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DECADAL ANALYSIS OF TEMPORAL VARIABILITY IN RAINFALL TRENDS IN OGBOMOSO

Kamaldeen Olasunkanmi Suleman[1], Lukman Ayobami Sunmonu[2], George Atilade Àlàgbé[2*], Akeem Lawal Sheu[3], Suliat Kemi Rasaq[2]

[1]Department of Physics, School of Basic Sciences, Nigeria Maritime University, Okerenkoko, P.M.B. 1005, Warri, Delta State, Nigeria

[2]Department of Pure and Applied Physics, Faculty of Pure and Applied Sciences, Ladoke Akintola University of Technology, PMB 4000, Ogbomoso, Oyo state. Nigeria

[3]Department of Physics, Emmanuel Alayande College of Education, Oyo, Oyo State, Nigeria

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ABSTRACT

Ten-year (2009-2018) monthly rainfall data was obtained from the Nigerian Meteorological Agency (NIMET). The data was processed and analysed using OriginPro 8.5 software. Statistical tools such as standard deviation and Coefficient of Variation (CV) were used for data presentation while analyses were done using the Mann-Kendall and Sen's slope of linear regression to examine variations across the months and years. Results revealed higher values around July and September while lower values were recorded around December and January. Seasonal variability shows a remarkable increasing trend with the exception of post-wet which recorded an insignificant downward trend. The Mann-Kendall and Sen's slope estimator analyses revealed both downward and upward trends in rainfall the study period and the changes are strongly marked for certain years and less for others. This result would contribute significantly to the effective management and sustainable development of the social economic activities which are heavily rain-dependent, within the study area.

Keywords: Rainfall; Trend; variability; decadal; Mann-Kendall.

Author Correspondence, e-mail: galagbe@lautech.edu.ng

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1. INTRODUCTION

1.1. Background

Rainfall variability has historically been found as the main cause of food shortage and famine in the world. Rainfall variability affects the agricultural sector, a sector that has been facing increased and continued risk of climate change [1]. The Intergovernmental Panel on Climate Change (IPCC) [2] has previously reported that future climate change is likely to affect agriculture, increase the risk of hunger and water scarcity, and lead to more rapid melting of glaciers. Freshwater availability in many river basins may likely decrease due to climate change. This decrease coupled with population growth and rising costs in living standards, would most likely, adversely affect many people as we approach the 2050s. Accelerated glacier melt on the other hand, is likely to cause an increase in the number and severity of glacier melt related floods, slope destabilization and a general decrease in river flows as glaciers recede [2].

Trend analysis and variability in precipitation series have been investigated by many researchers throughout the world. These include the work of [3] which reported that, with the exception of northern Africa, southern Italy and the western Iberian Peninsula, there is a declining as well as an increasing trend of rainfall in the majority of Mediterranean regions with no defined pattern. In the same vein, [4,5] reported a declining trend of rainfall in Kashmir India as well as in west and south Turkey while [6,7] reported significant increase in trends in annual rainfall in the Wainganga basin of central India and in different regions of the UK. Previous attempt at investigating rainfall trends and variability in Africa have revealed that the continent exhibits higher inter-annual and intra-seasonal rainfall variability [7-10].

In Nigeria, several attempts have been made to determine trends in the rainfall at national and regional scales. Most of the rainfall studies were confined to the analysis of annual and seasonal series for individual or group of stations. These include, but not limited to, Onitsha [12], Kafanchan [13], Ebonyi [14], Abuja [15], Ikeduru, [16], Kwara [17], Northeast [18], South-south [19]. These studies have revealed both increase and decrease in trends. However, there is a dearth of information on the trend and variability of rainfall in Ogbomoso, Nigeria. Hence, the present study analysed changes in rainfall on annual and seasonal scales in

Ogbomoso. Intra-seasonal variability in rainfall was also studied by analysing the trends in monthly rainfall. The time series of rainfall data used in this study spanned 10 years. Thus, the present analysis is a significant contribution to the studies carried out previously.

1.2. Description of the Study Area

Ogbomoso is a city in Oyo State, South-western Nigeria. Geographically, it lies between Latitudes 8.1227 ºN and Longitudes 4.2436 ºE, with a population of over 245,000 people [20]. It spreads over a land mass of about 1.343 km^2. It falls within the area of savannah and farmland at the intersection of roads from Oyo, Ilorin, Oshogbo and Ikoyi. The area enjoys a typical tropical climate and prolonged seasonal variation in monthly rainfall and extreme seasonal relative humidity with an annual temperature of 26 ℃. The Yoruba constitutes the major ethnic group in the study area. There are plenty of businesses and agricultural activities in the city. Figure 1 is the map of Oyo state, showing the study area.

