

*Dr. Suleiman Y. Mohamud
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
 Professor O.D Jimoh
 Mrs. H.W Umaru
 Dr. S Odunuga
 Mr. K Ogbu
 Dr. G.T Amangabara
 Mr. M Okechukwu
 Engr. D.A Amodu
 Professor C.C Mbajorgu
 Emeritus Prof. Lekan Oyebande
 Professor S. Mustafa

National President
 Vice President 1
 Vice President 2
 Secretary
 Assistant Secretary
 Publicity Secretary
 Financial Secretary
 Treasurer
 Editor-in-Chief
 Ex-Officio I
 Ex-Officio II

ZONAL COORDINATORS

Alh. Ahmed Abubakar Jalingo
 Ima. S. Hogan
 Engr. Dr. Luke O. Uzoigwe
 Mal. Abdullahi Muhammed Tyabo
 Prof. Olasumbo Martins
 Prof. Abubakar Ismail

North East Zonal Coordinator
 South-South Coordinator
 South-East Coordinator
 North-Central Coordinator
 South West Coordinator
 North west Coordinator

NIGERIA ASSOCIATION OF HYDROLOGICAL SCIENCES EDO_2018 LOC MEMBERS

1. Prof. J.O Ehiorobo
2. Prof. O.C. Izinyon
3. Prof. C. Ikhile
4. Prof. Tito Aighewi
5. Engr. A.I Agbonaye
6. Mr. Blessing E Omosefe
7. Engr (Mrs) E.S Isagba
8. Dr. R.I Ilaboya
9. Dr N.I Ihimekpen
10. Dr. H.A.P Audu
11. Engr. Oria-Usifo Ehi
12. Dr. S.D Iyeke
13. Engr. Prince Ogbeifun
14. Engr. O. Osarenren
15. Engr. Solomon E. Okonofua
16. Miss Sarah Omosegho
17. Uwadia N.O
18. Miss Juliet Akpejiori
19. C.N Emeribe

Chairman/Deputy Vice Chancellor (Administration)
 University of Benin
 Vice Chairman/Department of Civil Engineering
 Sec. /Dept. of Geography and Regional Planning
 Member
 Member/ Chairman, Fund Raising Sub-committee
 Member/ Department of Civil Engineering
 Member/ Department of Civil Engineering
 Member/ Department of Civil Engineering
 Member/ Department of Civil Engineering
 Member / Department of Civil Engineering
 Member/ Department of Civil Engineering
 Member/ Department of Civil Engineering
 Member/ Department of Civil Engineering
 Member/ Department of Civil Engineering
 Member/Power specialist
 Member/ Department of Civil Engineering
 Member
 Member /Energy Commission of Nigeria
 Assistant Sec II/Department of Geomatics
 Assistant Sec I/ Energy Commission of Nigeria

TABLE OF CONTENTS

		PAGE
	Foreword	iii
	NAHS National Executive Committee Members	v
1	Lead Paper I: Water: An Ingredient for Energy, Food Security and Environmental Equilibrium Prof. J.O Aribisala Res. Fell. (Aalog), FNSE, FNICE, COREN R	3-18
2	Lead Paper II: Water, Energy, Food and Environment (WEFE) linkages: The Integrated Water Resources Management Approach Dr. Martins O. Eduvie FNAH, FNMGS, mIAH	19-28
 SUBTHEME 1: WATER AND FOOD SECURITY		
3	Analysis of the Shortage of Ground Water in Gwantu Town Sanga Local Government Area, Kaduna State Nigeria Philip Nyam Giwa, Bulus Elisha Gimba and Tanimu Musa	31-42
4	Soil Surface Feature Responses to Rainfall in Obudu Local Government Area, Cross River State – Nigeria M. A. Abua; O. O. Ayiri and P. A Ojugbo	43-52
5	Analysis of the Potentials of Dadin-Kowa and Balanga Dam Sites for Sustainable Tourism Development in Gombe State, Nigeria Ishaku D., Emigilati A.M, Dan Y, Yason B	53-62
6	Heavy Metal Levels in Soils at Solid Waste Dumpsites in Akure, Ondo State, Nigeria: Implication for groundwater Pollution Ezemonye, M .N; Emeribe C .N and Egharegbemi, O.O	63-72
7	Assessment of Soil and Water Quality from Minjibir Irrigation Scheme for Sustainable Agriculture Salisu Dan'azumi and Rabilu Abdulkadir Barau	73-78
8	Estimation of Stream Discharge Data For Ungauged Basin Using SCS.CN Method Izinyon O.C, Isagba E.S, Emeribe C.N	79-90
9	Assessment of The Spatio-Temporal Variations of Surface Water Areas (SWA) And Impacts of a Man- Made Lake ABDULKADIR, Isah Funtua and GIN, Nuhu Sambo	91-100
10	Understanding the factors of flooding in Parts of Port Harcourt Metropolis (Parts of Obio/Akpor & Parts of Ikwerre LGAs) of Rivers State Amangabara, G.T‡., Ogwu, C. M., Oguine, C. E., and Ojiah, J.E	101-113
11	Water Crisis as Major Factor of Herdsmen-Farmers Conflicts in North Central Nigeria Joel Efiog & Opaminola N. Digha	114-120

