Quantification of historical drought conditions over different climatic zones of Nigeria

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Abstract
The impact of extreme climate such as drought and flooding on agriculture, tourism, migration and peace in Nigeria is immense. There is the need to study the trend and statistics for better planning, preparation and adaptation. In this study, the statistical and temporal variation of climatic indices Standardized Precipitation Index (SPI) and Standardized Precipitation Evapotranspiration Index (SPEI) was computed for eighteen (18) stations covering four climatic zones (Sahel, Midland, Guinea Savannah and Coastal) of tropical Nigeria. Precipitation, minimum and maximum temperature from 1980 to 2010 obtained from the archives of the Nigerian Meteorological Services were used to compute both the SPI and SPEI indices at 1-, 3-, 6- and 12-month timescales. The temporal variation of drought indices showed that droughts were more prominent at 6- and 12-month timescales. SPI and SPEI were found to be better correlated at longer timescales than short timescales. Predominant small, positive and significant trend across the region suggest an increasing trend due to climate change.

Keywords Climate indices · Standardized Precipitation Index · Standardized Precipitation Evapotranspiration Index · Nigeria · Climate change

Introduction
Drought is an unusual period of dryness as a result of low precipitation or high temperature (Sordo-Ward et al. 2017). A drought event is characterized by a continuous shortage of water due to low rainfall over a period of time (Chen et al. 2009). The occurrence of drought in a location over a long period of time is referred to as severe drought (Muhammad et al. 2017). Droughts have become a consistent global climatic occurrence (Pereira et al. 2009). Intense drought conditions have been linked to the accumulation of greenhouse gases especially from decades of industrial activities (Gudmundsson and Seneviratne 2015; Stocker 2014; Field et al. 2012). Drought events in different regions of the globe vary in intensity (severity or magnitude), frequency of occurrence and duration (Wilhite 1993; Dracup et al. 1980). The effects of drought have far reaching impact on agriculture, ecology, health. Droughts that have direct effects on crop growth and yield as a result of dryness in their roots are referred to as agricultural droughts. Ahmad et al. (2004) reported that agricultural drought occurred in Pakistan during years 2000 and 2001. During the same period, there was a severe drought in North Korea that led to a significant drop in food production (Josserand et al. 2008). Other types of physical droughts are: meteorological and hydrological droughts (Khan et al. 2018). Keyantash and Dracup (2002) described a non-physical form of drought referred to as socioeconomic drought. Blain (2012) emphasized the slowly accumulating effect of drought and the need for its early detection. Notably, there is an expected increase in the severity, spread and effect of drought in some African countries by 2020 (Pachauri and Reisinger 2008) and increase in politically neglected people (Detges 2017).

Several indices have been developed to quantify the effect and impact of drought. These include the Standardized Precipitation Index (SPI), Standardized Precipitation Evapotranspiration Index (SPEI), Percent of Normal (PN), Effective Drought Index (EDI), Surface Water Supply Index (SWSI), Palmer Drought Severity Index (PDSI),
Reconnaissance Drought Index (RDI) and Normalized Difference Water Index (NDWI). The choice of a drought index depends on the type of drought as each index in use has its uniqueness and application; some of which were highlighted in Khan et al. (2018) and Mishra and Singh (2010). SPI has an advantage in its usefulness for impact assessment of agricultural droughts (Zargar et al. 2011). Furthermore, the SPI is also recommended for the characterization of meteorological droughts all over the world (Blain 2012). Statistical relationship has been established between some of the indices. Oloruntade et al. (2017) found high correlations values of 0.65 and 0.55 between SPI and SPEI at 3 months and 12 months in the Niger-South Basin area of Nigeria. SPI and SPEI values were found to produce similar droughts characteristics over the Volta basin with a correlation of 0.97 in observed and simulated data (Oguntunde et al. 2017).

The role of large-scale oscillations in continental drought phenomena have been investigated by several authors. Positive correlation has been reported between Atlantic Nino 1 along the coastal regions of West Africa, while a negative correlation prevails in the Sahel region (Adeniyi and Dilau 2018). Ndehedehe et al. (2016) reported that El Nino Southern Oscillation (ENSO), Atlantic Multi-decadal Oscillation and Atlantic Meridional Mode (AMM) are associated with extreme rainfall conditions with statistically significant relationship between Atlantic Multi-decadal Oscillation (AMO) and SPI at 12 months. Coupled ocean–atmosphere phenomena has been found to influence drought events within the Greater Horn of Africa region (Mpelasoka et al. 2018). The role of large-scale oscillation in drought over West Africa was investigated by Ogunjo et al. (2019). The authors reported that Southern Oscillation Index showed positive correlation with drought in the West African region, while Pacific Decadal Oscillation and North Atlantic Oscillation both showed negative correlation with drought in the region.

