TREND OF RAINFALL CYCLE AND ITS IMPLICATION FOR AGRICULTURAL AND HYDROLOGICAL PLANNING IN THE GUINEA ECOLOGICAL ZONE, NIGERIA

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Abstract
The impact of rainfall on man in the Guinea Ecological Zone, Nigeria (GEZN) is great because it controls greater part of his economic activities especially agriculture and hydrology/water resources. This study aimed at assessing the trend of rainfall cycle over the GEZN and its implication on agriculture and hydrology/water resources. Daily rainfall for the period of thirty five (35) years (1981-2015) for the nine (9) synoptic stations within the study area were obtained from Nigerian Meteorological Agency and analysed. The data were analysed using various programs written in MATLAB (and named prepNN1.m, prepNN2.m, plot_Year.m, running1.m, periodogram) and other statistical methods. Results were presented in figures and table. Part of the results showed that the highest cycle per year of 0.2 was observed over Jos, while the lowest of 0.0898 was observed over Lafia. The conclusion revealed an inter-annual variability in rainfall across the data collection points, number of cycles within the study period is between 3-5, highest number of years per cycle was 12.8 years, while the lowest was 5 years, year with highest rainfall before a trough ranges between 2013-2015, while year with the lowest rainfall before a peak ranges between 2011-2015. The peak year of rainfall ranges between 2017 and 2019, while the drop year ranges between 2016 and 2019. The peak rate of rainfall ranges between 36.2 mm and 82.1 mm, while the trough rate ranges between 26.8 mm and 73.6 mm. Rainfall amount for the peak year ranges between 1232.2 mm and 1555.7 mm, while rainfall amount for the trough year ranges between 1040 mm and 1893.3 mm. Recommendations focused on the need for frequent rainfall forecast, irrigation, hybrid cropping, construction of more water reservoirs and dams in the study area.

Keywords: Rainfall monitoring, Rainfall variability, Rainfall cycle, Flooding, Irrigation

Introduction
The most important weather parameter in the Guinea Ecological Zone, Nigeria (GEZN) in particular and Nigeria in general is rainfall which varies in types, such as convectional, relief (or orographic) and cyclonic (or frontal). Rainfall is considered as the most important weather variable due to its significant role in providing the largest percentage of water needed for agriculture, rural domestic water supply, stream/river flow, recharging of underground water and modification of temperature at the lower tropospheric level. Ochei and Oluleye (2017) observed that the study of weather and climate elements of a region is vital for sustainable development of agriculture and planning such as the temporal analyses for trends, fluctuations and periodicities of rainfall and temperature. Abubakar (2015) on his part averred that rainfall plays an important role in the hydrological cycle.

Rainfall is highly varied over time and space. This variability is viewed in the onset, cessation, duration, total amount (daily, weekly, pentad, annual and decadal), intensity and periodic peak. According to Usman *et al*. (2015) cited in Ibrahim *et al.* (2018), there is high inter-annual and intra-seasonal rainfall variabilities. These attributes of rainfall have great impacts on rain-fed agriculture which is the main socio-economic activity of the rural dwellers and hydrology/water resources in Nigeria. Rainfall peak occurs in cycles over the years. Although, researches have shown that global warming is leading to an increase in rainfall across Nigeria Jain and Kumar, 2012 cited in (Adamu & Umar, 2016); rainfall fluctuation over the years have led to inter-annual variations. The period it takes from low to the peak of rainfall forms a cycle. The study conducted by Labaran and Ogallo (1986) using time series methods based on ARIMA and spectral analysis of areal annual rainfall of two (2) homogenous regions in East Africa recommended ARMA (3,1) as the best fit for areal indices of relative wetness/dryness and dominant quasi-periodic fluctuates around 2.2-2.8 years, 3-3.7 years, 5-6 years and 10-13 years.

Many researches have been carried out on rainfall including few on rainfall cycle in Nigeria. Umar (2012), Olatunde and Alaci (2012); Yusuf and Mohammed (2012) observed that, in Nigeria; rainfall varies in amount and intensity from one year, season and month to another. However, none has been done on the trend of rainfall cycle over the Guinea Ecological Zone, Nigeria (GEZN). Hence, this research aimed at assessing the trend of rainfall cycle over the Guinea Ecological Zone, Nigeria (GEZN) and its implication for agricultural and hydrological/water resources.

Objectives of the Study

The following are the objectives of the study:

(i) To determine the features of inter-annual rainfall over the GEZN

(ii) To examine the trend of rainfall cycle over the GEZN.

Research Questions

The following research questions were raised to guide the study:

(i) What are the features of the inter-annual rainfall over the GEZN?

(ii) What is the trend of rainfall cycle over the GEZN?

The Study Area

The Guinea Ecological Zone, Nigeria (GEZN) lies in the central part of Nigeria and it is the largest ecological zone in Nigeria. It is bordered to the north by the Sudano-Sahalian Ecological Zone, Nigeria (SSEZN) and to the south by the Forest Ecological Zone, Nigeria (FEZN). The zone lies between longitudes 3^o-15^oE and latitudes 9^o-10^o5^1. There are two (2) seasons in the area, namely; wet and dry. There are both inter-annual and inter-seasonal rain variations in the region (Audu *et al.,* 2018). Figure 1 shows the study area.

