TREND ANALYSIS OF EXTREME RAINFALL EVENTS FOR DECISION-MAKING IN NORTH-WEST NIGERIA

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Abstract

Global climate change have trigger extreme rainfall events leading to meteorological hazards around the world. This paper examines the trends in extreme rainfall from five (6) synoptic stations in North-West Nigeria for a period of 35 years (1981-2015). Daily rainfall data acquired from Nigeria Meteorological Agency were converted into indices (heavy, very heavy, extremely heavy rainfall days, one day maximum rainfall amount and five days maximum rainfall amount). Statistical tests of Mann-Kendall Test (MK), based on a non-parametric approach to trend detection were used to evaluate the possible trend in the derived indices. Results showed significant positive trends in the five indices at Kano and Katsina station. The insignificant positive trends were detected in the indices across other station with exception to Gusau for heavy, very heavy rainfall days and Yelwa for five days maximum rainfall amount where the trends were negative. The trends were attributed to a possible change in climate. It is recommended that similar research, utilising longer-term data extending to entire Nigeria, to facilitate generalisation of the outcome of this finding

Keywords: rainfall trends, extreme rainfall, Mann-Kendall

1 Bacground to the Study

The global climate change has been linked to anthropogenic activities (Kyei-baffour, 2017) and is an issues of international importance at the contemporay time. The global climate change associated to anthropogenic activities remain a major challenge for mankind (Stott et al., 2016) as well as natural ecosystems. Although precipitation extreme could occur under normal climate conditions (Zhang, et al., 2017), recent studies (Han, et al., 2014; Kug & Ahn, 2013; Sibanda, et al., 2017) suggest that rising extreme precipitation events are linked with global warming. This is understood to bring about an increased in atmospheric moisture content. The extreme precipitation events is therefore a pointer to understanding of global climate change.

Due to importance of extreme precipitation and their effects on ecological systems and society have lead to global attentions in the field of science of climate change and other related decipline. For example (Zhang et al., 2017) found that precipitation indices have experienced increasing trend in the central Asia, (Croitoru, et al., 2015) found a dominant increasing trend for the number of isolated days with moderate and heavy precipitation in Romania, (Chen, et al., 2017) found a positive trends in indices of extreme precipitation in Hunan Province, central south China, in Mali (Kyei-baffour, 2017) found significant positive and positive insignificant increase in extreme precipitation indices, (Ongoma, et al., 2016) found insignificant declining trends in extrmr precipitation indices, (Marofi, et al., 2011) showed significant trends in extreme precipitation indices in Iran and (Libanda, et al., 2017) showed significant increase in extreme precipitation indices. These findings suggested that extreme precipitation for different have varied regionally around the world (Mei et al., 2018) and this futher support the need for localised studies.

In the recent time (2012 and 2018) the North-West part of Nigeria have experienced extreme rainfall events resulting to flooding with significant impact on social, economic, and loss of lives. The need to support decision-making processes associated with water resource management and flood prevention under changing environments at a local scales require contemporay assesment of etreme rainfall. This study cover the North-West part of Nigeria. The trends of extreme rainfall patterns is assess to provide essential information in developing new management strategies for policy makers.

2.0 Research Methodology

2.1 The Study Area

The location of North-West part Nigeria is represented in Figure 1. The zones lie between Longitudes 4^0 8^1E and 6^0 54^1E and Latitudes 10^0 00^1N and 13^0 58^1N. The weather observation stations located in the study area are Sokoto, Yelwa, Gusau, Katsina, Kano, and Kaduna respectively.

The major climatic feature of the region is the alternating wet and dry seasons called, rainy and dry seasons (Garba, et al., 2018). The location of inter-tropical discontinuity (ITD) determine season over the study area. The ITD position is influence by the two air mass of Tropical Maritime (mT) and Tropical Continental (cT). The ITD travels northwards between January and August over Nigeria and retreat southward from frontier of the Sahara desert after August (Ifabiyi & Ojoye, 2013). The rainy season in this area is related with the late start and early termination. The beginning and end are additionally described by damaging storms, which affect life and property (Abdulkadir, *et al.*, 2013). The seasonal and latitudinal variations influence daily and average temperature ranges.

