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Statistical Study of Rainfall Patterns in Ondo State, Nigeria

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Abstract: **Rainfall is very crucial in the assessment of climate change. This paper examines the trend of rainfall for Ondo state between 2010 and 2020 using data from NIMET, Ondo State Office. Descriptive and inferential statistics were used to access the distribution of rainfall. The results from the linear trend and standardized anomaly show a high temporal variation with more negative anomalies with upward trend which indicates a higher rainfall intensity.**

Keywords: **Rainfall, fluctuation, trend, Analysis, Ondo State.**

1. INTRODUCTION

The knowledge of climate variability over the period of instrumental records and beyond on different temporal and spatial scale is important to understand the nature of different climate systems and their impact on the environment and society (Oguntunde *et al*. 2012). Most of the observational and numerical simulation studies on climate are based on the instrumental records of about a century which are aimed at the understanding of the natural variability of climate system and to identify processes and forcing that contribute to this variability. This is essential if we are to predict global and regional climate variations, determine the extent of human influence on the climate and make sound projections of human induced climate change.

Significant climate conditions such as temperature, precipitation, sunshine and wind can affect and accelerate their dispersion and their increase. Increasing flood risk is now being recognized as the most important sectoral threat from climate change in most parts of the region which has prompted public debate on the apparent increased frequency of extreme, and in particular, on perceived increase in rainfall intensities. Several studies have adduced extreme rainfall to be the major cause of flood worldwide.

Several studies have been carried out at different temporal scales and in different part of the globe. For example, Omogbai (2010) studied rainy days in South Western Nigeria between 1970-2006, Guhathakurta and Rajeevan (2006) studied the trends in the rainfall pattern over India between 1901-2003, Obot *et al.,* (2011) also consider the trends of rainfall in Abeokuta, Nigeria between 1981-2002 etc. Many findings considering the long term structure of rainfall in Nigeria show significant trend in rainfall time series in the Northern part falling into Sahel climate and insignificant trend in the South and other Northern places outside the Sahel with steady regime of rainfall (Ati *et al.,* 2009; Obot *et al.,* 2010, 2011). Akinyemi et. al. (2013) posited a shift in the beginning and ending of rainy seasons in Ekiti State.

In Africa, about 75 to 50 million individuals will be prone to increased effects caused by weather extremes by 2022 (IPCC, 2007). In Nigeria, available literature shows that about 27 to 53 million people in the coastal area have been displaced due to sea-level rise (USAID, 2012). On human health, the World Health Organization (WHO) estimated that at least 150,000 deaths each year could be traced to the outcome of CC. Moreover, this figure is expected to double by 2030 with connections

to flooding and water-related diseases (WHO, 2021). Studies have claimed that climate change-related torrential flooding has led to disease outbreaks in various regions of the globe. Consequently, the Nigerian population could be exposed to such threats.

The impacts of CC experienced in the developed countries are less serious compared to the developing countries (Maikasuwa, 2013). Although the developed countries are the key contributors, they have over the years developed advanced adaptation technologies, productive research, and working institutional policies. This has enabled adequate adaptive responses and reduced the outcomes of CC effects in developing nations like Nigeria; these modern adaptation technologies are limited. Although several studies have assessed CC impacts across Nigeria, it is as important to assess how the research evolved and whether it reflects the level of preparedness towards projected future trends.

Climate change according to IPCC (2007) refers to changes in modern climate which are 90-95 percent likely to have been in part caused by human action. Climate Change and Agriculture With increasing global warming and higher temperatures, a number of phenomena associated with water bodies in different ecological zones of Nigeria hence this research investigates the pattern of rainfall in Ondo State between year 2010 and year 2020.

2. METHODOLOGY

In this research, time series analysis of the annual and monthly rainfall values will be used to illustrate the trend and pattern in rainfall behavior Standardized anomaly of rainfall distribution will be obtained. In carrying out the analysis, Microsoft EXCEL and IBM SPSS Statistics software packages were used.

2.1 Time Series Model

The four components of time series are trend, seasonal variation, cyclical variation and irregular variation.

An approach to represent time series data is to multiply the four components of time series.

$Y = T \times C \times S \times I$ (2.11)

Where Y is the observed value of a time series at a particular time point.

T is Trend

C is Cyclical Variation

S Seasonal Variation

I Irregular or Random Variation

This is called Multiplicative time series model.

Another approach is based on additive law, known as 'Additive Model'

$Y = T + C + S + I$ (2.12)

2.2 Standardized Anomaly

It is a measure of distance in standard units between a data value and its mean. Standardized anomaly removes influence of location and spread of data. It is also known as normalized anomaly or deviation from the mean.

In computing the mean, deviation score, Standard deviation and the standardized anomaly we use the following formulae.

Standardized Anomaly = $\frac{x-\bar{x}}{\sigma}$ (2.21)

where x is the variable

$\bar{x}$ is the mean of the observations

σ is the standard deviation of the observations.

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3. RESULTS AND DISCUSSION

Statistical analysis was conducted on the monthly rainfall data for Ondo state between years 2010 and 2020.