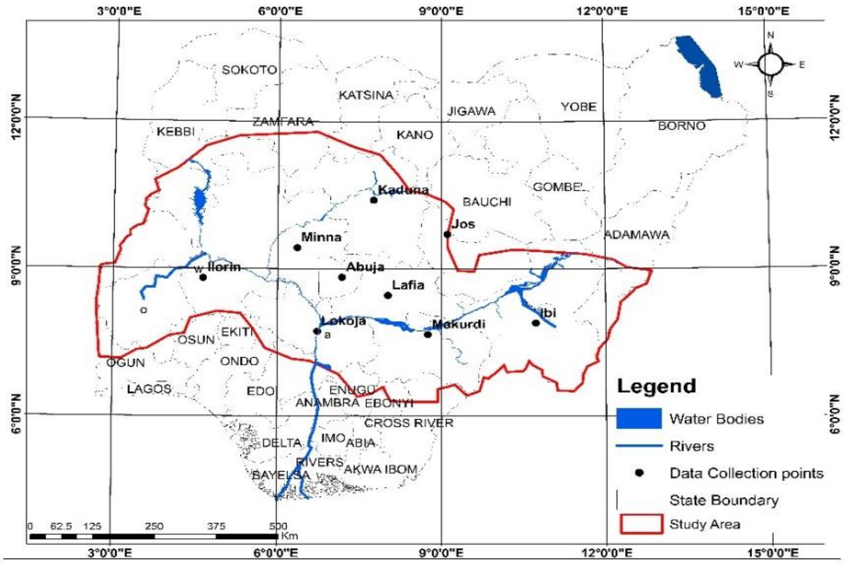

Figure 1: Guinea Ecological Zone, Nigeria (GEZN)
Source: Adapted from Audu (2019)

Materials and Methods

Daily rainfall data for the period of thirty five (35) years (1981-2015) in Makurdi, Lokoja, Ibi, Ilorin Lafia, Abuja, Minna, Jos and Kaduna synoptic meteorological stations were collected from Nigerian Meteorological Agency.

Check was carried out for and corrected errors in the data, for example; some data values had more than one decimal point in them. The data was moved to notepad and saved. A program written in MATLAB (and named as prepNN1.m) was used to translate the data into a form that has 3 columns (for Year, Day of Year, and Rainfall amount). The prepNN1.m was used to also create a file containing total monthly values of rainfall. Another program written in MATLAB (and named as prepNN2.m) was used to compute the total annual rainfall values from the daily rainfall values. The total annual rainfall was computed using equation the following equation:

Sum of $\sum R_T = \sum_{i=1}^{n} R_i$ equation 1

Where:
$R_T = total\ annual\ rainfall$
$n = total\ number\ of\ days\ in\ a\ year\ (366)$
$i = 1st\ day\ of\ the\ year$
$R_i = rainfall\ amount\ for\ day\ i$

The annual rainfall variation for all the data collection points was created using a program written in MATLAB and named as Plot_Year.m. To determine the peak of the next rainfall cycle, computation was made first using data of the previous peak rainfall cycles 2-4 of the average duration it takes for the cycle to rise from the minimum to the peak. That is:
$\bar{T} = \frac{T_1+T_2+T_3+\cdots\ldots\ldots\ldots T_n}{n} = \frac{1}{n}\sum_{i=1}^{n} T_i$ equation 2

Where $\bar{T}$ is the average duration it takes for the cycle to rise from minimum to peak, T_i is the duration it takes for the individual cycle to rise from minimum to peak (*i* in this case runs from 2 to 4), *n* is the number of cycles.

To smoothen the total annual rainfall profile, the 3-year running mean which includes the year before, the year of interest and after the year of interest was computed using the program written in MATLAB and named as running1.m. The formula for running mean used was:

$$R_m = \frac{R_{y-1} + R_y + R_{y+1}}{3} \qquad equation \quad 3$$

Equation 3 was further summarized into equation 4 as thus:

$$\frac{1}{3}\sum_{i=y-1}^{y+1} R_i \qquad \text{equation} \quad 4$$

Where R_m is the running mean computed for a year of interest, *y* and *R* are the total rainfall amount for the years; -1 is the year before the year of interest; while +1 is the year after the year of interest; 3 stands for the number of years involved that is, year before the year of interest, year of interest and year after the year of interest.

To investigate periodicity in annual rainfall pattern, a periodogram was constructed using MATLAB periodogram power spectral density estimate function. Linear extrapolation was used to estimate total amount of rainfall for peak and drop years that is, 2019.

Results and Discussion

Figures 2-19 show the total inter-annual rainfall and smoothening of rainfall profiles for all the data collection points. Smoothening reduces the errors in inter-annual rainfall values. One major feature observed is the inter-annual rainfall variabilities across the data collection points. 1982/83 are years of lowest rainfall over the study area which corroborated the findings of NiMet (2017) which stated that the lowest rainfall of 1080.3 mm occurred in 1983. Of recent, rainfall is on the decline over the study area. NiMet (2019) reported rainfall of 1003 mm over Abuja which is below the normal long-term mean. This agreed with the study of Salawu *et al.* (2014) which observed that rainfall and temperature are changing in Lavun Local Government Area, Niger State, Nigeria over time.