Estimated drought vulnerability index over Africa during the period 1960–2015 showed that northern African countries such as Egypt, Tunisia and Algeria were the least drought vulnerable countries, and the trend will continue in the future (Ahmadalipour and Moradkhani 2018). Studies on drought over Nigeria have always considered subregions. Report by Oloruntade et al. (2017) showed that the Niger-South basin is dominated by wet conditions in the period 1970–2008. The investigation by Ndehedehe et al. (2016) around the Lake Chad basin showed relatively wet conditions in the last two decades using SPI at 12 month scale. Using data from 1916 to 1987, the length and severity of drought in the northern part of the country were found to vary from sub-area to sub-area with very low interannual persistence (Oladipo 1993). High-resolution, multiproxy paleolimnological record from northeastern Nigeria suggests that abrupt cooling events and intense El Nino Oscillation might have been responsible for prolonged drought in the region (Street-Perrott et al. 2000).

Statistical investigation of drought in the savanna region of Nigeria revealed a significant long-term increasing trend in the region (Oladipo 1995). Using the Bhalme and Mooley Drought Index (BMDI) approach, the intensity of drought in the Sudano-Sahelian region of Nigeria, low intensity drought was found to be prevalent in the region from 1948-2010 (Kayode and Francis 2012).

In this study, we aim to investigate the statistics of drought across the different climatic zones of Nigeria using SPI and SPEI. The correlation between the two drought indices will be investigated, as well as, their regression analysis, trend and frequency distributions. Results from this study are expected to show the comparative drought risks across the different regions in Nigeria and provide information for strategic planning and adaptation.

**Methodology**

Eighteen locations across the four climatic zones of Nigeria, as described by Adeyemi and Emmanuel (2011), were considered in this study. The geographical coordinates and statistics of the location are presented in Table 1, and the temporal variation of mean regional precipitation is shown in Fig. 1. Stations were chosen based on availability of data in the study period. Monthly precipitation, minimum temperature and maximum temperature data were obtained from the archives of the Nigerian Meteorological Services from 1980 to 2010. To compute the impact of drought, the Standardized Precipitation Index (SPI) and Standardized Potential Evapotranspiration Index (SPEI) were chosen for their simplicity. They require simple and ready to use atmospheric variable, easy to compute and generally recognized as efficient in capturing drought events. To analyze the results, the linear correlation, regression and trend analyses were used. While correlation shows how one variable changes with respect to another, linear regression gives quantitative value to the dependence of a variable on another. Mann–Kendall analysis is used to detect consistently increasing or decreasing trends in a given data. As a nonparametric test, it does not make assumption about the distribution of the data.

The Standardized Precipitation Index (SPI) is based on the use of probability distribution to evaluate the departure of precipitation during a time span from the mean value (Oguntunde et al. 2017). The parameters, $\alpha$ and $\beta$, of a gamma distribution obtained are from maximum likelihood estimation when precipitation data are fitted to a gamma distribution given by

$$G(x) = \frac{1}{\beta^\alpha \Gamma(\theta)} \int_0^x x^{\alpha-1} e^{-x/\beta} dx$$  \hspace{1cm} (1)

where $x > 0$, $\Gamma$ is the gamma function, $\alpha$ and $\beta$ are the form and scale parameter, respectively. The Standardized Potential evapotranspiration Index is computed in the same way,
however, with the consideration of potential evapotranspiration (Oguntunde et al. 2017; Oloruntade et al. 2017). In the computation of SPEI, the difference between precipitation and potential evapotranspiration is used instead of precipitation in SPI. To compute the potential evapotranspiration, the method proposed by Thornthwaite (1948) was used because of its simplicity. The drought indices are classified as

\[
\text{SPI} = \begin{cases} 
\text{SPI} \geq 2.00, & \text{Extremely wet (EW)}; \\
1.50 \leq \text{SPI} < 2.00, & \text{Very wet (VW)}; \\
1.00 \leq \text{SPI} < 1.50, & \text{Moderately wet (MW)}; \\
-1.00 \leq \text{SPI} < 1.00, & \text{Near Normal (NN)}; \\
-1.50 \leq \text{SPI} < -1.00, & \text{Moderately drought (MD)}; \\
-2.00 \leq \text{SPI} < -1.50, & \text{Severely drought (SD)}; \\
\text{SPI} < -2.00, & \text{Extreme drought (ED)}.
\end{cases}
\]
Correlation coefficient shows the degree of association between two variables. The Pearson’s correlation coefficient, \( \rho \) is defined as

\[
\rho = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2 \sum_{i=1}^{n}(y_i - \bar{y})^2}}
\]  

