International Journal of Scientific Research & Engineering Trends
Volume 9, Issue 3, May-Jun-2023, ISSN (Online): 2395-566X

Rainfall and Temperature Patterns in Ondo State, Nigeria

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Abstract- Rainfall and temperature are the most prominent climatic variables in the assessment of climate change globally. In this paper, the trend and relationship between rainfall and temperature using data from NIMET, Akure, Ondo state. The result revealed that both rainfall and temperature show fluctuations with equal number of negative anomalies with a significant negative correlation between rainfall and temperature.

Keywords- rainfall, temperature, correlation, trend, standardized anomaly.

I. INTRODUCTION

The climate of a location can be understood most easily in terms of annual or seasonal averages of temperature and precipitation. The global climate has changed rapidly with the global mean temperature increasing by 0.70 C within the last century (IPCC 2007). However, the rates of change are significantly different among regions (IPCC 2007). This is primarily due to the varied types of land surfaces with different surface albedo, evapotranspiration and carbon cycle affecting the climate in different ways (Meissner et al. 2003).

Studies on the Spatio-temporal variability and trend in temperature are very limited in Africa. Several studies have been done at various temporal scales and in different parts of the globe. For example, Hasanean (2001) examined trends and periodicity of air temperature from eight meteorological stations in the east Mediterranean and observed positive significant trends in Malta and Tripoli, and negative trend in Amman. Turkes et al. (2002) evaluated mean, maximum and minimum air temperature data in Turkey during the period 1929–1999. Their analysis revealed spatio temporal patterns of long-term trends, change points, and significant warming and cooling periods.

Nigerian Agriculture depend highly on climate because temperature, sunlight, water, relative humidity are the main drivers of crop growth and yield (Adejuwon, 2004). Crops generally require certain amount of rainfall during growth periods for maximum yield and when this becomes excessive it leads to poor harvest if at all. Also when this is added to high temperature the soil environment will become unconducive to micro-organism which decomposes biomass into organic matters. This phenomenon will result into soil infertility w-hich leads to very poor yield. This places climate change as an important parameter in agricultural production for rural household food security.

The impacts of climate change (CC) have been experienced globally, especially in the tropics (Idowu et al., 2011; Williams et al., 2018). These have triggered a wide variety of physical and biological changes across the world with negative effects on agriculture, humans, and the environment. It is important to note that while the vulnerability to CC impacts is higher in lower-middle- and low-income countries, particularly Africa, the readiness to improve resilience ranks very low in such countries. A recent report, for example, shows that Nigeria is one of the top ten of the most exposed countries to the effects of CC, with about 6% of its land area estimated to be exposed to extreme weather events (World Bank, 2019). This research investigates the rainfall cum temperature pattern in Ondo State between year 2010 and 2020.

II.METHODOLOGY

In this research, time series analysis of the annual and monthly rainfall and temperature values will be used to illustrate the trend and pattern in rainfall and temperature behavior. Standardized anomaly of rainfall and temperature distributions will be obtained. Correlation statistics will be used in detecting the relationship between the rate of rainfall and temperature in Ondo State. In carrying out the analysis, Microsoft EXCEL and IBM SPSS Statistics software packages were used.

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.Moving Average Method

This method is appropriate only when the trend is linear. It is also used to eliminate seasonal, cyclical and irregular fluctuations in the data. In this method, we find the simple average successively taking a specific number of values at a time e.g. If we want to find 12 month moving average, we shall find the average of the first twelve values, then drop the first value and include the thirteenth value. The process will be continued till all the values in the series are exhausted.

3.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 $= \frac{x-\bar{x}}{\sigma}$ (2.31)

where x is the variable

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

σ is the standard deviation of the observations.

4.Correlation Coefficient

Correlation coefficient measures the strength of a linear relationship between two variables. It is measured on a scale that varies from +1 through 0 to -1.

$$\rho = \frac{n\sum xy - \sum x \sum y}{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}$$

III. RESULTS AND DISCUSSION

Statistical analysis was conducted on the monthly rainfall and temperature data for Ondo state between years 2010 and 2020. The statistical summary for the rainfall meteorological variables is as presented in Table 3.1

Table 1 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 1.

