Dr. Suleiman Y. Mohammed
Dept. of Geography
FUT, Minna. 2018.

# THE NIGERIA ASSOCIATION OF HYDROLOGICAL SCIENCES (NAHS)

## PROCEEDINGS OF THE

# 9th INTERNATIONAL CONFERENCE

## EDO 2018

**Theme: Water, Energy, Food and Environment (WEFE) Linkages**

Edited by:
J.O Ehiorobo, A.I Agbonaye,
C.N Emeribe, O.C. Izinyon

New Senate Chambers, University of Benin
9th - 12th October, 2018

# NIGERIA ASSOCIATION OF HYDROLOGICAL SCIENCES
# NATIONAL EXECUTIVE COMMITTEE MEMBERS

| | |
|---|---|
| Professor A.A. Adebayo | National President |
| Professor O.D Jimoh | Vice President 1 |
| Mrs. H.W Umaru | Vice President 2 |
| Dr. S Odunuga | Secretary |
| Mr. K Ogbu | Assistant Secretary |
| Dr. G.T Amangabara | Publicity Secretary |
| Mr. M Okechukwu | Financial Secretary |
| Engr. D.A Amodu | Treasurer |
| Professor C.C Mbajorgu | Editor-in-Chief |
| Emeritus Prof. Lekan Oyebande | Ex-Officio I |
| Professor S. Mustafa | Ex-Officio II |

**ZONAL COORDINATORS**

| | |
|---|---|
| Alh. Ahmed Abubakar Jalingo | North East Zonal Coordinator |
| Ima. S. Hogan | South-South Coordinator |
| Engr. Dr. Luke O. Uzoigwe | South-East Coordinator |
| Mal. Abdullahi Muhammed Tyabo | North-Central Coordinator |
| Prof. Olasumbo Martins | South West Coordinator |
| Prof. Abubakar Ismail | North west Coordinator |

# NIGERIA ASSOCIATION OF HYDROLOGICAL SCIENCES
# EDO_2018 LOC MEMBERS

| | |
|---|---|
| 1. Prof. J.O Ehiorobo | Chairman/Deputy Vice Chancellor (Administration) University of Benin |
| 2. Prof. O.C. Izinyon | Vice Chairman/Department of Civil Engineering |
| 3. Prof. C. Ikhile | Sec. /Dept. of Geography and Regional Planning |
| 4. Prof. Tito Aighewi | Member |
| 5. Engr. A.I Agbonaye | Member/ Chairman, Fund Raising Sub-committee |
| 6. Mr. Blessing E Omosefe | Member/ Department of Civil Engineering |
| 7. Engr (Mrs) E.S Isagba | Member/ Department of Civil Engineering |
| 8. Dr. R.I Ilaboya | Member/ Department of Civil Engineering |
| 9. Dr N.I Ihimekpen | Member/ Department of Civil Engineering |
| 10. Dr. H.A.P Audu | Member / Department of Civil Engineering |
| 11. Engr. Oria-Usifo Ehi | Member/ Department of Civil Engineering |
| 12. Dr. S.D Iyeke | Member/ Department of Civil Engineering |
| 13. Engr. Prince Ogbeifun | Member/ Department of Civil Engineering |
| 14. Engr. O. Osarenren | Member/Power specialist |
| 15. Engr. Solomon E. Okonofua | Member/ Department of Civil Engineering |
| 16. Miss Sarah Omosegho | Member |
| 17. Uwadia N.O | Member /Energy Commission of Nigeria |
| 18. Miss Juliet Akpejiori | Assistant Sec II/Department of Geomatics |
| 19. C.N Emeribe | Assistant Sec I/ Energy Commission of Nigeria |

# TABLE OF CONTENTS

**SUBTHEME 5: DECISION SUPPORT SYSTEM IN WATER RESOURCES MANAGEMENT**

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

**Ibrahim Ishiaku[1], Ojoye Samsideen[2], Badaru Yahaya Usman[2], Safiyanu Garba Yauri[1], Suleiman A. Y**

1 Department of Geography, Federal University Birnin Kebbi, Nigeria

2 Department of Geography, Federal University of Technology Minna, Nigeria

**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 $4^0$ $8^{\prime}$E and $6^0$ $54^{\prime}$E and Latitudes $10^0$ $00^{\prime}$N and $13^0$ $58^{\prime}$N. 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.