(3)

The values of \( \rho \) in the ranges \(-1 \leq \rho \leq 0 \) and \( 0 \leq \rho \leq 1 \) represent positive and negative correlation, respectively. If \( \rho = 0 \), the two time series are said to be uncorrelated. The linear relationship between SPI and SPEI was computed using the regression analysis. Regression analysis shows the dependence of a variable on another (Fuwape and Ogunjo 2018). A simple linear regression is of the form \( y = ax + b \), where \( x \) and \( y \) are the independent and dependent variable, respectively, \( a \) and \( b \) are constants to be determined by minimizing the function

\[
Q = \sum_{i=1}^{n} \left( y_i - (ax_i + b) \right) = 0
\]  

(4)

The Mann–Kendall test statistics \( S \) is based on the pairwise comparison of each data points with all preceding data points.

\[
S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} \text{sgn}(x_j - x_k)
\]  

(5)

where \( n \) is the length of the time series \( x_1, \ldots, x_n \), \( \text{sgn}(\cdot) \) is a sign function, while \( x_j \) and \( x_k \) are values in years. The variance of \( S \) is computed as:

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

(6)

where \( q \) is the number of tied groups and \( t_p \) is the number of data values in the \( p \)th group (Oguntunde et al. 2017; Fuwape and Ogunjo 2018). The test statistic \( Z \) obtained as:

\[
Z = \begin{cases} 
\frac{S-1}{\sqrt{\sigma^2(S)}}, & \text{if } S > 0; \\
0, & \text{if } S = 0; \\
\frac{S+1}{\sqrt{\sigma^2(S)}}, & \text{if } S < 0.
\end{cases}
\]  

(7)

If the trend of a time series is assumed to be linear and of the form \( f(t) =\beta t + B \), Sen slope (\( Q \)) can be estimated from the expression

\[
Q = \frac{x_j - x_k}{j - k}
\]  

(8)

Results and discussion

The temporal evolution of mean SPI and SPEI values at 1-, 3-, 6- and 12-month timescales is presented in Figs. 2, 3, 4 and 5, respectively. The SPEI values at 1-month in the Sahel and Midland region showed periodic occurrences which can be attributed to the short but intense dry seasons experienced in the regions (Fig. 2a, b). The drought intensity in these regions tends to be higher than the intensity in the Guinea Savannah and Coastal regions. At 3-month scale (Fig. 3), the seemingly periodicity in mean SPI/SPEI values persists in the Sahel but not in the Midlands. A significant drought event could be seen in 1982–1983 in the Coastal region. Considering the temporal variation of the indices at 6- and 12-month timescales, periodicity was no more obvious in the Sahel region. Prominent drought regimes and general agreement between SPI and SPEI could be observed in 1983, 1990, 1992/93 and 2004. The drought periods observed are in agreement with reported drought periods in the region (Oguntunde et al. 2017; Ndihedehe et al. 2016).

The linear correlation between SPI and SPEI at different timescales (1, 3, 6, 12) for the locations in each climatic zones is presented in Table 2. In the Sahel region, the strongest was observed at 12-month. Maiduguri has the lowest correlation values at both 3- and 6-month scales, while Sokoto and Katsina have the lowest correlation values between SPI and SPEI at 1- and 12-month scale, respectively. In the Midland area, Kaduna has the highest correlation values between SPI and SPEI, while the lowest correlation values were observed in Yola. Warri, in the Guinea savannah, was found to have the highest correlation values for the region at all scales. The lowest correlation values were obtained at the 1-month scale. An unusually low correlation value was observed at 3-month scale for Calabar in the coastal region. The correlation values were observed to increase in the progression Sahel–Midland area–Guinea Savanna–coastal area. This increasing trend could be attributed to the reducing effect of evapotranspiration as one moves from the northern region to the coastal area of the country. In a study over the Niger-South basin of Nigeria, (Oloruntade et al. 2017) obtained correlation in the range 0.56–0.66. The study by Oloruntade et al. (2017) used gridded dataset produced by the Climate Research Unit, University of East Anglia for the period 1970–2008, while our investigation considered in situ data from the Nigerian Meteorological Services for the period for the period 1980–2010. This range is lower than the values obtained in this work for the same region.
Fig. 2 Mean SPI and SPEI values for a Sahel, b Midland, c Guinea Savanna and d Coastal regions at 1-month timescale