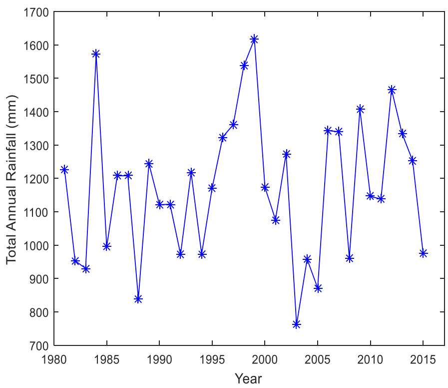

Figure 2: Annual Rainfall Variation for Makurdi

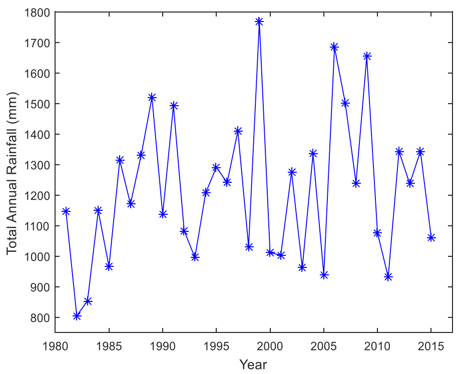

Figure 3: Annual Rainfall Variation for Lokoja

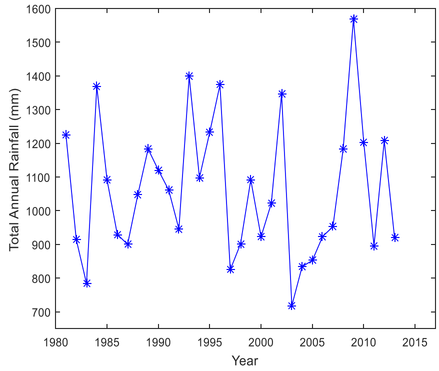

Figure 4: Rainfall Variation over Ibi

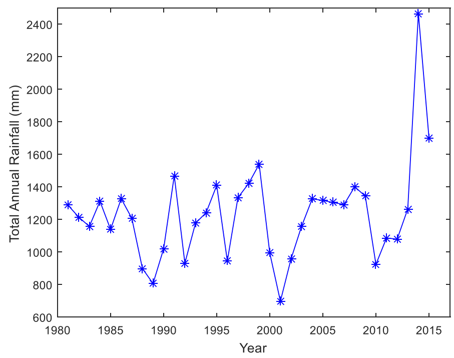

Figure 5: Rainfall Variation over Ilorin

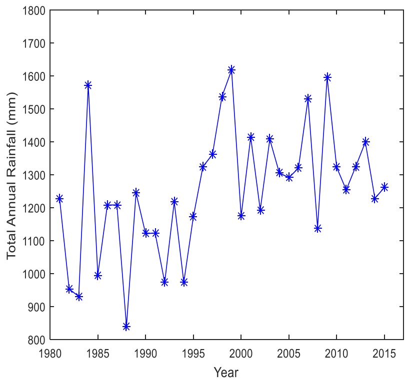

Figure 6: Rainfall Variation over Lafia

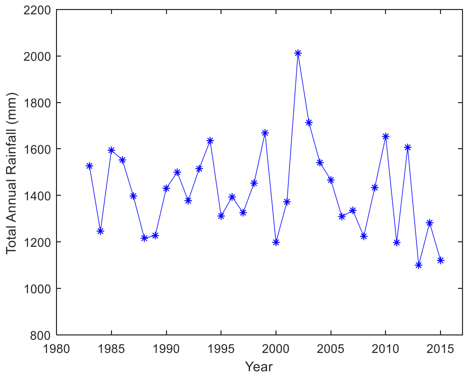

Figure 7: Rainfall Variation over Abuja

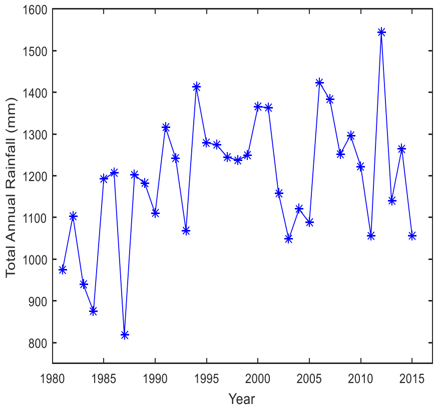

Figure 8: Rainfall Variation over Minna

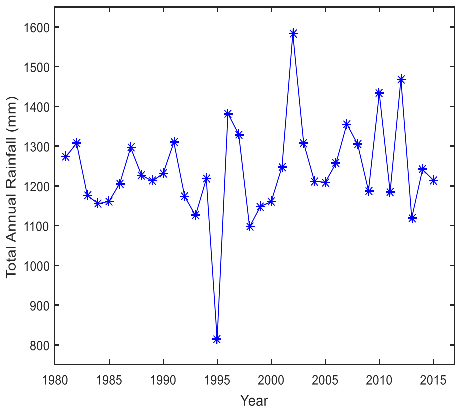

Figure 9: Rainfall Variation over Jos

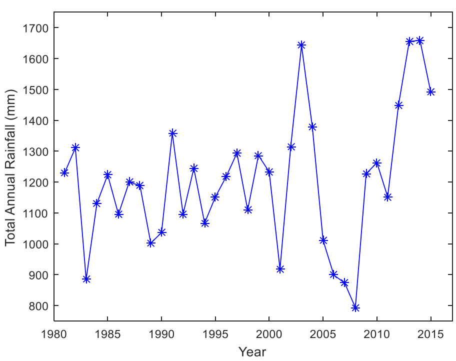

Figure 10: Rainfall variation over Kaduna

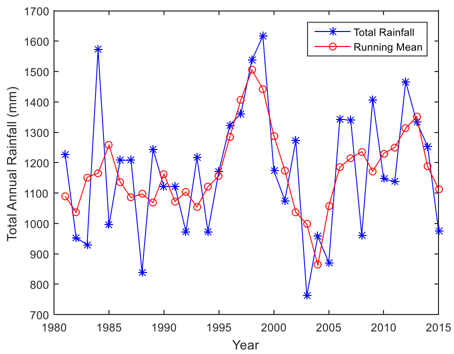

Figure 11: Smoothened Rainfall profile for Makurdi