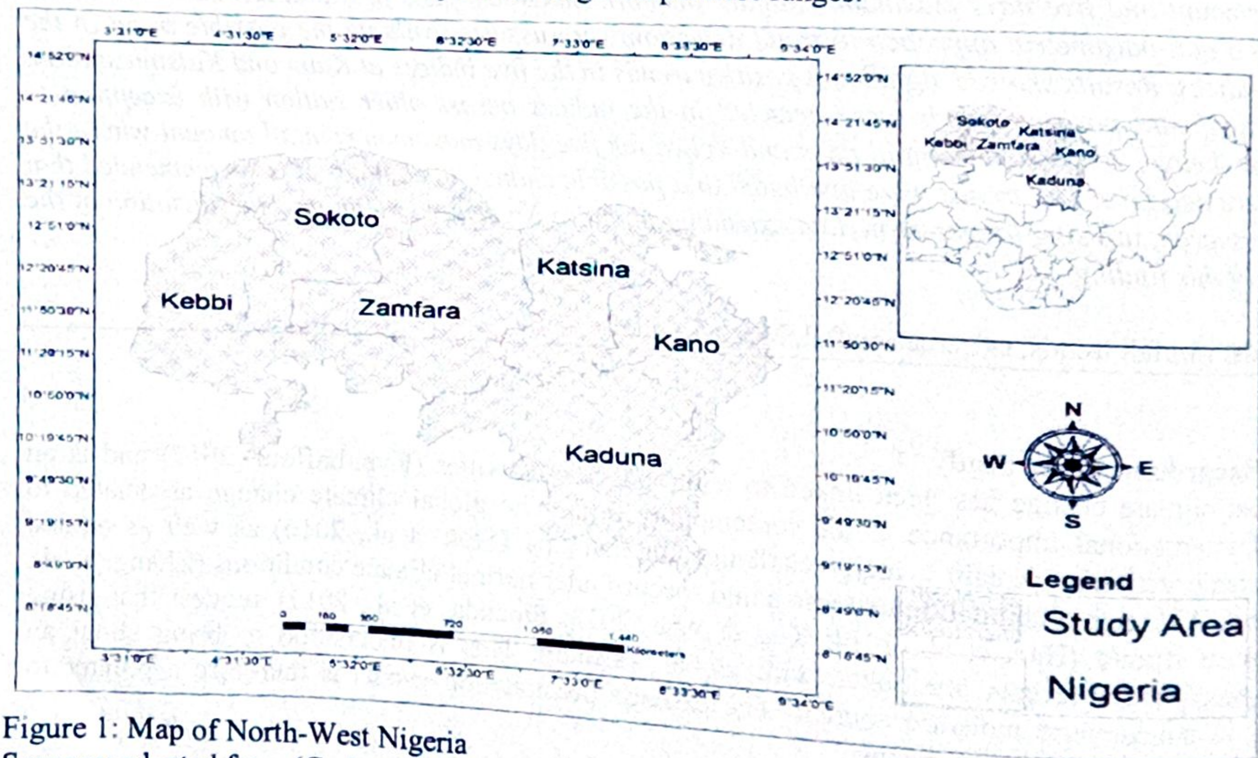


Figure 1: Map of North-West Nigeria
Sources: adapted from (Garba, et al., 2018)

### 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.

## References

Abdulkadir, A., Usman, M. T., & Shaba, A. H. (2013). Climate change , aridity trend and agricultural sustainability of the Sudano- Sahelian belt of Nigeria. *International Journal of Development and Sustainability*, *2*(2), 1436–1456.

Chen, A., He, X., Guan, H., & Cai, Y. (2017). Trends and periodicity of daily temperature and precipitation extremes during 1960–2013 in Hunan Province, central south China. *Theoretical and Applied Climatology*, *33*, 150–164. https://doi.org/10.1007/s00704-017-2069-x

Croitoru, A., Piticar, A., & Cristina, D. (2015). Changes in precipitation extremes in Romania. *Quaternary International*, *44*, 1–11. https://doi.org/10.1016/j.quaint.2015.07.028

Garba, M. I., Usman, M. T., Abdulkadir, A., & Ojoye, S. (2018). Analysis of Agricultural Drought Occurrences in Northwestern Nigeria. *International Journal of Scientific & Engineering Research Volume*, *9*(4), 864–867.