Table 2. Monthly statistical summary for temperature (°C) between years 2010 to 2020

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Min	32.40	32.70	33.30	31.80	30.70	29.40	27.90	27.20	28.10	28.90	31.80	32.10
Max	34.90	36.10	38.70	38.40	37.80	30.90	31.70	28.90	31.50	31.10	33.60	34.30
SE	0.22	0.33	0.62	0.56	0.58	0.15	0.34	0.16	0.27	0.19	0.15	0.22
Mean	33.98	34.61	35.33	33.14	32.10	30.02	29.11	28.08	29.46	30.47	32.67	33.69
SD	0.75	1.10	2.06	1.85	1.94	0.51	1.14	0.53	0.89	0.61	0.51	0.72
Skewness	-0.93	-0.23	1.05	2.67	3.02	0.45	1.59	-0.27	0.96	-1.73	0.29	-1.30

The maximum and minimum values of temperature values for the data series are 38.70 and 27.20 respectively, which indicate that Ondo state metrological station exhibits a very high range in temperature distribution over the years. Range of values for standard deviation and skewness coefficient were 1.55 and 4.75 respectively, while the mean and standard error values areas shown in Table .2. Statistical analysis of temperature time series data involves the computation of the temperature mean, standard deviation and coefficient of variation. This measures temperature variability around its mean value.

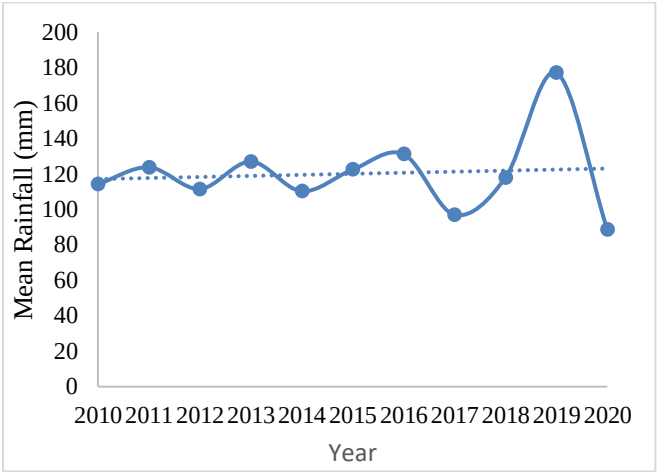

Figure 1 Mean Rainfall Pattern between years 2010 and 2020

Figure 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.

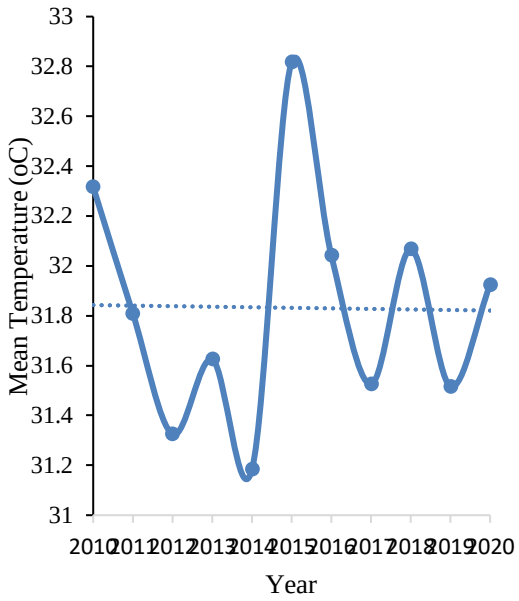

Figure .2 Mean Temperature Pattern between years 2010 and 2020

Figure .2 show the inter-annual variability of temperature in Ondo state for the years under consideration. The inter annual variability reveals an downward trend in the pattern when a trend line is fitted. The trend suggests a general decrease in temperature values in recent times.