SUBTHEME 2: WATER USE EFFICIENCY		123-127
12	Water Quality Assessment of Reservoir and Roof Harvested Rainwater Systems for the Ubulu –Uku Area of Delta State Ogbeifun, Nowamagbe P. and Muhammad Tijjani Yusuf	128-136
13	Water Demand Management (WDM) As A Water Use Efficiency Technique in Enugu Urban Area, Nigeria Ezenwaji E.E. and Nwafor, A. U	137-143
14	Assessing the Effectiveness of Mechanical Technology for Wastewater Treatment in WUPA Sewage Treatment Plant Abuja, Nigeria A.A Kadafa, M. F Ayeni, N.M Idris and O. Braimah	144-154
15	Assessing the Effectiveness of Wastewater Treatment Process of WUPA Sewage Treatment Plant Abuja, Nigeria A.A Kadafa, M. F Ayeni, N.M Idris and O. Braimah	155-162
16	Assessment of Small Holder Farmers' Rainwater Harvesting Techniques in Federal Capital Territory – Abuja, Nigeria Alkali Mohammed*, A.T Ogah, Samaila Taiye Tehinse	
SUBTHEME 3: ECOSYSTEMS SERVICES		
17	Sulphuric Acid-Activated Millettia Thoningii Pods Carbon as an Inexpensive Adsorbent for the Removal of Organic Dyes and Heavy Metals From Aqueous Solutions: A Preliminary Investigation Jasper Enebi Estella,a James Yusuf and Ugboaja Chijioko Vincent	165-171
18	Knowledge of the Forest Ecosystem among Forest Guards in Southern Nigeria Erhabor Igbinosa Norris	172-177
19	Cassava Whey as a substrate for ethanol production using Saccharomyces cerevisiae Cyprian E. Oshoma1*, Henrietta E. Obibiland Andrew C. Otobo	178-188
20	Production of ethanol from ripe Plantain peels hydrolysate by Saccharomyces Cerevisiae Cyprian E. Oshoma1*, Ese Okojie and Marcel J. Ikenebomeh	189-195
21	Preliminary Investigation of Some Selected Plants Seeds as Natural Coagulants for Water Treatment J. Sani., M.A. Gada., I.T. Peni, A.D. Tambuwal., and M.N. Almustapha	196-204
SUBTHEME 4: CLIMATE CHANGE, FOOD AND DROUGHT		
22	Goodness of Fit of Five Probability Distribution Models For Precipitation Frequency Analysis of Some Stations in Nigeria Using L-Moment Approach *O.C.Izinyon, E. Oturo and J.O.Ehiorobo	207-219
23	Evaluating the Performance of Log-Normal probability Distribution In Estimating the Amount of Rainfall in Samaru Area, Zaria, Kaduna State Aminu H.G and Aminu, Z	220-224
24	The Appraisal of the relationship between weather conditions and cassava Production in Enugu state Mba, Chinedu Lillian, Ezech, Christopher Uche, Umerah, Chukwuma Tooohukwu	225-230
25	Land Use Change and Rural Livelihood in Changing Climate in Semi-Arid Akko, Gombe, Nigeria G. O. Abu, *R. D. Abu and L. A. Mbaya	231-239