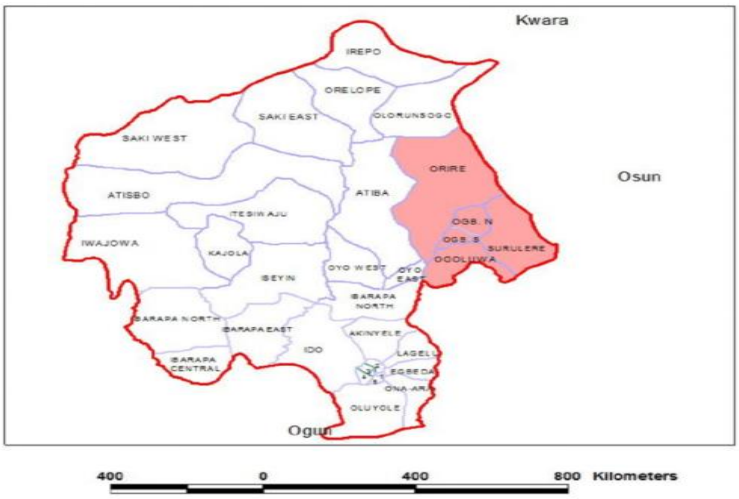

Fig.1. Map of Oyo state showing Ogbomoso [21]

1.3. Description of the Data Used

Monthly rainfall data of Ogbomoso prepared by the Nigerian Meteorological Agency, NIMET, (www.nimet.gov.ng) was used in this study. Before releasing these data, NIMET carries out quality checks to ensure that the data is error-free when used in analysis and design. As a result, the quality of this data set is very good and it is one of the most reliable long series of data available in the country. The monthly data used was for ten years (2009-2018).

To investigate the variability in rainfall for different seasons, a year was divided into four seasons namely; Winter (December-January-February, DJF), Pre-wet (March-April-May, MAM), Wet (June-July-August-September, JJAS), and post-wet (October-November, ON). The analysis was carried out for all the seasons as well as the whole year separately. For trend analysis, monthly time series of rainfall was used to form the annual and seasonal series.

1.4. Determination of trend

To determine the magnitude of the trend in the rainfall time series, Sen's Slope estimator [22] was used. This method, whose details can be found in [5, 21, 22] is the most widely used in determining magnitude of trend in hydro-meteorological time series. To statistically analyse the monthly, annual, and seasonal significance of the trends, the non-parametric Mann-Kendall (MK) test [25], [26] was used. This test has been previously used by researchers to ascertain the presence of statistically significant trend in hydrological climate variables, such as temperature, precipitation, and streamflow, with particular reference to climate change. The MK test checks the null hypothesis of no trend against the alternative hypothesis of the existence of increasing or decreasing trend. Details of this method can be found in [27].

Table 1. Statistical Properties of annual rainfall in Ogbomoso

Minimum	Maximum	Mean	S.D	CV
1110.8	1972.95	1476.2	317.3	0.21

2. RESULTS AND DISCUSSION

2.1. Variability in Rainfall

Basic statistics such as minimum, maximum, mean and coefficient of variation (CV) of annual rainfall of the data set is given in Table 1. The high variation observed makes Ogbomoso highly vulnerable to climate change [4]. Figure 2 and Figure 3 show the temporal variation of monthly and annual rainfall for Ogbomoso. As seen, for the entire period under consideration (with exception of 2009), maximum amount of rainfall usually occurs in the

month of September, with year 2014 witnessing the highest amount of rainfall.

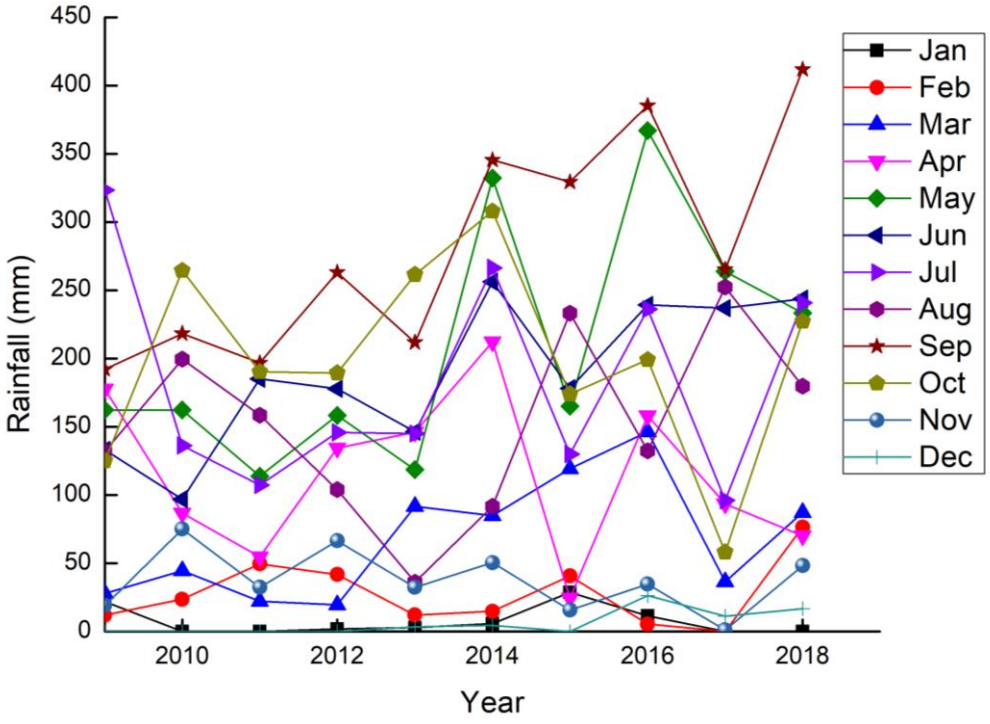

Fig.2. Temporal Variability of Monthly Rainfall (2009-2018)

