PRINT ISSN 1119-8362
Electronic ISSN 2659-1502

Full-text Available Online at
https://www.ajol.info/index.php/jasem
http://www.bioline.org.br/ja

J. Appl. Sci. Environ. Manage.
Vol. 26 (8) 1415-1422 August 2022

Rainfall Trend and its Implications for Sustainable Crop Production and Water Resources Management: A Case Study of Iwo, Nigeria

[*1]OGUNBODE, TO; [1]ESAN, VI; [2]SAMSON, TK; [3]OYELOWO, OJ; [4]ASIFAT, JT

*[*1]Environmental Management and Crop Production, College of Agriculture, Engineering and Science, Bowen University, Iwo, Nigeria*
[2]Statistics Programme, College of Agriculture, Engineering and Science, Bowen University, Iwo, Nigeria,
[3]Department of Forest Conservation and Protection, Forestry Research Institute, Ibadan
[4]Department of Geography, Obafemi Awolowo University, Ile-Ife, Nigeria

**Corresponding Author Email: timothy.ogunbode@bowen.edu.ng*
Other Authors Email: vincent.esan@bowen.edu.ng ; kayoed.samson@bowen.edu.ng ; tayooyelowo@yahoo.com ; janetasifat2@gmail.com

ABSTRACT: Studies have revealed that the pattern of rainfall will change in view of climate change scenario being experienced globally. Thus, a thirty-year (1989-2018) rainfall data analysis was conducted for Iwo in Osun State, southwestern Nigeria to determine the trend pattern of rainfall. One parameter Mann-Kendall statistic was used in the analysis of the data. The results showed that while five months (February, April, July, August and December) showed negative trend (Negative y-values) indicating declining rainfall over the period, seven months (January, March, May, June, September, October and November) revealed a positive trend (positive y-values) implying increasing rainfall over the period for those months. However, the general analysis of the 30-year data showed that there was negative trend in rainfall in the study area which means that there is general fall in the rainfall incidence over the period in Iwo. The results of monthly trend indicated that rainfall is no longer dependable for a viable agricultural practice, and so water conservation methodologies need to be embarked upon in order to salvage crops from the shortfall in the rain caused by climate change. It is therefore, recommended that shifting in the planting dates, irrigation, planting cover crops and planting heat tolerant crops and early matured crop varieties among others should be considered by farmers, especially the small scale farmers. Stakeholders in water resources management holds the responsibility on averting water scarcity and the challenge of water pollution in view of the erratic rainfall to ensure human survival.

DOI: **https://dx.doi.org/10.4314/jasem.v26i8.15**

Cite this paper as: OGUNBODE, T. O; ESAN, V. I; SAMSON, T. K; OYELOWO, O. J; ASIFAT, J. T. (2022). Rainfall trend and its Implications for Sustainable Crop Production and Water Resources Management: A Case Study of Iwo, Nigeria. *J. Appl. Sci. Environ. Manage.* 26 (8) 1415-1422

Dates: Received: 13 June 2022; Revised: 25 August 2022; Accepted: 26 August .2022

Keyword: Environment; Mann-Kendall; hydrology; Rainfall trend; Water Resources; Iwo

Investigations on the impacts of greenhouse warming had suggested that the timing and regional pattern of precipitation will change and more intense of rainfall is expected (Feng, *et al.*, 2019; Tabari, 2020). Such regional patterns in rainfall, especially in the tropical regions is already established in literatures (Lawal and Yamusa, 2018; Woo and Tarhule, 1998; Ogunbode and Ifabiyi, 2019). This hydro-climatological parameter, however, impacts on the livelihoods of man globally because of its influence on sustainability of natural resources and especially, agricultural practices and importantly in the developing countries. Apart from this, in-depth investigation into rainfall parameter enhances a result-oriented water resource management. For instance, incidence of flood, drought, water availability for home and industrial uses among others require adequate and timely information on rainfall characteristics such has its variability, amount, intensity among others. Kumar and Kumar (2015) noted that the spatial distribution and magnitude of rainfall trends is of immense significance from agricultural and water management point of view. Also, Woo and Tarhule (1998) and Valipour (2012) in corroborating this view stated that a long term rainfall data is very crucial in arriving at decisions about agriculture, water management and