- 26 **Climate Change in Nigeria: Implication for Food Security** 240-256
ADE, Joshua and IKAPE Mercy Ogeyi
- ~~27~~ **Trend Analysis of Extreme Rainfall Events in North-West Nigeria** 257-261
Ibrahim Ishiaku, Ojoye Samsideen, Safiyanu Garba Yauri, Badaru Yahaya Usman
- 28 **Adaptation Strategies of Rural Communities to Climate Change along the Gongola River in North Eastern Nigeria** 262-272
Yakubu Dan and Idoma Kim
- 29 **Spatially Interpolation of Rainfall Data Using ArcGIS in South-east Nigeria: A Comparative Study** 273-284
Okechukwu M.E, Mbajiorgu C.C. and Ugwu E.I
- 30 **Water scarcity, a challenge to an attainment of food security in Nigeria** 285-290
Mudi david enejoh
- 31 **The Negative External Effects of Climate Change in Nigeria; a Case Study of Sokoto State** 291-295
Sirajoddeen Al-Ameen
- 32 **Impact of Climate Change on Socioeconomic status of Households in Rural Areas of Nasarawa State: An Autoregressive Distributed Lag Analysis** 296-304
AJIDANI, Moses Sabo

SUBTHEME 5: DECISION SUPPORT SYSTEM IN WATER RESOURCES MANAGEMENT

- 33 **The Pollution Index of Groundwater from Boreholes around or closed to Refuse Dump in Benin City (Oredo L.G.A. as a Case Study)** 307-325
Cole, N. O. and Ori-Usifo, E. E
- 34 **Water Quality Assessment of Distribution Water Systems of some selected Hospitality homes in Benin City, Edo state, Nigeria** 326-337
*Olisaka F.N, Odjadjare E.E.O and Ekhaise F.O
- 35 **Assessment of Vulnerability of Surface and Groundwater Sources from Agricultural Pollutants in the Sokoto River-Rima floodplain** 338-350
Abdulqadir Abubakar Usman and Murtala Abubakar Gada
- 36 **Evaluation of Residual Chlorine Concentration in a Conventional Treatment Plant of a Municipal Water Distribution Network** 351-362
Audu, H.A.P. and Ikhafia, O. P
- 37 **Modelling and prediction of Ground Concentration of Gaseous Pollutants from Utorogu Gas Plant and flow station, Niger Delta Area, Nigeria** 363-372
Audu, H.A.P. and Okpoko, J. S.
- 38 **Preliminary Investigation of Groundwater Quality within And Around Hospitals in Makurdi Metropolis, Nigeria** 373-385
P.S. Anjembe, M. I. Ocheri and M.A. Onah
- 39 **Groundwater Quality Assessment around Igbatoro Dump Yard Using Geospatial Technology** 386-394
Okonofua E. Solomon, Uwadia Nicholas and Akpejiori I. Juliet
- 40 **Assessment of the Physicochemical Components of River Kaduna** 395-402
Ali Ikpo Ali
- 41 **Assessment of Bank Erosion Potential of River Meme, Lokoja Metropolis, Nigeria: Using Bank Erosion Hazard Index** 403-410
Kabir, A., and Musa, A
- 42 **Urbanization and Urban Drainage Challenges: Case Study of Dekina, Ankpa and Oguma towns of Kogi State** 411-418
Daniel Simon and Alkali Daniels Emmanuel