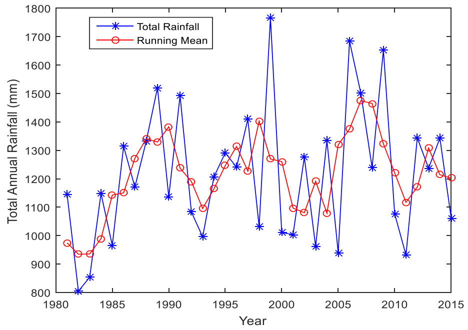

Figure 12: Smoothened Rainfall profile over Lokoja

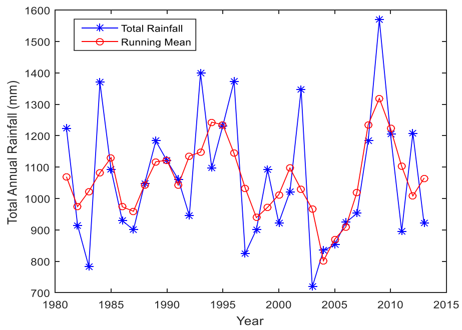

Figure 13: Smoothened Rainfall profile over Ibi

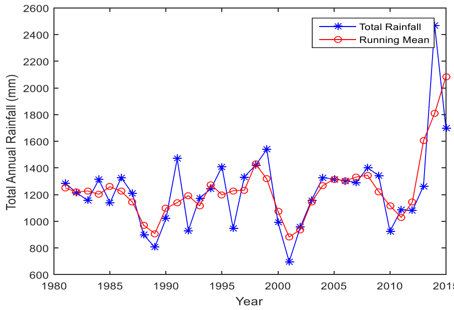

Figure 14: Smoothened Rainfall profile over Ilorin

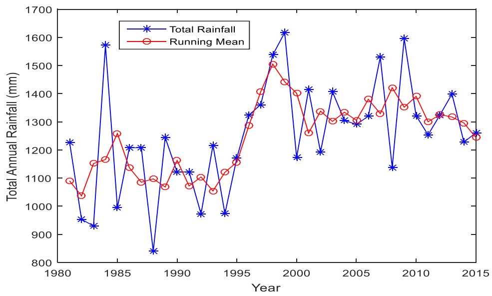

Figure 15: Smoothened Rainfall profile over Lafia

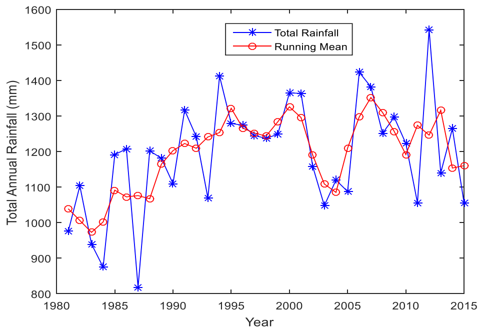

Figure 16: Smoothened Rainfall profile over Minna

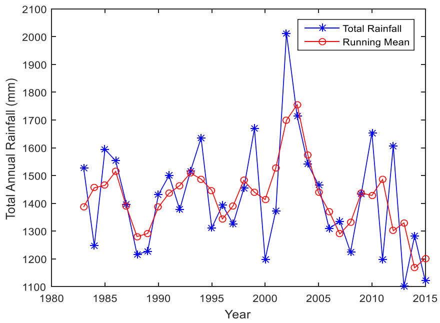

Figure 17: Smoothened Rainfall profile over Abuja

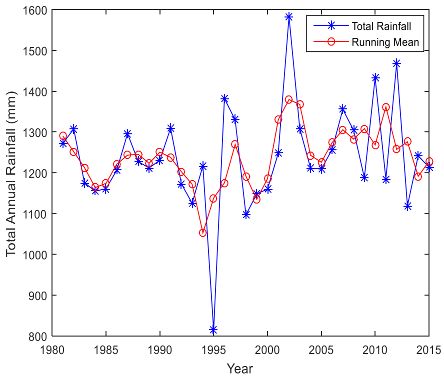

Figure 18: Smoothened Rainfall profile over Jos

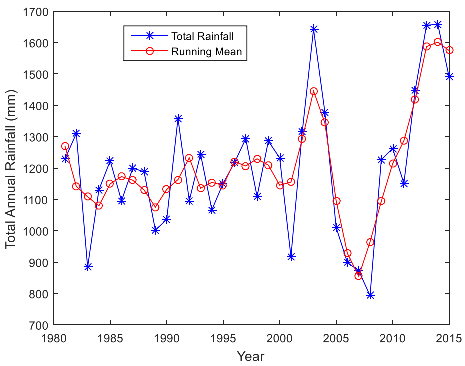

Figure 19: Smoothened Rainfall profile over Kaduna

Figures 20-28 show the results on periodogram of total annual rainfall over the data collection points.