**Corresponding Author Email: timothy.ogunbode@bowen.edu.ng*

crop pattern and also to locate drought prone areas. Dutta *et al* (2001) revealed that yield predictions of rice have been made by the models based on water requirement calculations and rainfall data in agro climatic zones of his study area. Rainfall pattern in Nigeria has been found to be variable over time and space that Okorie (2015) remarked that the variability in the weather and climate system of Imo State (in Nigeria) due to observed shifts in rainfall within the thirty-year climatic period which by implication showing the evidence of climate variations and change in the climate of the area. In the same vein, Ologunorisa and Tersoo (2006) noted that there was a remarkable downward trend in the annual rainfall over Makurdi, Nigeria and also attributed major floods in the metropolis to the high recurrence intervals of rainfall events. Similar observations have been made in other tropical countries in published works (Mehtal *et al*., 2002; Messay, 2006, Ogunbode and Ifabiyi, 2019, Ogunbode *et al*, 2019). Investigation into rainfall trend is demanded as it will help to optimize the use of rainwater available, identifying specific areas of high variability, knowledge of the amount of probable rainfall in the area and rainfall reliability with respect to meeting crop water requirements (also in Lawal and Yamusa (2018). Apart from the relevance of rainfall trends studies in agriculture, its relevance in water management cannot be overlooked. The incidence of flooding, water availability for home and industrial uses are intimately related to the variability feature of rainfall. Several scholars have worked on the variability of rainfall in their respective locations and its influence on water resource management (e.g. Odjugo, 2007; Muhammad, 2009; Onyenechere *et al*., 2011; Ifabiyi and Ashaolu, 2013). Many of these works discovered that rainfall is not static over space and time and that this feature has its influence on what is available of water for home and industrial uses. For instance Muhammad (2009) revealed that decrease in rainfall can lead to water shortages in lakes, dams, rivers for both hydroelectric generation and irrigation. Also, in the report of IPCC, it was asserted that changes in the total amount of rainfall and in its frequency and intensity directly affect the magnitude and timing of runoff and the intensity of floods and droughts. It was further stated that such variability can have major impacts on water resources, affecting both surface and subsurface water supply for human uses. Water is the lifeblood of the planet and its state in space and time influence all natural, social and economic systems (Ifabiyi and Ashaolu, 2013). In corroborating this fact, UNWater (2010) declared that water serves as the fundamental link between the climate system, human society and the environment while Ishaku and Majid (2010) also observed that variability of this hydro-climatological parameter impacts on water accessibility. Iwo, being a tropical city is also under the cycle of variation in rainfall. Thus, the objectives of this study are to determine the trend of rainfall in Iwo from 1989 to 2018 and to assess its implications for crop production and water resources management.

MATERIALS AND METHODS

Study Area: This research was carried out in Iwo Township (Figure 1). Iwo, located in Osun State in the southwestern Nigeria, has an area of 245km^2 with a population of 191,348 according to 2006 population census. It is located on the coordinate axis of 7^{0}38'N and 4^{0}11'E. The prevailing climatic condition is tropical with about eight months of rainfall (March to October) and about four months of dry season (November to February). Ogunbode (2015) discovered that annual rainfall in most tropical wet climate regions ranges between 1000mm and 2000mm with double maxima in July and September.

