models |
|---|---|---|---|---|---|---|---|
| | | | *a* | *b* | *c* | *d* | |
| **1.** | Ibadan | Gumbel | 108 | 1.18 | 0.86 | 44.18 | $I = \frac{108{T_r}^{1.18}}{(t+44.18)^{0.86}}$ |
| | | Log Pearson Type III | 134 | 1.26 | 0.75 | 36.79 | $I = \frac{134{T_r}^{1.26}}{(t+36.79)^{0.75}}$ |
| **2.** | Benin | Gumbel | 131 | 1.41 | 0.82 | 43.53 | $I = \frac{131{T_r}^{1.41}}{(t+43.53)^{0.82}}$ |
| | | Log Pearson Type III | 139 | 1.64 | 0.84 | 40.57 | $I = \frac{139{T_r}^{1.64}}{(t+40.57)^{0.84}}$ |
| **3** | Calabar | Gumbel | 442 | 3.88 | 1.06 | 96.04 | $I = \frac{442{T_r}^{3.88}}{(t+96.04)^{1.06}}$ |
| | | Log Pearson Type III | 140 | 1.57 | 0.83 | 43.54 | $I = \frac{140{T_r}^{1.57}}{(t+43.54)^{0.83}}$ |
| **4.** | Lagos | Gumbel | 192 | 1.20 | 0.72 | 29.95 | $I = \frac{192{T_r}^{1.20}}{(t+29.95)^{0.72}}$ |
| | | Log Pearson Type III | 149 | 1.58 | 0.80 | 39.37 | $I = \frac{149{T_r}^{1.58}}{(t+39.37)^{0.80}}$ |
| **5** | Port-Harcourt | Gumbel | 135 | 1.72 | 0.83 | 46.35 | $I = \frac{135{T_r}^{1.72}}{(t+46.35)^{0.83}}$ |
| | | Log Pearson Type III | 140 | 1.23 | 0.73 | 30.33 | $I = \frac{140{T_r}^{1.23}}{(t+30.33)^{0.73}}$ |
| **6.** | Warri | Gumbel | 136 | 1.50 | 0.79 | 39.18 | $I = \frac{136{T_r}^{1.50}}{(t+39.18)^{0.79}}$ |
| | | Log Pearson Type III | 148 | 1.36 | 0.77 | 34.94 | $I = \frac{148{T_r}^{1.36}}{(t+34.94)^{0.77}}$ |

Table 4 shows the different models derived for the estimation of future trends in rainfall in the study area and beyond.

## CONCLUSION

This research indicates the procedure for the development of precipitation (rainfall) intensity duration frequency models for selected locations in humid forest zones of Nigeria. The studied locations are Lagos, Ibadan, Benin, Calabar, Port Harcourt and Warri in Nigeria. The study also surveyed tendencies and fluctuations in rainfall, rainfall anomaly index and significant variations in rainfall pattern of the locations under investigation. The trend analysis result shows obvious fluctuating precipitation pattern across the observed years. This has made it impossible to forecast the precipitation for a feature season. The following conclusions and recommendation were drawn from the study; the climate of the studied regions shows precipitation characterized by alternating wet and dry periods. Rainfall and temperature are the core variables that enhance human well- being, plant growth and crop production etc. Incessant variation in rainfall pattern might result to unfavorable growth conditions and thereby enhances the breeding of anopheles mosquitoes, which in turn causes malaria. To achieve adequate climate forecasting capacity, the study therefore recommends that qualitative climatic data which should be made available and accessible for easy analysis and for future prediction a valuable model was derived to enhance researchers who may want to estimate the precipitation trends in Nigeria and the world.

## DECLARATION OF COMPETING INTEREST

Authors hereby declare that there is no conflicting of interest whatsoever.

## CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

The authors hereby declare that the contributions given are correct.
**Cordella Chika Emeka-Chris**: Writing original draft and statistical review.
**Christopher Ikechi Obineche**: Validation, review and methodology.
**Bejoy Otuobi Unanka:** Investigation and preview.

## ETHICS COMMITTEE DECISION

This article does not require any ethical committee decision.

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