Guan, Y., Zheng, F., Zhang, X., & Wang, B. (2017). Trends and variability of daily precipitation extremes during 1960–2012 in the Yangtze River Basin, China. *International Journal of Climatology*, *37*(3), 1282–1298. https://doi.org/10.1002/joc.4776

Han, J., Baik, J., & Lee, H. (2014). Urban impacts on precipitation Urban Impacts on Precipitation. *Asia-*

*Pacific Journal of Atmospheric Sciences*, *33*, 1–16. https://doi.org/ 10.1007/s13143-014-0016-7

He, Y., Ye, J., & Yang, X. (2015). Analysis of the spatio-temporal patterns of dry and wet conditions in the Huai River Basin using the standardized precipitation index. *Atmospheric Research*, *166*, 120–128. https://doi.org/10.1016/j.atmosres.2015.06.022

Ifabiyi, I. P., & Ojoye, S. (2013). Rainfall Trends in the Sudano-Sahelian Ecological Zone of Nigeria. *Earth Science Research*, *2*(2), 194–202. https://doi.org/10.5539/esr.v2n2p194

Kendall, M. G. (1975). *Rank Correlation Methods* (4th ed.). London: Griffin.

Kug, J., & Ahn, M. (2013). Impact of Urbanization on Recent Temperature and Precipitation Trends in the Korean Peninsula. *Asia-Pacific Journal of Atmospheric Sciences*, *49*(2), 151–159. https://doi.org/10.1007/s13143-013-0016-z

Kundu, S., Khare, D., Mondal, A., & Mishra, P. K. (2015). Analysis of spatial and temporal variation in rainfall trend of Madhya Pradesh , India ( 1901 – 2011 ). *Environmental Development*, *201*, 333–352. https://doi.org/10.1007/s12665-014-3978-y

Kyei-baffour, N. (2017). Assessment of changing trends of daily precipitation and temperature extremes in Bamako and Segou in Mali from 1961-2014. *Weather and Climate Extremes J*, *18*, 8–16. https://doi.org/10.1016/j.wace.2017.09.002

Libanda, B., Zheng, M., & Banda, N. (2017). Variability of Extreme Wet Events over Malawi. *Geographica Pannonica*, *21*(4), 212–223.

Mann, H. B. (1945). Nonparametric Tests Against Trend. *Econometrica*, *13*(3), 245–259.

Marofi, S., Sohrabi, M. M., Mohammadi, K., Sabziparvar, A. A., & Abyaneh, H. Z. (2011). Investigation of meteorological extreme events over coastal regions of Iran. *Theoretical and Applied Climatology*, *103*, 401–412. https://doi.org/10.1007/s00704-010-0298-3

Mei, C., Liu, J., Chen, M., Wang, H., Li, M., & Yu, Y. (2018). Multi-decadal spatial and temporal changes of extreme precipitation patterns in northern China (Jing-Jin-Ji district, 1960-2013). *Quaternary International*, *55*, 1–13. https://doi.org/10.1016/j.quaint.2018. 03.008

Mishra, V., Wallace, J. M., & Lettenmaier, D. P. (2012). Relationship between hourly extreme precipitation and local air temperature in the United States. *Geophysical Research Letters*, *39*, 1–7. https://doi.org/10.1029/2012GL052790

Mukherjee, S., Aadhar, S., Stone, D., & Mishra, V. (2018). Increase in extreme precipitation events under anthropogenic warming in India. *Weather and Climate Extremes*, *20*, 45–53. https://doi.org/10.1016/j.wace.2018.03.005

Oguntunde, P. G., Lischeid, G., Abiodun, B. J., & Dietrich, O. (2014). Analysis of spatial and temporal patterns in onset, cessation and length of growing season in Nigeria. *Agricultural and Forest Meteorology*, *194*, 77–87. https://doi.org/10.1016/j.agrformet.2014.03.017

Ongoma, V., Chen, H., & Omony, G. (2016). Variability of extreme weather events over the equatorial East Africa, a case study of rainfall in Kenya and Uganda. *Theoretical and Applied Climatology*, *39*, 86–101. https://doi.org/10.1007/s00704-016-1973-9

Sibanda, S., Grab, S. W., & Ahmed, F. (2017). Spatio-temporal temperature trends and extreme hydro-climatic events in southern Zimbabwe. *South African Geographical Journal*, *62*, 1–23. https://doi.org/10.1080/03736245.2017.1397541

Stott, P. A., Christidis, N., Otto, F. E. L., Sun, Y., Vanderlinden, J., Oldenborgh, G. J. Van, … Zwiers, F. W. (2016). Attribution of extreme weather and climate-related events. *WIREs Climate Change*, *7*, 23–41. https://doi.org/10.1002/wcc.380

Zhang, M., Chen, Y., Shen, Y., & Li, Y. (2017). Changes of precipitation extremes in arid Central Asia. *Quaternary International*, *436*, 16–27. https://doi.org/10.1016/j.quaint. 2016.12.024