STATISTICAL ANALYSIS OF TREND IN EXTREME RAINFALL AND TEMPERATURE EVENTS IN PARTS OF NORTH CENTRAL STATES, NIGERIA

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Abstract

The study investigated trend in extreme rainfall and temperature indices using thirty (30) years daily data from Climatic Prediction Center Merged Analysis of Precipitation (CMAP) for Five stations in the North Central States of Nigeria. Nine (9) extreme rainfall and Five (5) extreme temperature indices developed by Expert Team on Climate Change Detection and Indices (ETCCDI) under the World Meteorological Organization (WMO) were generated using the RClimDex Software. Mann-Kendall, a non-parametric test was used for trend detection while Theil-Sen slope estimator approach was used to examine the magnitude of trend change in the derived indices. Result showed mixed trends of significant and insignificant in the selected extreme indices across the stations. The extreme rainfall indices of Consecutive Dry Days (CDD) and Maximum 1-day rainfall (R1D) showed steady increase across the stations during the study period while the indices of Consecutive Wet Days (CWD) and Number of heavy rainfall days (R10) showed decreasing trend across the stations. Further result showed decreasing trend for the extreme temperature indices of Monthly minimum value of daily minimum temperature (TNn) and Diurnal Temperature Range (DTR) across the study area while the other variables showed mixed trend during the same period. The study established that the fluctuating trends in the variables are conceivable indicator of climate change in the study areas. The study recommended that future climate change adaptation strategies should take into account the observed and projected changes in the extremes.

Keywords: Climate, Prediction, Extreme rainfall, Extreme temperature, Diurnal Temperature

1.0 Introduction

The influence of climate and extreme events is particularly extensive, affecting diverse fields such as agriculture, public work, transportation, water resources etc. Because of the occurrence of extreme events such as floods, extreme heat and

extreme cold, casualties have increased and the social infrastructure globally has become more vulnerable. The extent of damage and damaged areas has also increased. Therefore, accurate understanding and analysis of long-term changes in climate extreme event data are necessary to prevent future damages to the social infrastructure caused by climate change (Kim *et al*., 2011).

Though several studies exist on trend of climatic variables in the study area (Ibrahim, *et al*., 2015; Musa, *et al.,* 2019; Itiowe, *et al*., 2019), the trend in extreme climatic variables using the new indices by Expert Team on Climate Change Detection and Indices (ETCCDI) has rarely been documented for the study area. This study therefore, investigated trends in daily extreme rainfall and temperature in the study area.

2.0 Materials and Methods

2.1 The Study Area

The study area lies between Latitude 7^0 48^1 N and 9^0 36^1 N and Longitude 4^0 32^1 E and 8^0 30^1 E. The study area includes: Minna, Lokoja, Abuja, Ilorin and Lafia.