- 43 **Geographical Review of Drainage Basin Morphometric (Fluvial) Parameters** 419-429
Salau Wahab
- 44 **An Appraisal of Factors Affecting Groundwater Formation and Recharge in Parts of Northern Kano State, Nigeria** 430-440
Amir Abdulazeez* and Adamu G. K/Naisa
- 45 **Impact Of Land Use Change On Watershed Dynamics In Suleja, Niger State Nigeria** 441-447
Emmanuel D, T, Mohammed M
- 46 **Statistical Approach to Modelling and Analysis of Hydrological Data** 448-461
Ilaboya, I. R, Ihimekpen, N.I and Omosefe, E.B
- 47 **Application of Critical Path Method to Small Town Water Supply Scheme. A Case Study of Ugbakele Water Project Delta State** 462-471
Agbonaye, A.I
- 48 **An Assessment of Waste-Water Quality for Domestic and Irrigational Uses at the Kamanzo-Stadium Bridge-Kudende Stream Section of River Kaduna, Kaduna State** 472-486
MEJABI, Dele Joseph Jacksolomon HABILA, Sunday Kazahshii
- 49 **Assessment of River Tudun Amba Water Quality for Domestic Use in Lafia Local Government Area of Nasarawa State, Nigeria** 487-494
Ruth Benbella. M. . Chunwate B. T. Alkali . Adem Samuel ,Alfa Y. Funmilayo M.N. Idris
- 50 **Groundwater Quality Assessment Using Water Quality Index And Map Generation Of Akoko-Edo Region** 495-509
Izinyon O. C. and Iyalekhue, I
- 51 **A Review: Performance of Sediment Detachment and Transport Functions for Overland Flow Conditions** 510-525
Ogwo, V.*, Mbajiorgu, C.C., Ndulue, E.L., Onyekwelu, I. and Ogbu, K.N
- 52 **Investigation of Groundwater Challenge in Crystalline Basement Complex of Southwestern Nigeria: Case study of Ada and Environs using Integrated Approach** 526-539
Ojo A. Olabanji and Akinlabi J. Oluwafemi
- 53 **Generation Of Rainfall Intensity Duration Frequency Curve For Benin City** 540-552
Omosefe E.B., Izinyon O.C
- 54 **Water Quality For Effective Food Production In Zobe Dam Dutsinma Area, Katsina State, Nigeria** 553-560
Tasi'u Yalwa Rilwanu
- 55 **Water Demand Assessment For Benin City** 561-573
Ngozi Ihimekpen , Prince N. Ogbeifun Atikpo, E
- 56 **Impact of Water Resources on Economic Activities along River Benue: A Study of Iggah District of Benue and Nasarawa States** 574-582
AJIDANI, Moses Sabo
- 57 **An Assessment of Water Quality of River Obi in Obi Local Government Area of Benue State** 583-597
M. A. Onah and M, L. Odeh
- 58 **An Assessment Of Water Quality Status Of Woji River In Obio-Akpor Local Government Area Of River State, Nigeria** 598-603
Abua, M. A., Igelle E.I and Oji, C.P

- 59 **Comparative evaluation of the models used for the calculation of re-aeration coefficient of surface water bodies (a case of luubara creek and deezim creek)** 604-617
O.C. Izinyon and B.M. Akatah
- 60 **Utilization of dimensional analysis approach for modelling Re-aeration Coefficient** 618-622
O.C. Izinyon and B.M. Akatah
- 61 **Validation Of Satellite-Image Derived Reservoir Bed Profile** 623-635
Abdulkadir. I. F and Ojinnaka O.C.
- 62 **Impact of Sand Mining on Water Quality and Bank Morphology of Otamiri River in Owerri, Imo State** 636-643
Okeke, P.N, Anyanwu, J.C and Edenta, V.I
- 64 **Surface Water Quality Evaluation And Health Implications At In-Stream Sand Mining Sub-Catchment Of Abak Local Government Area, Akwa Ibom State** 644-650
Nyetiobong William

SUBTHEME 6 &7: COOPERATION AND PARTNERSHIP IN WATER RESOURCES MANAGEMENT/HEALTH AND GENDER ISSUE IN WATER

- 65 **An Analysis of River Water Quality and Health Challenges faced by Women in Southern Kaduna, Kaduna State, Nigeria** 653-660
Adams Joyce and Bonoh Friday
- 66 **Health and Gender Dimension of Potable Water Supply in Lafia City: Implications for Community Development and Well Being** 661-668
Muhammad K. DAHIRU and Emankhu, S. ETEMINI

SUBTHEME 8: LEGAL AND INSTITUTIONAL FRAMEWORK IN THE WATER SECTOR

- 67 **Food, Water and Gender in Nigeria: A Legal Assessment** 671-685
Juliet A. Aimienrovbiye, Irene Airen Aigbe



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

Ibrahim Ishiaku¹, Ojoye Samsideen², Badaru Yahaya Usman²,
Safiyanu Garba Yauri¹, 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 Background 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 contemporary 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^o 8¹E and 6^o 54¹E and Latitudes 10^o 00¹N and 13^o 58¹N. 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.