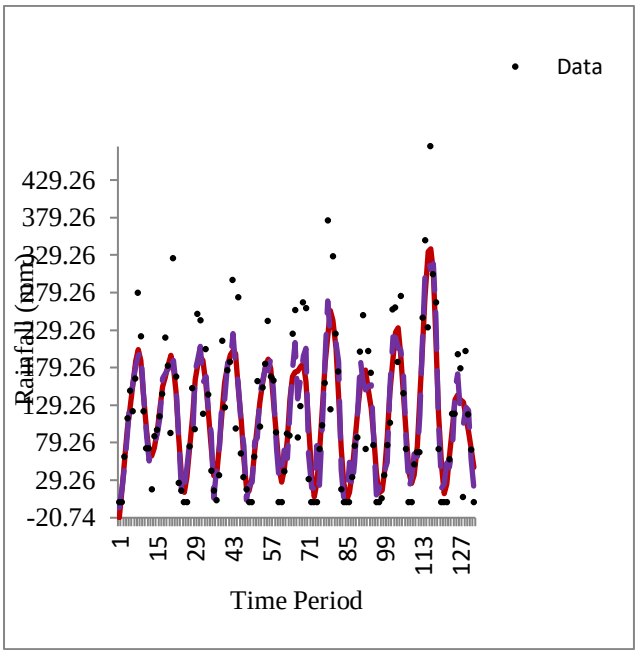

Figure3 The smoothed Trend Pattern of Rainfall in Ondo State.

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.

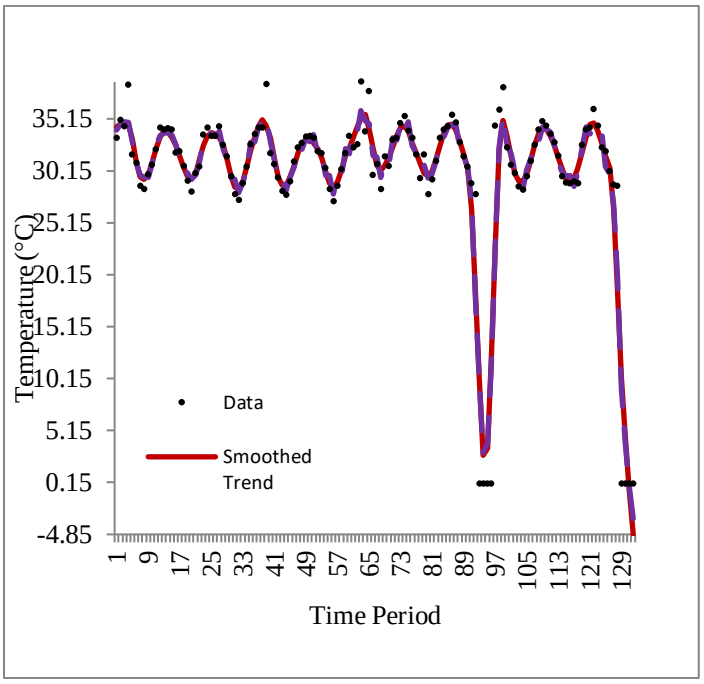

Figure 4 The Smoothed Trend Pattern of temperature in Ondo State.

The chart shows the seasonal trend of temperature using additive model in Ondo State. The trend suggests a decreasing but fluctuating trend pattern of temperature in Ondo State.

Table 3. Annual Mean Rainfall and Standardized Anomaly

Year	Mean Rainfall (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

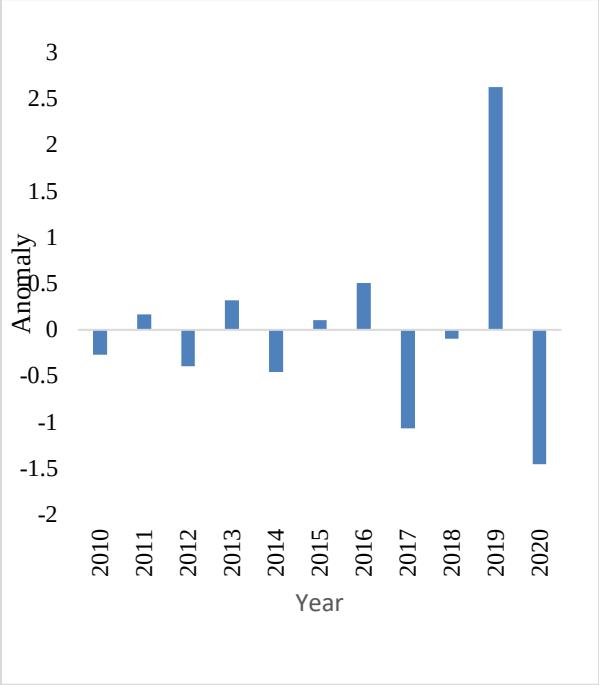

Figure 5 Standardized Rainfall Anomalies

Figure 5 reveals that the highest positive deviation was recorded in the year 2019. 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.