Fig. 3 Mean SPI and SPEI values for a Sahel, b Midland, c Guinea Savanna and d Coastal regions at 3-month timescale
The differences can be attributed to different data sources and time range. SPI and SPEI have better comparative performance at longer timescales than shorter durations.

A linear regression of the two indices showed the same trend as correlation analysis (Table 3). The best fit in the Sahel region was found in Kano at 12-month
scale with slope and $r^2$ values close to 1. The weakest fits were observed in Sokoto at 1- and 3-month scales.

The regression fit for the Sahel region showed better fit at 12-month scale compared to other scales. In the Midland region, the worst regression fit could be found in Yola. The location has the lowest slope and $r^2$ values for the region. The performance of the fit was better in the Guinea Savannah and the Coastal region. Calabar showed perfect fits with good coefficient of determination for the Coastal region. The Guinea Savannah and Coastal regions of Nigeria have longer wet seasons, short dry seasons and larger amount of precipitation than the Midland and Sahel region.

Trend over the study period was computed for SPI and SPEI (Table 4) using Mann–Kendall algorithm. Trends in SPI and SPEI at all timescales were in the range $-0.00349$ to $-0.007$ and $-0.00135$ to $-0.007$ respectively. The trend values obtained for SPI are less than the range of $-0.026$ to $-0.011$ obtained in Southern Portugal at 12-month timescale (Costa 2011). In the Sahel region, all locations exhibit positive trends at all timescales except Sokoto which has negative trends. In the Midland region, Minna has positive trends at all timescales, while the other two locations in the region showed negative trends. In the Guinea Savannah, Warri is the exception with negative trend at all timescales, while in the Coastal region, Lagos, Akure and Owerri are the stations with negative trends. The varying trend signs within regions are attributed to local dynamics and topography. Locations in all the regions have the same trend sign in both SPI and SPEI except Markudi, Warri and Akure at the 1-month timescale.
timescale; Lagos, Owerri and Akure at 3-month timescale; Yola, Lagos and Owerri at 6-month timescale; and Owerri at 12-month timescale. All these locations have negative signs in SPI but positive signs in SPEI computation. The trends were found to be significant at 95% confidence interval except locations in Sahel and Midland regions at 1- and 3-month timescale for SPEI and Sokoto, Minna and Yola at 6- and 12-month timescales. The trend values are similar to those obtained in Cyprus by Katsanos et al. (2018) but lower than that reported by Oguntunde et al. (2017) for the same region at 12-month scale. In the report by Oguntunde et al. (2017), a longer period of time was used, different data source as well as a different method of computing the slope was used, and ecological zones were considered rather than climatic zones at only 12-month timescale.

Frequency distribution of SPI and SPEI classes is shown in Tables 5, 6, 7 and 8 at 1-, 3-, 6-, and 12-month timescales, respectively. In the Sahel and Midland regions, the occurrences of near normal events were greater in SPI than SPEI at 1- and 3-month timescales as opposed to the occurrences being greater in SPEI for both Guinea Savannah and Coastal regions. This trend was not noticeable at 6- and 12-month timescales. This implies that both SPI and SPEI have comparative performance at higher timescales than shorter timescales. It can be inferred that atmospheric–land interactions such as El Nino and Atlantic Nino 1 influence drought at short timescales. Atlantic Nino 1 has been reported to have positive correlation with SPEI in the coastal regions of West Africa but negative correlation in the Sahel regions (Adeniyi and Dilau 2018). It has also been posited that El Nino Southern Oscillation—ENSO, Atlantic Multi-decadal Oscillation—AMO, and Atlantic Meridional Mode—AMM can be responsible for the results obtained 12-month timescale (Ndehedehe et al. 2016). Near normal condition was found to be predominant in all the analyses. A noticeable trend in all climatic zones is the higher number of occurrences of MD values in SPI than the MD values obtained under SPEI.