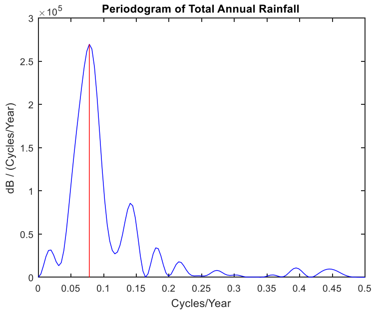

Figure 20: Rainfall periodogram over Makurdi

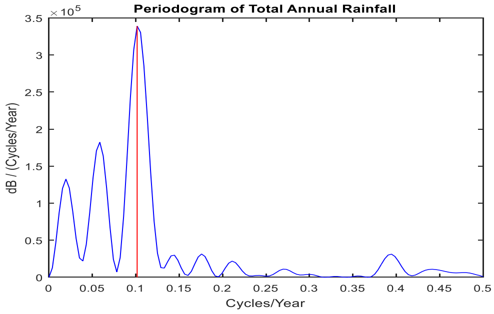

Figure 21: Rainfall periodogram over Lokoja

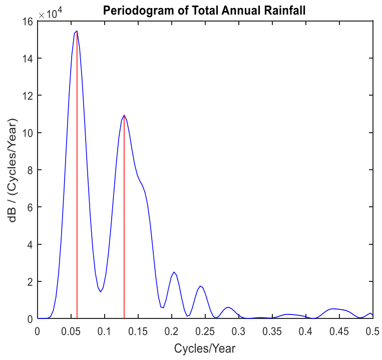

Figure 22: Rainfall periodogram over Ibi

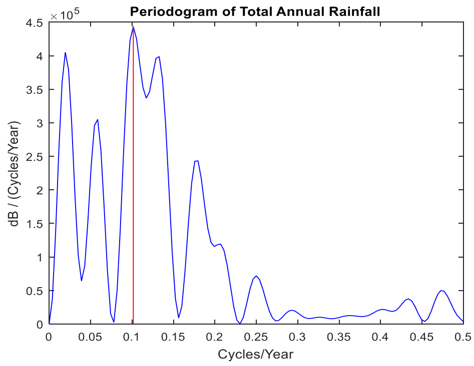

Figure 23: Rainfall periodogram over Ilorin

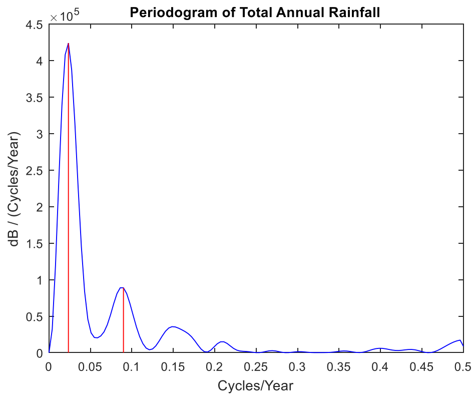

Figure 24: Rainfall periodogram over Lafia

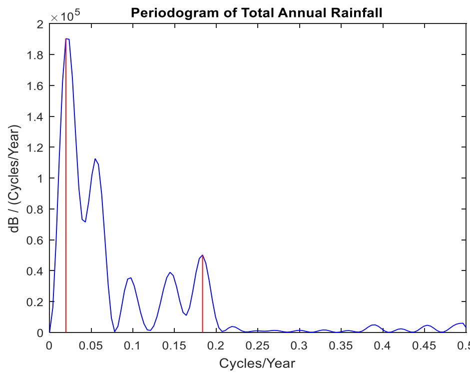

Figure 25: Rainfall periodogram over Minna

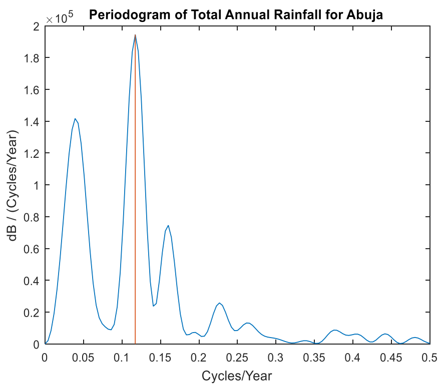

Figure 26: Periodogram of Rainfall over Abuja

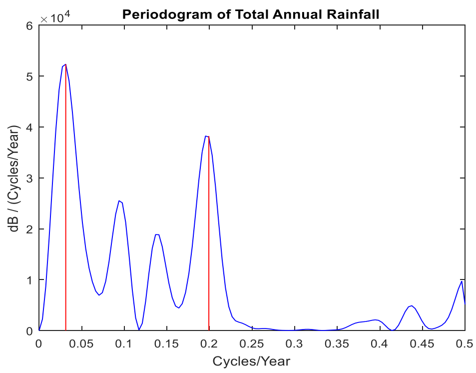

Figure 27: Periodogram of Rainfall over Jos

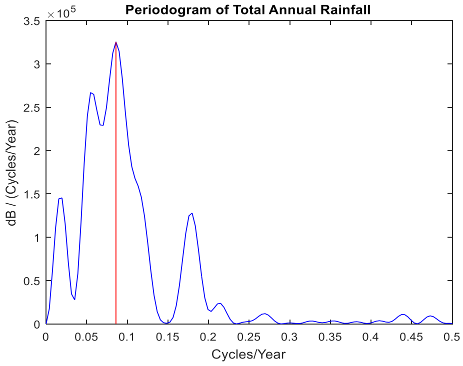

Figure 28: Periodogram of Rainfall over Kaduna

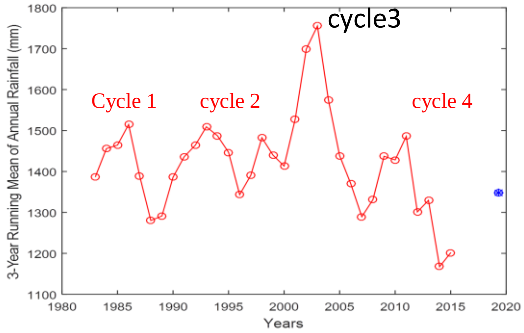

Figure 29: Cycles of 3-Running Mean Rainfall over Abuja

The results displayed in figures 2-29 are further summarized in Table 1.

Table 1: Parametres of the trend of rainfall cycle over Guinea Ecological Zone, Nigeria

Station/ parametre	**P**	**NC**	**YC**	**PK**	**T**	**PY**	**TY**	**PR**	**TR**	**RPY**	**RTY**
Makurdi	0.0781	4	12.8	2013	NA	NA	2016	NA	73.6	NA	1040
Lokoja	0.1016	4	9.8	NA	2011	2017	NA	53.6	NA	1435.2	NA
Ibi	0.1289	5	7.6	NA	2012	2017	NA	56	NA	1232.2	NA
Ilorin	0.1016	5	9.8	2015	NA	NA	2019	NA	47.7	NA	1893.3
Lafia	0.0898	3	11.1	NA	2015	2019	NA	77.8	NA	1555.7	NA
Abuja	0.1172	4	5.3	NA	2014	2019	NA	33.8	NA	1348	NA
Minna	0.1836	5	5.5	NA	2015	2017	NA	82.1	NA	1324.7	NA
Jos	0.2	4	5	NA	2014	2017	NA	36.2	NA	1300	NA
Kaduna	0.0859	5	11.6	2014	NA	NA	2019	NA	26.8	NA	1467.6