Table .4 Annual Mean temperature and Standardized Anomaly

Year	Mean Temperature (°C)	Anomalies
2010	32.31667	1.060614
2011	31.80833	0.056818
2012	31.325	-1.1553
2013	31.625	-0.32198
2014	31.18333	-1.4962
2015	32.81667	2.026523
2016	32.04167	0.70075
2017	31.525	-0.5303
2018	32.06667	0.719705
2019	31.51667	-0.45455
2020	31.925	-0.5303

Figure 6 shows the standardized temperature anomaly in Ondo state with 2015 indicating the highest deviation and 2014 having the lowest negative deviation.

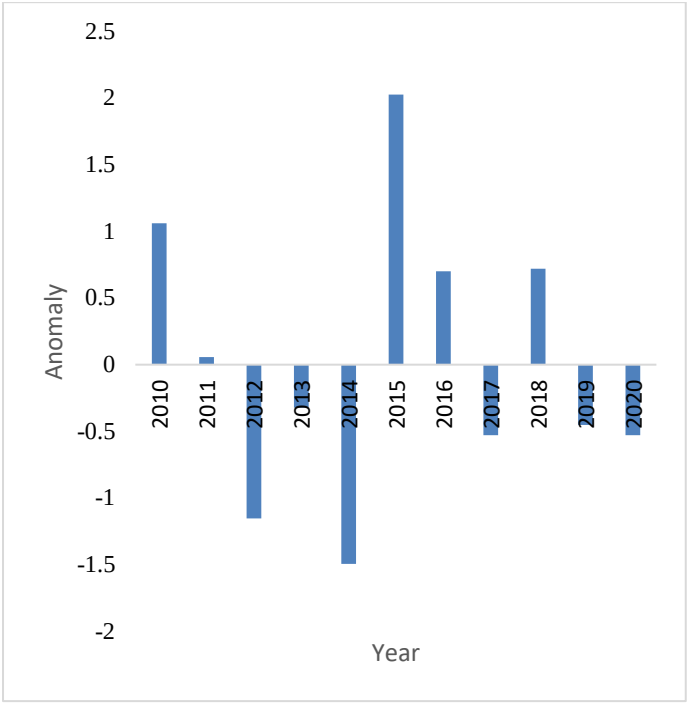

Figure 6 Standardized Temperature Anomalies.

Correlation Analysis

H_0: there exist no association between rainfall and temperature values

H_1: there exist association between rainfall and temperature values Decision Rule: Reject Ho if p-value < 0.05, otherwise accept.

Table 5 Correlations

		Rainfall (mm)	Temperature (°C)
Rainfall (mm)	Pearson Correlation	1	-.618
	Sig. (2-tailed)		.000
	N		132

Conclusion: since p-value < 0.05 we reject the null hypothesis and conclude that there exist association between the rainfall and temperature values. The correlation between rainfall and temperature at Ondo state from year 2010 to 2020 is -0.6184 which shows a moderate negative correlation across the years. This implies that as amount of rainfall increases, the degree of temperature decreases and vice versa.

IV. CONCLUSION

This present study has enabled us to understand the temporal variations in monthly and annual rainfall amount and temperature in Ondo state. The driest and the wettest year and months, including the month with lowest and highest temperature in Ondo for the period of study have been identified. The study reveals a significantly high value of the mean annual rainfall and temperature in Ondo within the period of studyof 123.92 mm and 31.89°C

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 and 3.4% in 2015 for temperature. The frequency of rainfall in the state correlates with the degree of temperature.

Recommendations

Hence, in this project we recommended 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. The study further suggests that proper flood control mechanism should be put in place while it is recommended that rain fed Agriculture is best practiced under this type of rainfall trend pattern and its corresponding effect of temperature. 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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