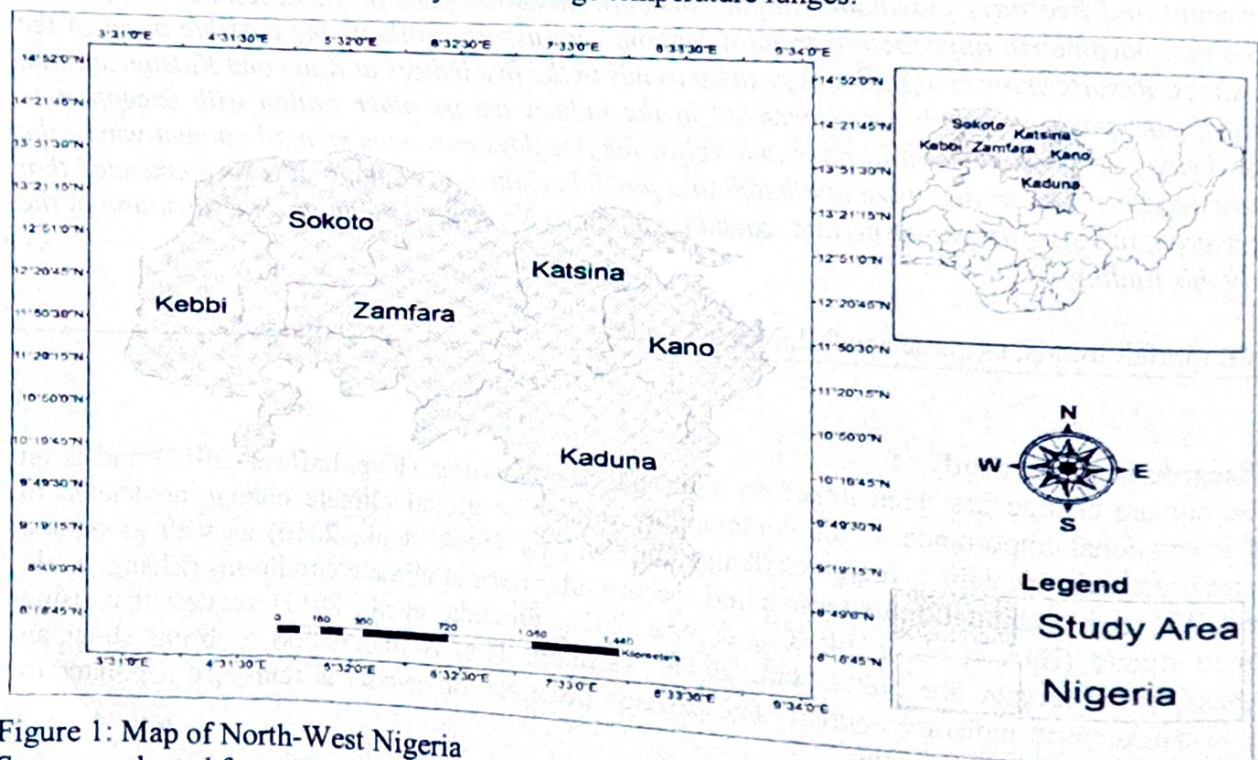


Figure 1: Map of North-West Nigeria
Sources: adapted from (Garba, et al., 2018)

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 $\alpha = 0.001, 0.01, 0.05,$ 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 positive trend in R10, R20, R25 and RX1 respectively. The RX5 reveals 60% significant trends.

Table 2. Basic percent of Trends

	% of stations with negative trends	% of stations with positive trends	% of stations with Sig negative 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	60
RX5	20	80		

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 states 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, $\geq R20$ mm, $\geq R25$ 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 rainfall 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 consistent 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 $\alpha = 0.001$, ** Significant trend at $\alpha = 0.01$, * Significant

trend at $\alpha = 0.05$, + Significant trend at $\alpha = 0.1$

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 increasing 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 availability in the environment. The number of days at which the heavy rainfall occur is also on the rise. The increasing trends could trigger 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 and 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-*

- 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>