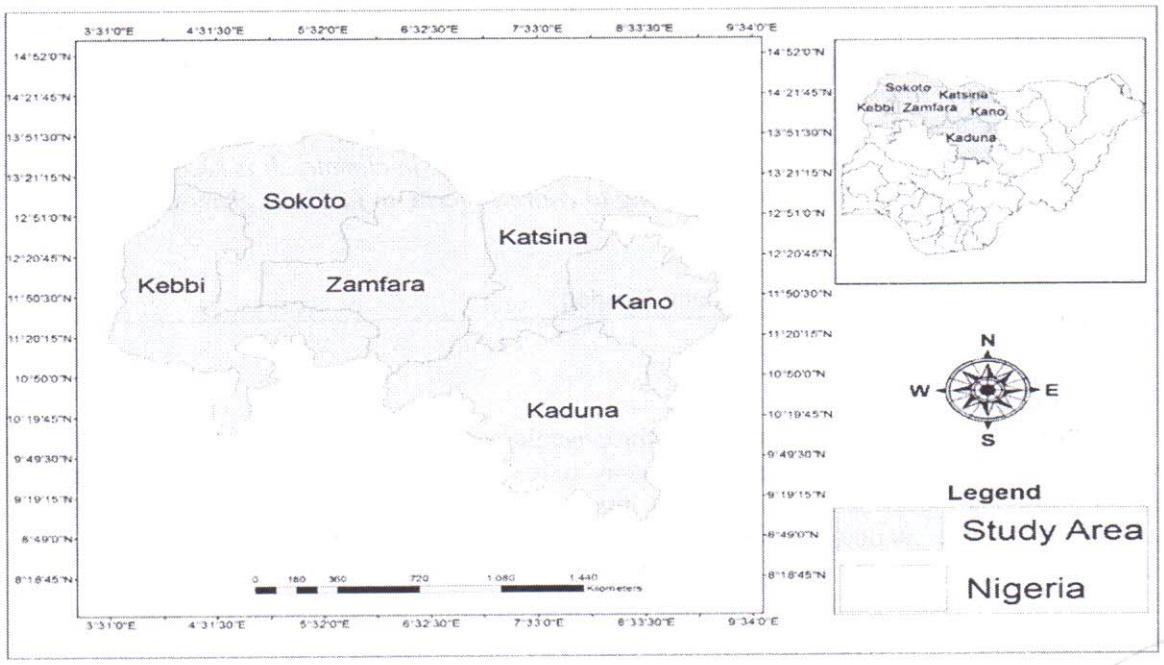

Figure 1: Map of North-West Nigeria
Sources: adapted from (Garba, et al., 2018)

2.2 The Data used

The daily rainfall data from Kaduna, Yelwa, Kano, Gusau, Sokoto, and Katsina being globally referenced meteorological stations was acquired from Nigeria Meteorological Agency (NIMET) for a period of 35 years (1981-2015).

2.3 Indices for extreme Rainfall

To improve a constant perspective on observed change climate and weather extremes, ETCCDI (Expert Team on Climate Change Detection and Indices) has defined a core set of descriptive indices of extreme. The indices describe special characteristics of extremes including amplitude, frequency and persistence.

The core set includes 27 extreme indices for precipitation and temperature. In this paper, five (5) indices on extreme precipitation were used (Table 2). All the indices were calculated by employing RClimDex software.

Table 1. ETCCDI precipitation-related extreme indices adapted for this study

No	Acronym	Name of the index	Description	Unit
1.	R10	Heavy precipitation days	Annual number of days with ≥10 mm/day	Days
2.	R20	Very heavy precipitation	Annual number of days with ≥20 mm/day	Days
3.	R25	Extremely heavy precipitation days	Annual number of days when precipitation ≥25 mm	days
4.	Rx1day	Max 1-day precipitation amount	Annual maximum 1-day precipitation	mm
5.	Rx5days	Max 5-day precipitation Amount	Annual maximum consecutive 5-day precipitation	mm

2.4 Trend Analysis

The data analysis was done using the Mann-Kendall (MK) test. It is a non-parametric approach originally used by Mann, (1945) and modified by Kendall, (1975). The significant levels at α= 0.001, 0.01, 0.05, and 0.1 was taken as thresholds to classify the significance of upward and downward trends. The MK test is a non-parametric test commonly used to detect significant trends in hydrological and meteorological time series (Oguntunde, et al., 2014; He, et al., 2015; Kundu, Ket al., 2015) as a standard. The MK is distribution-free and does not assume any special form for the distribution function of the data, the test has low sensitivity to abrupt breaks due to inhomogeneous time series.