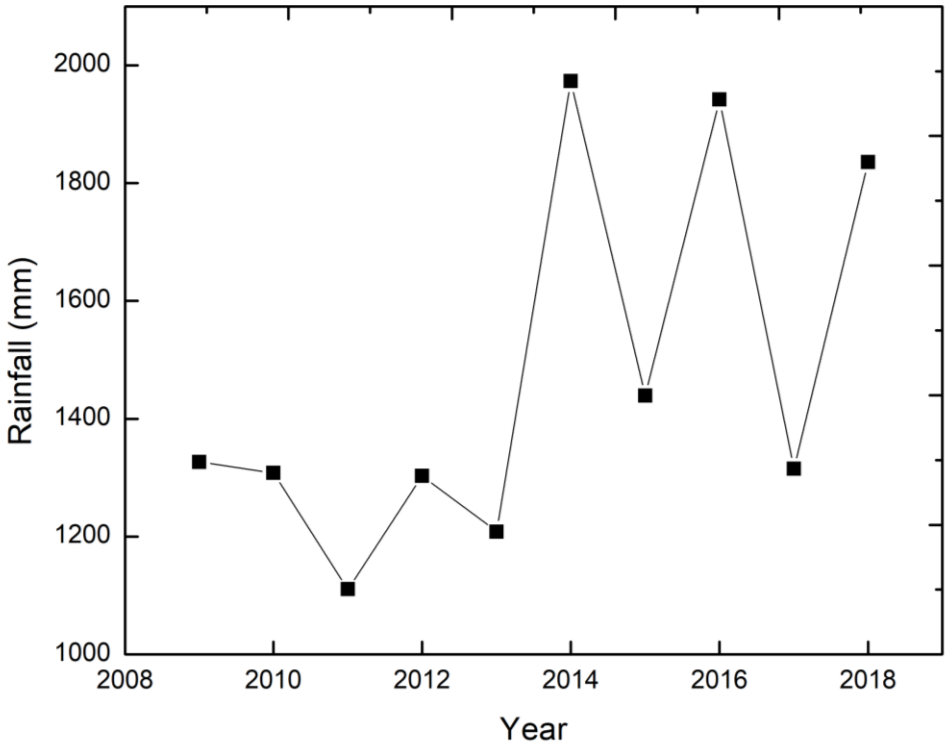

Fig.3. Temporal Variability of Annual Rainfall (2009-2018)

2.2. Magnitude and Significance of Trend

The magnitude of the trend in the time series as determined using the Sen Estimator is given in Tables 2 and 3. Monthly analysis of the rainfall trends indicated that there is marked trend across some months. The months of January, February, July, and October show little or no change in rainfall. Two months, April and November witnessed decreasing rainfall, with November recording the maximum reduction (-0.18 mm/yr). The remaining months witnessed increasing rainfall, with September recording the highest increase (0.69 mm/yr). On seasonal basis, only the post-wet season witnessed little or no change in rainfall. The other seasons experienced increasing rainfall with the highest (0.38 mm/yr) increase occurring in the pre-wet season, MAM (March-April-May).

Table 2. Sen estimator slope (mm/yr) for Monthly rainfall

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Kendall's Tau	0.02	-0.09	0.38	-0.11	0.38	**0.56**	-0.07	0.20	**0.69**	-0.02	-0.18	**0.68**

*Bold face values signify statistical significance at 95 % confidence level for the Mann-Kendall test (+ for increasing and - for decreasing).

Table 3. Sen estimator slope (mm/yr) for Annual and seasonal rainfall

	Annual	**DJF**	**MAM**	**JJAS**	**ON**
Kendall's Tau	0.02	0.11	0.38	0.20	-0.02

*Bold face values signify statistical significance at 95 % confidence level for the Mann-Kendall test (+ for increasing and - for decreasing).

Negative trends were observed in the months of February, April, July and November, while the rest months experienced positive trends. Results of the Mann-Kendall test, employed to ascertain the significance of trends in monthly rainfall (Table 2) showed that increasing rainfall was only statistically significant during the months of June, September, and December.

3. CONCLUSION

In this work, trends in the monthly, seasonal and annual rainfall in Ogbomoso have been examined. A ten-year data set was used. Expectedly, rainfall trend showed large variability across the months. Seasonal analysis also showed a marked increase in the rainfall trend across the seasons with the exception of the dry season (ON), which showed no change. This work recommends a follow-up work to review hydrological and agricultural practices in Ogbomoso in the light of trends in hydroclimatic variables.

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