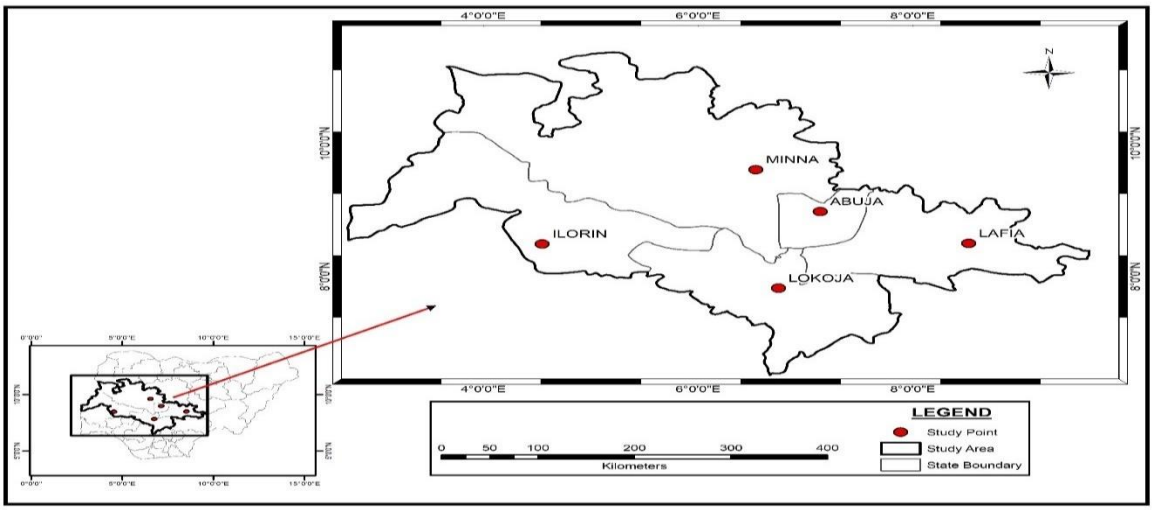

Figure 1: Map showing the Study Area

2.3 Data Analysis

Daily rainfall and temperature data for thirty years (from1989 to 2018) obtained from Climate Prediction Center Merged Analysis of Precipitation (CMAP) for the five stations were used. The study adapted Nine (9) indices on extreme rainfall

and Five (5) on extreme temperature developed by Expert Team on Climate Change Detection and Indices (ETCCDI) under the World Meteorological Organization (WMO). The RClimDex software was used to extract the selected extreme indices.

Mann-Kendall test was used to examine trends in extreme rainfall and temperature indices with significance levels at a = 0.001, 0.01, 0.05 and 0.1 taken as thresholds to classify the significance of upward and downward trend. The equation (Mann-Kendall statistic) is given as:

$$S = \sum_{k=1}^{n-1} \sum_{i=k+1}^{n-1} \mathrm{sgn}(\mathrm{x_j} - \mathrm{x_k}) \qquad (1)$$

$\mathrm{x_j}$ is a time series ranked from i = 1,2,……n-1 and $\mathrm{x_j}$, ranked from $j = i$ +1,2,…….n.

To establish the magnitude of trend change, the Theil-Sen slope estimator approach was used.

$$\beta = \left(\frac{x_{j-}\, x_k}{j-k}\right) \forall k < j \qquad (2)$$

The analysis was done using MAKESENS 1.0 software.

3.0 Results and Discussions

Table 1 depicts the result for extreme rainfall indices. Result shows consistent increasing trend for Consecutive dry days (CDD) and Maximum 1-day rainfall (R1D) across the stations. Conversely, the result for Consecutive wet day (CWD) and Number of heavy rainfall days (R10) shows consistent decreasing trends in all stations. Further results showed mixed trend in the derived indices across the stations.

Table 1: Trend in Extreme Rainfall Indices over the Study Area (1989 – 2018)

Stations	CDD	CWD	SDII	R1D	R5D	R95T	R10	R20	R50
Minna	2.20*	-3.46***	2.11*	2.89**	1.68+	1.55	-1.83+	0.34	1.52
Lokoja	1.34	-2.63**	-2.09*	2.16*	-1.39	-.05	-3.32***	-2.76**	1.37
Abuja	2.41*	-2.75**	3.39***	3.28**	1.86+	2.57*	-1.66+	0.52	3.03*
Ilorin	1.23	-1.80+	1.59	1.64	0.64	1.53	-1.86+	0.00	2.38*

Lafia	1.04	-3.18**	-1.50	2.00*	-1.89+	-0.71	-3.59***	-3.42***	-0.71

***Trend is significant at a = 0.001, **Trend is significant at a = 0.01, *Trend is significant at a = 0.05, +Trend is significant at a = 0.1 confidence levels.

Table 2 depict the result of magnitude of trend change in the extreme rainfall indices in the study area. Result shows increasing magnitude of change for CDD at 1.5 mm yr^{-1}, 0.82 mm yr^{-1}, 2.20 mm yr^{-1}, 0.63 mm yr^{-1} and 1.00 mm yr^{-1} for Minna, Lokoja, Abuja, Ilorin and Lafia stations respectively. while CWD shows decreasing magnitude of change at 0.12 mm yr^{-1}, 0.17 mm yr^{-1}, 0.20 mm yr^{-1}, 0.05 mm yr^{-1} and 0.33 mm yr^{-1} at Minna, Lokoja, Abuja, Ilorin and Lafia stations respectively. Further result shows varying magnitude of change for the derived indices across the stations.