### Conclusion

In this study, the performance and statistics of two drought indices were investigated over different climatic zones of Nigeria. The study considered eighteen locations over a period of thirty-one years. At 1- and 3-month scale, both SPI and SPEI are predominantly periodic in the Sahel and Midland regions indicating a harsh and severe dry season. At longer timescales, SPI and SPEI have stronger correlation than at shorter timescales. This trend was also reflected in the regression coefficient between the two indices. The regression fits were better in the southern part of the country than the northern part of the country. Comparative trend
analysis of drought over Nigeria using SPI and SPEI were also carried out. Results obtained indicate that small but positive significant trends were predominant over the region in the period under consideration. Finally, the statistical distribution of both SPI and SPEI at different timescales reveals the prevalence of near normal conditions. It is posited that

| Region    | Location | SPI         | SPEI        |
|-----------|----------|-------------|-------------|
|           |          | EW  | VW  | MW  | NN  | MD  | SD  | ED  | EW  | VW  | MW  | NN  | MD  | SD  | ED  |
| Sahel     | Sokoto   | 4   | 18  | 45  | 221 | 50  | 19  | 3   | 7   | 40  | 25  | 211 | 27  | 12  | 8   |
|           | Maiduguri| 4   | 21  | 34  | 230 | 52  | 14  | 5   | 8   | 7   | 54  | 199 | 19  | 10  | 5   |
|           | Kano     | 12  | 11  | 30  | 255 | 28  | 10  | 14  | 9   | 8   | 55  | 197 | 17  | 11  | 3   |
|           | Katsina  | 5   | 19  | 39  | 233 | 40  | 14  | 10  | 5   | 14  | 30  | 216 | 21  | 10  | 4   |
| Midland   | Kaduna   | 5   | 14  | 37  | 240 | 37  | 22  | 5   | 7   | 40  | 25  | 211 | 27  | 12  | 8   |
|           | Minna    | 2   | 23  | 46  | 231 | 37  | 13  | 8   | 5   | 18  | 33  | 264 | 22  | 8   | 10  |
|           | Yola     | 6   | 13  | 43  | 233 | 39  | 21  | 5   | 7   | 38  | 61  | 213 | 23  | 9   | 9   |
| Guinea    | Lokoja   | 3   | 18  | 48  | 228 | 40  | 18  | 5   | 7   | 15  | 41  | 254 | 24  | 12  | 7   |
|           | Warri    | 7   | 11  | 49  | 228 | 40  | 22  | 3   | 8   | 11  | 42  | 254 | 28  | 16  | 1   |
| Coastal   | Lagos    | 5   | 19  | 42  | 230 | 44  | 16  | 4   | 3   | 17  | 37  | 244 | 33  | 15  | 11  |
|           | Akure    | 7   | 18  | 35  | 233 | 45  | 17  | 5   | 2   | 14  | 42  | 235 | 35  | 23  | 9   |
|           | PH       | 4   | 22  | 28  | 244 | 39  | 17  | 6   | 7   | 11  | 37  | 252 | 25  | 18  | 10  |
|           | Owerri   | 6   | 18  | 33  | 236 | 42  | 21  | 4   | 7   | 12  | 30  | 249 | 37  | 18  | 7   |
|           | Enugu    | 7   | 14  | 31  | 241 | 46  | 14  | 7   | 2   | 18  | 40  | 257 | 20  | 12  | 11  |
|           | Calabar  | 7   | 17  | 36  | 239 | 39  | 12  | 10  | 8   | 9   | 40  | 250 | 26  | 16  | 11  |
|           | Ogoja    | 5   | 21  | 31  | 248 | 30  | 20  | 5   | 8   | 19  | 28  | 260 | 23  | 12  | 10  |
|           | Abeokuta | 6   | 19  | 33  | 232 | 38  | 15  | 5   | 7   | 9   | 44  | 232 | 30  | 18  | 8   |