Note: P= cycle per year, **NC**= no of cycles for the period of study, **YC**= no of years per cycle, **PK**=year with highest rainfall before a trough, **T**= year with lowest rainfall before a peak, **PY**= peak year of rainfall, **TY**= trough year, P**R**= peak rate, **TR**= trough rate, **RPY**=rainfall amount for peak year, **RTY**= rainfall for trough year, **NA**= not applicable.

According to figures 2-29 and Table 1, there are variations in inter-station, inter-annual and the trend of rainfall cycle over the data collection points in GEZN between 1981-2015 in the areas of periodicity, number of cycles, years with highest rainfall before a trough, years with the lowest rainfall before a peak, rainfall peak year, trough year, peak and trough rates per annum over the stations as well as the total rainfall for the trough and peak years. This agreed with the studies on periodicities, ENSO effects and trends of rainfall conducted by Kane (2009) which observed year-to-year rainfall fluctuations, long-term running mean fluctuations and distinct peaks; Adejuwon (2010) who observed that Benin showed significant spectral peaks at 6.7, 4.6 and 3.7 years.

In Table 1, number of cycle per year for the data collection points varied. Over Makurdi it is about 0.0781, Lokoja is 0.1016, Ibi is 0.1289, Ilorin is 0.1016, Lafia is 0.0898, Abuja is 0.1172, Minna is 0.1836, Jos is 0.2 and Kaduna is 0.0859. Number of cycle over the study period for Makurdi, Lokoja, Abuja and Jos is four (4) years each; that of Ibi, Ilorin, Minna and Kaduna is five (5) years each; while that of Lafia is three (3) years. The number of years per cycle varied across the data collection points (Table 1) with Makurdi having the highest of about 12.8 years and Jos having the lowest of 5 years. There also exist variations in trough years rainfall before a peak and peak years of rainfall before a trough. Abuja, Ibi, Lokoja, Jos, Minna and Lokoja have trough years before a peak, while Kaduna, Ilorin and