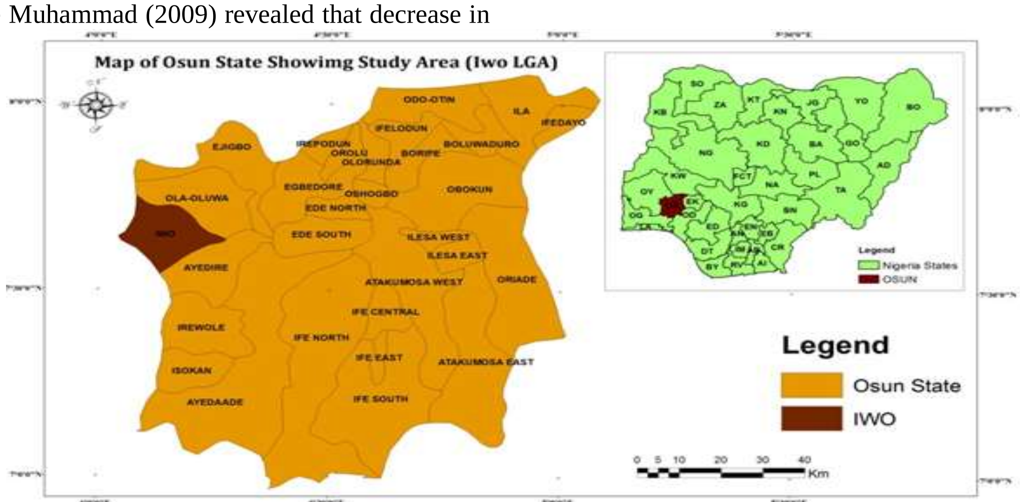

Fig 1. This research was carried out in Iwo Township

Iwo habitants are predominantly farmers with high dependence on rainfall for agricultural practices. Apart from this the dominant vegetation is tropical forest comprising hardwoods such as obeche, walnuts, acacia, eucalyptus among others. In addition, the dominant agricultural practice is growing of permanent and annual crops such as cocoa, kolanut, oil palm, yam, maize and so on. However, the dry period in the year is often dominated with farming in the wetlands and along some river banks. Aiba Water Reservoir located within Government Forest Reservation Area in Iwo forms one of the sources of potable water for home use in the area. However, as a result of unreliable and erratic supply from this Water Works and, in view of the susceptibility of the surface to pollutants, inhabitants have resorted to the exploitation of subsurface sources. Iwo is underlain by Precambrian Basement Complex comprising mostly gneiss, granite, schist, undifferentiated met-sediment rocks and overburden that are comprised mainly of clay, sand and silt soils. These compositions are neither porous nor permeable except where they are deeply weathered or along the lines of weakness. Also, Iwo is drained by rivers such as Oba and Yanyanhun River among others.

Data collection and analysis: A thirty-year rainfall data from 1989 to 2018 which was collected from the office of Nigeria Meteorological Agency (NiMET) (1989-2008) and Forest Research Institute of Nigeria (FRIN) (2009-2018) for the purpose of this investigation while XLSTAT software was used to determine seasonal Mann-Kendall and sen's slope trend statistics for the period.

RESULTS AND DISCUSSION

Composite 30-Year Rainfall Trend Analysis: Table 1 shows the summary of the descriptive statistics. The Table shows that there is no month without rainfall over the 30-year period. Also the seasonal variations in rainfall manifests in the pattern of rainfall with the lowest mean rainfall in the months of January (10.207±18.097mm), February (35.363±18.097mm), November (32.337±38.327mm) and December (6.573±11.278mm). Furthermore, the raining months as observed in the Table revealed that mean rainfall were highest in the months of July (188.048±96.065mm) and September (188.207±63.043mm) but lowest in the month of March (81.677±48.243mm).

Table 1: Summary Statistics

Variable	Observation	Obs with missing Data	Obs. Without missing data	Minimum (mm)	Maximum (mm)	Mean (mm)	Standard Deviation
Jan	30	0	30	0.000	78.700	10.207	18.097
Feb	30	0	30	0.000	165.500	35.363	43.318
Mar	30	0	30	0.000	200.400	81.677	48.243
Apr	30	0	30	39.500	246.900	124.033	52.104
May	30	0	30	59.600	303.800	174.060	57.342
Jun	30	0	30	62.900	323.800	173.950	64.679
July	30	0	30	26.200	447.100	188.048	96.065
Aug	30	0	30	11.200	384.000	130.615	83.073
Sept	30	0	30	99.800	312.500	188.207	63.043
Oct	30	0	30	0.300	350.300	187.243	78.727
Nov	30	0	30	0.000	182.200	32.337	38.327
Dec	30	0	30	0.000	48.300	6.573	11.278