Table 3.1: Monthly distribution of Rainfall in Ondo-State from 2010 – 2020 in (mm)

Year/Month	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
2010	0	0	60.7	112	148	121	164.5	279	220.5	121	71.8	71.8
2011	17	88.1	96.1	114	144	219.1	181.4	92.4	325	167	25.8	15
2012	0	0	74.1	152.1	96.8	250.5	242.3	117.9	204.1	143.1	42	15
2013	2.5	35.6	215.1	126.2	176	186.5	295.6	97.9	273.3	64.3	33.3	17
2014	0	0	60.6	161	100.6	152.9	184	241.6	167.4	161.7	93.1	0
2015	0	40.5	90.8	88.2	224.4	255.6	86.4	127.8	266.2	258.7	30.3	0
2016	0	0	70.4	102.1	158.6	375.3	124	327.8	224.3	174.1	16.9	0
2017	0	0	33.4	75.3	85.9	200.2	249.1	71.1	201.4	171.8	75.8	0
2018	0	4.8	36.1	75.9	106	256.5	259.3	186.6	274.3	144.7	70.8	0
2019	0	50.4	66.8	66.5	245.4	348.4	233.2	473.9	303.4	266.2	70.8	0
2020	0	0	57	118	118	197	178	7	201	117	69.9	0

The statistical summary for the rainfall meteorological variables is as presented in Table 3.2

Table 3.2.: Monthly statistical summary for rainfall (mm) between years 2010 to 2020

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Min	0.00	0.00	33.40	66.5	85.90	121.00	86.40	7.00	167.4	64.30	16.90	0.00
Max	17.00	88.10	215.10	161.00	245.40	375.30	295.60	473.90	325.00	266.20	93.10	71.80
SE	1.54	8.97	14.85	9.29	15.83	23.09	18.83	40.95	14.89	17.68	7.65	6.47
Mean	1.77	19.95	78.28	108.30	145.79	233.00	199.80	183.91	241.90	162.69	54.59	10.80
SD	5.11	29.76	49.27	30.80	52.51	76.57	62.44	135.82	49.37	58.63	25.38	21.47
Skewness	3.20	1.42	2.43	0.36	0.84	0.64	-0.32	0.96	0.27	0.52	-0.15	2.70

where SE=standard error , SD=standard deviation

The maximum and minimum values of rainfall values for the data series are 473.90 and 0.00 respectively, which indicate that Ondo state metrological station exhibits a very high range in rainfall distribution. Range of values for standard deviation and skewness coefficient were 80.53 and 1.00 respectively, while the mean and standard error values are as shown in Table 3.2.

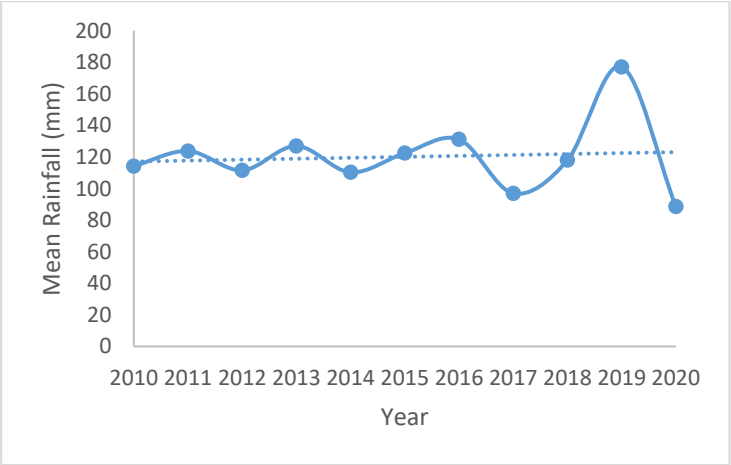

Figure 3.1: Mean Rainfall Pattern between years 2010 and 2020

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Figure 3.1 show the inter-annual variability of rainfall in Ondo state for the years under consideration. The inter annual variability reveals an upward trend in the pattern when a trend line is fitted. The trend suggests a general increase in rainfall values in recent times.

Table 3.3: Annual Mean Rainfall and Standardized Anomaly

Year	Rainfall amount (mm)	Anomalies
2010	114.1917	-0.27108
2011	123.7417	0.169318
2012	111.4917	-0.39559
2013	126.9417	0.316886
2014	110.2417	-0.45323
2015	122.4083	0.107832
2016	131.125	0.509799
2017	97.00	-1.06387
2018	117.9167	-0.0993
2019	177.0833	2.62916
2020	88.575	-1.45239