Makurdi have peak years before a trough. There is an upward trend in rainfall peak over the study area. This has corroborated the findings of Adeoluwa *et al.* (2017) which observed a significant increasing trend in the frequency of rainy days at the centre of the northern region of Nigeria. Audu *et al.* (2018) also averred that there is a general upward trend in rainfall over the Guinea Savanna Zone, Nigeria (GSZN) in recent times. The peak year of rainfall for Lokoja, Ibi Minna and Jos is 2017; that of Lafia and Abuja is 2019; while that of Makurdi, Ilorin and Kaduna is not applicable. The trough year for Makurdi is 2016, Ilorin and Kaduna is 2019; while for other stations is not applicable. The peak rate for Makurdi, Ilorin and Kaduna is not applicable (NA); Lokoja is 53.6 mm; Ibi is 56 mm; Lafia is 77.8 mm; Abuja is 33.8 mm; Minna is 82.1 mm and Jos is 36.2 mm. The peaks of both peak and trough years in rainfall confirmed the study Ibrahim *et al.* (2018) which observed a projected increase in rainfall extremes such as intense rain as well as severe dry and wet phases. The trough rate of rainfall for Makurdi is 73.6 mm, Ilorin is 47.7 mm, Kaduna is 26.8 mm and other stations is not applicable (NA). Rainfall amount for the peak year in Makurdi, Ilorin and Kaduna is not applicable, Lokoja is 1435.2 mm, Ibi is 1232.2 mm, Lafia is 1555.7 mm, Abuja is 1348 mm, Minna is 1324.7 mm and Jos is 1300 mm. Rainfall amount for the trough year in Lokoja, Ibi, Lafia, Abuja, Minna and Jos is not applicable; Makurdi is 1040 mm; Ilorin is 1893.3 mm and Kaduna is 1467.6 mm.

In Table 1, Ibi, Abuja, Lokoja, Jos, Minna and Lafia are observing increasing trend of rainfall during the peak period, hence there is a trough (T) and a peak year (PY). The peak (PK), trough year (TY), trough rate (TR) and rainfall amount for the trough year (RTY) are not applicable (NA). The converse is true for Kaduna, Ilorin and Makurdi in which the trend of rainfall amount is observed to be decreasing during the peak period, there is a peak (PK) and a trough year (TY). The trough (T), peak year (PY), peak rate (PR), and rainfall peak year (RPY) are not applicable (NA).

The implication of this study is that, more rainfall peak is expected in the nearest future over the study area which would be beneficial to agriculture (if there are normal onset, cessation, duration, intensity and distribution), abundant water to recharge the water bodies and underground water, erosion as well as flooding. NiMet (2017) opined that Ilorin recorded an annual rainfall of about 1545 mm, Kaduna, 1654 mm and Lafia, 1916 mm. NiMet (2018) reported an annual rainfall of about 2340 mm over Lokoja and 1615 mm over Bida. These rainfall values are above normal because they are higher than the normal long-term mean. The major traditional occupation in the study area remains agriculture which is nearly rain-fed and as such, any variation in the occurrence of rainfall cycle would have adverse effect on crop production. Adequate annual rainfall is necessary for cropping which would ensure high and quality yield. Further, two (2) major hydro-meteorological hazards in the study area are erosion as well as flooding (Audu, *et al*., 2014). Erosion destroys the topography of farmlands, while flooding submerges the crop farm especially the riverine areas. Increasing rainfall would lead to increases in both hazards. NiMet (2013) reported that 300 houses, livestock and crops were also damaged in Plateau State. Likewise, NiMet (2019) stated that increase in water levels in various rivers especially Rivers Niger and Benue caused devastating floods which affected 32 states as well as the Federal Capital Territory (FCT) and affected over 210, 000 people. In Bosso and Chanchaga Local Government Areas of Niger State, Nigeria, 3 people were reportedly killed by the flood; while farmlands were equally submerged. According to Ugbah *et al*. (2018), the flood which ravaged Nigeria in 2012 lasted for several days and caused great loss of lives, properties, agricultural produce, transportation and general livelihoods.

Conclusion

This study was centred on assessing the trend of rainfall cycle over the Guinea Ecological Zone, Nigeria (GEZN) which would serve as a very good tool for long-term rainfall monitoring and warning since the lives of the people are largely depended on rainfall. In this study, it has been established that there are both inter-station and inter-annual rainfall variabilities. The highest cycle per year of 0.2 is over Jos, while the lowest of 0.0898 is over Lafia. The number of cycles within the study period is between 3-5. Highest number of years per cycle of 12.8 years is over Makurdi, while the lowest of 5 years is over Jos. Year with highest rainfall before a trough ranges between 2013-2015, while year with the lowest rainfall before a peak is between 2011-2015. The peak year of rainfall ranges between 2017 and 2019, while the trough year ranges between 2016 and 2019. The peak rate of rainfall ranges between 36.2 mm and 82.1 mm, while the trough rate ranges between 26.8 mm and 73.6 mm. Rainfall amount for the peak year ranges between 1232.2 mm and 1555.7 mm, while rainfall amount for the trough year ranges between 1040 mm and 1893.3 mm. This study recommends very short, short, medium and long-term rainfall monitoring/forecast to serve as an early warning tool so as to minimize the consequences of extremely high annual rainfall. More dams and water reservoirs should be constructed along water courses to store water and regulate the effect of high volume of water downstream and store adequate water for the drop years. More drainage systems should be constructed in urban areas to drain excess rain water. Again, irrigation farming should be intensified to mitigate the effect of inadequate soil moisture during the drop years as well as the planting of hybrid crops and the introduction of drought resistant crops.