Table 2: Magnitude of Trend Change in Extreme Rainfall Indices

Stations	CDD	CWD	SDII	R1D	R5D	R95T	R10	R20	R50
Minna	1.55	-0.12	0.10	1.36	0.87	4.55	-0.33	0.00	0.00
Lokoja	0.82	-0.17	-0.07	0.45	-0.86	-2.80	-1.00	-0.41	0.00
Abuja	2.20	-0.20	0.19	1.98	1.93	8.68	-0.33	0.06	0.07
Ilorin	0.63	-0.05	0.05	0.44	0.34	3.83	-0.25	0.00	0.00
Lafia	1.00	-0.33	-0.07	0.53	-1.44	-1.52	-1.71	-0.77	0.00

Table 3 shows result of trend in extreme temperature indices. Generally, the Tables shows decreasing trend in in bulk of stations. Result for Monthly minimum value of daily minimum temperature (TNn) and Diurnal Temperature Range (DTR) shows consistent decreasing trend across the stations while other indices showed varying trend of significant and non-significant increasing and decreasing trend.

Table 3: Trend in Extreme Temperature Indices over the Study Area

Stations	TXn	TXx	TNn	TNx	DTR
Minna	0.11	0.98	-0.80	0.89	-1.27
Lokoja	-0.50	2.05*	-2.03*	-2.03*	-3.48***
Abuja	1.71+	-0.34	-2.37*	-1.82+	-2.50*
Ilorin	-0.70	0.39	-2.46*	3.09**	-1.07
Lafia	1.62	-0.36	-1.96*	-2.18*	-3.03**

***Trend is significant at a = 0.001, **Trend is significant at a = 0.01, *Trend is significant at a = 0.05, +Trend is significant at a = 0.1 confidence levels.

Table 4, depict the result of magnitude of trend change in the extreme temperature indices. Result for TXn shows increasing magnitude of change in Minna, Abuja and Lafia stations at 0.01^{0}C, 0.07 ^{0}C and 0.05 ^{0}C, and a decreasing magnitude of change in Lokoja and Ilorin stations at 0.03 ^{0}C and 0.02 ^{0}C, while Minna station shows no change. Result for TNx shows increasing rate of change in Minna and Ilorin at 0.02 ^{0}C and 0.04 ^{0}C, while Lokoja, Abuja and Lafia depict decreasing rate of change at 0.07 ^{0}C, 0.06 ^{0}C and 0.11 ^{0}C, respectively.

Table 4: Magnitude of Trend Change in Extreme Temperature Indices

Stations	TXn	TXx	TNn	TNx	DTR
Minna	0.01	0.05	-0.03	0.02	-0.01
Lokoja	-0.03	0.09	-0.07	-0.07	-0.09
Abuja	0.07	-0.02	-0.12	-0.06	-0.05
Ilorin	-0.02	0.01	-0.04	0.04	-0.01
Lafia	0.05	-0.01	-0.19	-0.11	-0.09

4.0 Conclusion

The study examined trend in extreme rainfall and temperature indices for the period of thirty years (1989 to 2018) from the Five (5) stations that constitute the study area. Result shows varying trend of significant and insignificant increase and decrease across the stations. The mixed trend could be an indicator to the influence of station's specific physical characteristic. The study concluded that the fluctuating trends in the extreme variables are likely pointer to the evidence of climate change in the study areas. It is recommended that future adaptation strategies should take into account the observed and projected changes in the extremes.

References

Ibrahim, I., Usman, M. T., Abdulkadir, A. & Emigilati, M. A. (2015). Analysis of rainfall distribution, temporal trends, and rate of change in the Savannah zones of Nigeria. *Journal of Atmosphere-Ocean*. 1-10.

Itiowe, T., Hassan, S. M. & Agidi, V. A. (2019). Analysis of Rainfall Trends and Patterns in Abuja, Nigeria. *Current Journal of Applied Science and Technology*. *34(4), 1-7*.

Kim, B. S. Yoon, Y. H. Lee, H. D. (2011). Analysis of Changes in Extreme Weather Events Using Extreme Indices. *Environ. Eng. Res.* 16(3), 175-183.

M. Musa, Y. M. Suleiman, & **T. I., Yahaya.** (2019). Trend Analysis in Rainfall Variability in Parts of North Central States, Nigeria: A Non – Parametric Approach. International Journal of Agriculture and Agricultural Technology. 11(1), 235 – 244. ISSN: 0196 – 3488.