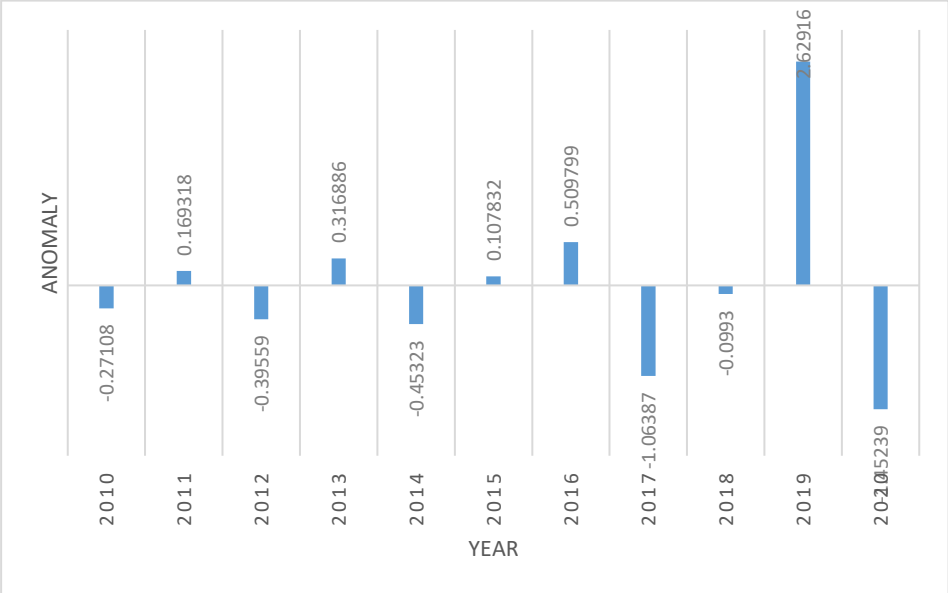

Figure 3.2: Standardized Rainfall Anomalies

In figure 3.2, annual rainfall data were standardized and these standardized rainfall deviations were averaged for the period. Rainfall was above average for years 2011, 2013, 2016 and 2019. The highest positive deviation was recorded in the year 2019.

Rainfall was below normal for years 2010, 2012, 2014, 2017, 2018 and 2020. The highest negative departure was recorded in the year 2020.

The figure further suggests an even distribution of the departures in annual rainfall from the mean with four anomalous situations on one side and six anomalous situations on the other side.

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Figure 3.3: The Moving Average of Rainfall in Ondo State

The chart above shows the moving average of rainfall in Ondo state in months, in which March to July has the highest rate (221.33mm-352.83mm) of annual rainfall across each year.

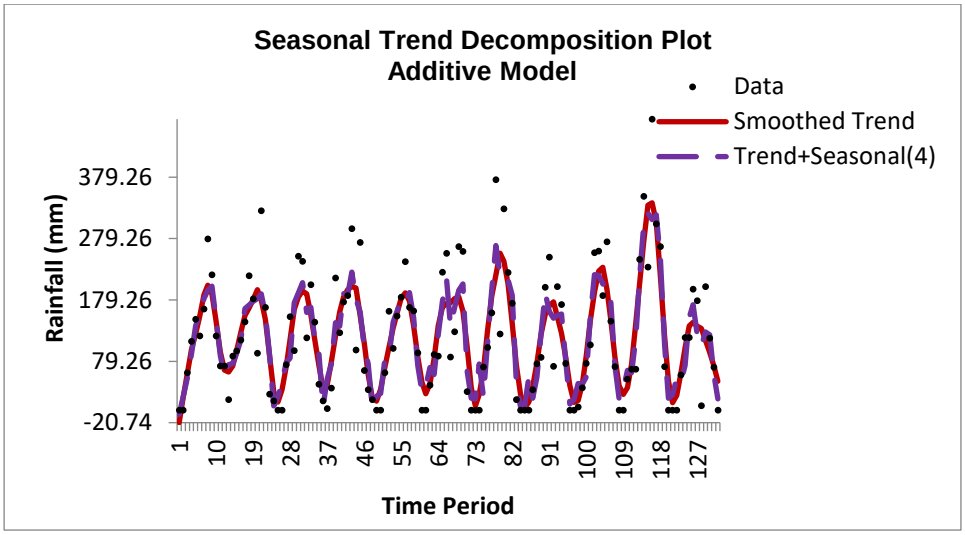

Figure 3.4: The smoothed Trend Pattern of Rainfall in Ondo State.

The chart above shows the seasonal trend pattern of rainfall in Ondo State using additive model, it assumes that the observed data can be expressed as the sum of multiple components: trend, seasonal variable, and residuals. The trend suggests an increasing but fluctuating trend pattern of rainfall in Ondo State.

4. CONCLUSION

This present study has enabled us to understand the temporal variations in monthly and annual rainfall amount in Ondo state. The driest and the wettest year and months in Ondo state for the period of study have been identified. The study reveals a significantly high value of the mean annual rainfall in Ondo state within the period of study (2010 – 2020) of 1440.78 mm which is good for agriculture and water resources planning.

The anomalous departures from the mean were observed to be very small with the highest positive departure from the mean of 9.9% in 2016 for rainfall.

5. RECOMMENDATIONS

In this paper, we recommend an integrated water resources management especially during the dry season and application of instrument that detect climatic change. Also, the risks from flooding can be greatly reduced by the introduction of a well-maintained flood control and sanitation infrastructure and public health resources.

Also, due to the increase in the trend pattern of rainfall amount and intensity in Ondo State according to the study, it is recommended that rain fed Agriculture should be practiced.

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