References

Abubakar, A. S. (2015). Hydrometeorology: Enhancing the Capacity for Hydroelectricity Generation in our Homes and Industries. Inaugural Lecture Series 36. Published by University Seminar and Coloquium Committee, Federal University of Technology, Minna, Niger State, Nigeria. Pg. 8.

Adamu, A., & Umar, A. (2016). *Trend Analysis of Rainfall and Temperature Time Series of Zaria, Nigeria*. in O. D. Jimoh, M. Y. Otache, R. A. Adedeji and M. Saidu (eds). Nigeria Association of Hydrological Sciences (NAHS). Proceedings of the 7th International Conference on Water Resources and Sustainable Development. Pg. 50.

Adejuwon, J. O. (2010). A spectral analysis of rainfall in Edo and Delta States. *International Journal of Climatology.* 31,(2), 365-370.

Adeoluwa, A., Ana, C. C., Jorge, M., & Robert, H. (2017). Geospatial Analysis of Extreme Events in Nigeria (1985-2015) using self-organising Maps. *Advances in Meteorology*.

Audu, E. B., Abubakar, A. S., Ojoye, S., Mohammed, M., & Mohammed, S. Y. (2018). Characteristics of annual rainfall over Guinea Savanna Zone, Nigeria. *Journal of Information, Education, Science and Technology (JIEST),* 5(1),87-94.

Audu, E. B. (2019). Development of a heavy rainfall forecasting model for Guinea Savanna Zone, Nigeria. Unpublished PhD Thesis, Postgraduate School, Federal University of Technology, Nigeria.

Ibrahim, I., Emigilati, M. A., Suleiman, Y. M., Ojoye, S., & Yahaya, T. I. (2018). Effectiveness of early warning methodology and standardized precipitation index for drought monitoring over Guinea Savanna Zone, Nigeria. *Journal of Science, Technology, Mathematics and Education,* 14(2),1-8.

Kane, R. P. (2009). Periodicities, ENSO Effects and Trends of some South African Rainfall Series: An Update. *South African Journal of Science*. 105(5),199-207.

Labaran, A. J., & Ogallo, H. (1986). Stochastic modelling of regional annual rainfall anomalies in East Africa. *Journal of Applied Statistics*, 13,49-56.

Nigerian Meteorological Agency (2013). Climate Review Bulletin. Pg. 42.

Nigerian Meteorological Agency (2017). Climate Review Bulletin. Pg. 9.

Nigerian Meteorological Agency (2018). Climate Review Bulletin. Pg. 48.

Nigerian Meteorological Agency (2019). Seasonal Rainfall Prediction. Pp. 32 and 55.

Ochei, M. C., & Oluleye, A. (2017). Climate variability impact on the frequency of occurrence of mesoscale convective systems in Northern Nigeria. *Journal of Climatology and Weather Forecasting,* 5(3), 213. Doi:10.4172/2332-2594.1000213.

Olatunde, A. F., & Alaci, D. S. A. (2012). *Is the trend and persistence of drought in the Sudan-Sahel Region of Nigeria and Indication of Climate Change?* In M. A. Iliya and I. M. Dankani (eds). Climate Change and Sustainable Development in Nigeria. Publication of the Association of Nigerian Geographers (ANG) and the Department of Geography, Usumanu Danfodiyo University, Sokoto. Pg. 84.

Salawu, E., Mohammed, A. E., Solomon, N. J., & Ishiaku, I. (2014). Perception of climate change and implications on the livelihood of the People of Lavun-South (DOKO Area) in Lavun Local Government Area of Niger State, Nigeria. *Developmental Journal of Science and Technology Research (DOSTER)*, 3(1), 94-106.

The Nigerian Meteorological Agency (2017). Climate Review Bulletin. Pp. 10 and 52.

Ugbah, P. A., Olaniyan, O., Sabastine., D. F., & Adamu, J. (2018). Impact of climate change on growing season in Nigeria: Seasonal Rainfall Prediction (SRP) as Assessment and adaptation tool. In Handbook of Climate Change Resilience. *Springer*. Pp. 1-27.

Umar, A. T. (2012). Climate change in Nigeria: Evidence from Meteorological Parametres. In M. A. Iliya and I. M. Dankani (eds). Climate Change and Sustainable Development in Nigeria. Publication of the Association of Nigerian Geographers (ANG) and the Department of Geography, Usumanu Danfodiyo University, Sokoto. Pg. 53.

Yusuf, Y. O., & Mohammed, N. A. (2012). An assessment of spatial distribution of rainfall amount in Zaria, Kaduna State. In M.A. Iliya, M.A. Abdulrahim, I.M. Dankani and A. Opponkumi (eds). Climate Change and Sustainable Development. A Publication of Geography Department, Usumanu Danfodiyo University, Sokoto and Association of Nigerian Geographers. Pg. 69.