EW extremely wet, VW very wet, MW moderately wet, NN near normal, MD moderately dry, SD severely dry, ED extremely dry.
Table 7 Frequency distribution of SPI and SPEI drought indices at 6-month timescale

| Region      | Location | SPI       | SPEI       |
|-------------|----------|-----------|------------|
|             |          | EW 13 VW 38 MW 22 NN 2 MD 1 SD 2 | EW 7 VW 12 MW 26 NN 254 MD 33 SD 18 ED 10 |
|             |          | EW 23 VW 46 MW 20 NN 2 MD 3 SD 6 ED 17 | EW 7 VW 12 MW 26 NN 254 MD 33 SD 18 ED 10 |
| Sahel       | Sokoto   | 3 20 34 | 228 51 22 9 15 27 258 29 14 8 |
|             | Maiduguri| 3 20 34 | 228 51 22 9 15 27 258 29 14 8 |
|             | Kano     | 13 11 25 | 254 35 11 10 12 36 250 31 18 3 |
|             | Katsina  | 0 13 26 | 225 43 20 3 6 17 42 248 26 17 4 |
| Midland     | Kaduna   | 6 12 39 | 240 34 26 3 7 12 26 254 33 18 10 |
|             | Minna    | 1 20 51 | 225 40 16 7 2 15 36 258 21 11 17 |
|             | Yola     | 7 15 31 | 244 33 23 7 4 18 25 263 27 14 9 |
|             | Warri    | 4 17 44 | 239 31 22 3 12 11 38 243 39 12 5 |
|             | Lagos    | 2 22 36 | 237 35 24 4 0 21 34 248 27 16 14 |
|             | Akure    | 9 15 30 | 242 39 20 5 5 14 31 247 31 21 11 |
|             | Warri    | 7 17 27 | 249 31 24 5 9 15 28 245 34 28 1 |
|             | Warri    | 2 20 42 | 229 34 16 5 6 11 40 228 30 28 5 |

EW extremely wet, VW very wet, MW moderately wet, NN near normal, MD moderately dry, SD severely dry, ED extremely dry

Table 8 Frequency distribution of SPI and SPEI drought indices at 12-month timescale

| Region      | Location | SPI       | SPEI       |
|-------------|----------|-----------|------------|
|             |          | EW 13 VW 38 MW 22 NN 2 MD 1 SD 2 | EW 7 VW 12 MW 26 NN 254 MD 33 SD 18 ED 10 |
|             |          | EW 23 VW 46 MW 20 NN 2 MD 3 SD 6 ED 17 | EW 7 VW 12 MW 26 NN 254 MD 33 SD 18 ED 10 |
| Sahel       | Sokoto   | 1 20 43 | 228 47 20 1 0 29 22 246 29 22 12 |
|             | Maiduguri| 1 20 43 | 228 47 20 1 0 29 22 246 29 22 12 |
|             | Kano     | 7 26 20 | 253 40 2 12 1 30 34 222 42 31 0 |
|             | Katsina  | 3 17 39 | 227 51 23 0 2 16 66 216 28 25 7 |
| Midland     | Kaduna   | 5 15 36 | 235 36 29 4 7 12 15 262 24 29 11 |
|             | Minna    | 7 12 36 | 248 27 21 9 0 14 40 263 7 11 25 |
|             | Yola     | 5 23 21 | 245 35 27 4 0 13 42 255 24 5 21 |
| Guinea Sav. | Lokoja   | 2 25 38 | 233 33 29 0 8 14 48 223 42 17 8 |
|             | Markudi  | 12 3 51 | 242 37 17 6 15 19 13 252 35 20 6 |
|             | Warri    | 3 21 47 | 224 43 19 3 10 12 37 238 44 14 5 |
| Coastal     | Lagos    | 6 16 42 | 235 37 21 3 3 19 38 247 27 13 13 |
|             | Akure    | 12 12 24 | 247 40 21 4 17 7 24 256 23 22 11 |
|             | PH       | 10 10 39 | 241 37 18 5 3 17 51 228 33 22 6 |
|             | Owerri   | 1 29 28 | 237 39 26 0 12 13 23 262 22 13 15 |
|             | Enugu    | 5 15 32 | 239 51 12 6 0 14 49 250 31 3 13 |
|             | Calabar  | 3 22 37 | 233 45 16 4 20 14 26 242 39 17 2 |
|             | Ogoja    | 1 25 56 | 221 45 6 6 11 20 48 226 39 10 6 |
|             | Abeokuta | 0 22 56 | 211 40 17 2 3 17 46 217 33 20 12 |

EW extremely wet, VW very wet, MW moderately wet, NN near normal, MD moderately dry, SD severely dry, ED extremely dry
coupled ocean–atmosphere is responsible for the statistical distribution across the different climatic regions.

There is the need for spectral analysis to determine the frequency of occurrence of drought in the region. Furthermore, the role of ocean–atmosphere coupling such as ENSO in drought frequency over the region is worthy of investigation.

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