3. Results and Discussion

3.1. General changes in extreme precipitation based on all indices used

Trends were calculated for each of the selected 5 indices datasets. The number of negative trend, positive trend, and significant trends was expressed as a percentage of all examined indices (Table 2). As a general overview, increasing trends are the most frequent, with 80% in R10, R20, and RX5 while 100% in R25 and RX1 respectively. In 40% of the indices, we have detected significant postive trend in R10, R20, R25 and RX1 respectively. The RX5 reveals 60% significant trends.

Table 2. Basic parcent of Trends

	% of stations with negative trends	% of stations with positive trends	% of stations with Sig negtive trends	% of stations with Sig positive trends
R10	20	80	0	40
R20	20	80	0	40
R25	0	100	0	40
RX1	0	100	0	40
RX5	20	80	0	60

Source: Author's Computation (2018)

3.2 Trends In Extreme Rainfall

The trends in extreme rainfall indices is represented in Table 3. The changes in statges of heavy rainfall to extremely heavy rainfall is associated with the destruction of property, especially in areas which are prone to flash floods (Ongoma et al., 2016). The Mann-Kendall trends is a count of days when rainfall ≥ 10 mm, ≥R20 mm, ≥R25 mm, maximum one day (RX1) rainfall amount and five days (RX5) rainfall amount.

The results reveals positive trends in R10 for all the rain guage stations with exception to Gusau rrainfall guage station which depict negative trends. The study detected significant trends in R10 at Kano and Katsina stations. The R20 indicates positive trends in all the station with exception Gusau station that reveals negative trends. The significant positive trends in R20 were detected at Kano and Katsina stations. The R25 reveals positive trends in all the studied stations. Significant positive trend is detected at Kano, Katsina and Sokoto stations. The findings of this study are consitent to those found in other studies across the world (Mishra, et al., 2012; Croitoru et al., 2015; Guan, et al., 2017; Zhang et al., 2017; Mukherjee, et al., 2018;)

Table 3. Mann-Kendall Trends Test in Extreme Rainfall

Stations	R10	R20	R25	RX1	RX5	
Gusau	-0.16	-0.69	0.03	0.14	1.08	
Kaduna	0.81	0.7	1.34	1.53	0.62	
Kano	2.25*	3.63***	4.14***	4.62***	3.78**	
Katsina	2.62**	2.92**	2.27*	1.16	2.43*	
Sokoto	1.1	0.83	1.4	2.37*	2.02*	
Yelwa	1.1	0.93	1.43	1.19	-0.06	

****Significant trend at α = 0.001, ** Significant trend at α= 0.01, * Significant trend at α= 0.05, + Significant trend at α= 0.1*

Source: Author's Computation (2018)

4. Conclusion

In this study the trend of five (5) of rainfall extremes during 1981-2015 in North-West Nigeria, based on daily rainfall records from six (6) synoptic stations were analysed. The MK test, were employed for data analysis. The results show number of heavy, very heavy and extremely heavy wet days increaseing insignificantly in some stations and significantly in other stations. R10 show an overall increase in heavy rainfall in all stations except Gusau. The changes remained insignificant throughout the study period except Kano and Katsina where significant changes were detected. Similarly, very heavy rainfall (R20) and extremely heavy rainfall (R25) are observed to increase during the study period. The maximum one day and five days rainfall amount in a year showed increasing trends across the study area. It is worth noting that Kano station revealed consistent significant trend in all the indices. The trends in the indices could increase water availbility in the environment. The number of days at which the heavy rainfall occur is also on the rise. The increasing trends could triger flood with consequence on life and properties. A positive trends in indices has been linked increase is a possible indicator of climate change in the region (Ongoma et al., 2016). This findings is critical to water resources management agency. It is recommended that similar research, utilising longer- term observed data extending to entire Nigeria, to facilitate generalisation of the outcome made herein.

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