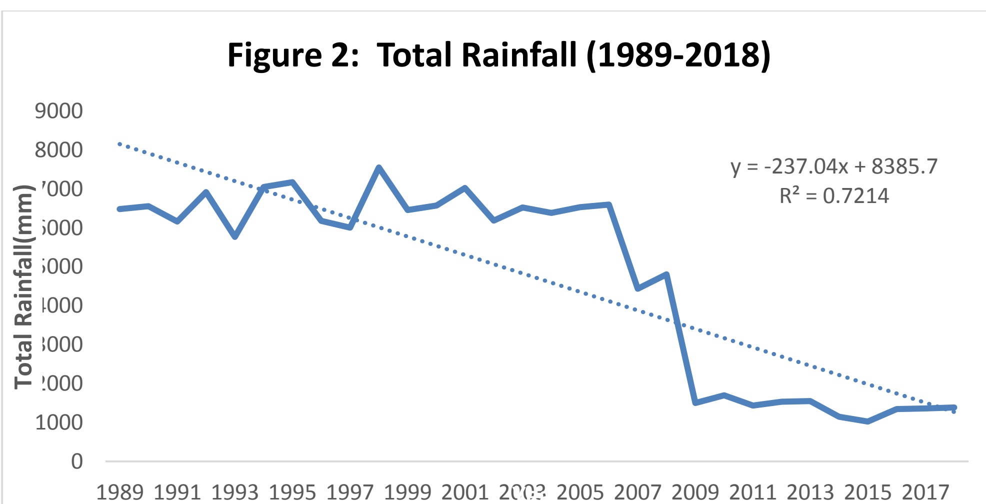

Fig. 2: Total Rainfall (1989-2018)

Rainfall Pattern over the 30-Year Period: The results of the analysis showed that rainfall in Iwo varies over the 30-year period. The results as depicted in Fig. 2 revealed that there is a negative trend, (with negative Y value) in the rainfall incidence in Iwo indicating a decreasing rainfall over the period. This finding portends the effect of climate change, which is a menace being tackled globally. Falling in the rainfall incidence over the thirty-year period calls for the attention of all relevant stakeholders in the area of agriculture and environmental/water resource management to checkmate the possible negative implication of such trend at least to ensure food security and household water accessibility.

30-Year Trend of rainfall by months: Figures 3(i-xii) shows the graphical description of the monthly trends in rainfall over the 30-year period (1989-2018).

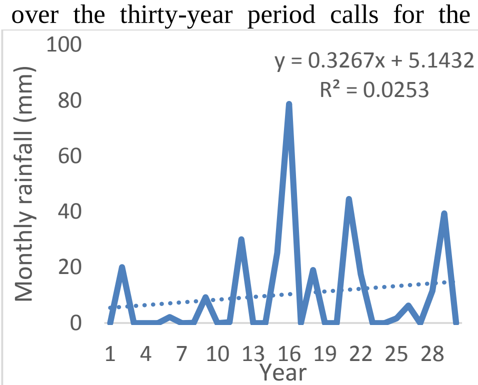

Fig 3(i): January Trend

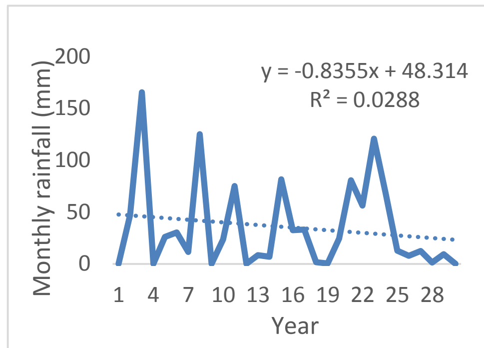

Fig. 3(ii): February Trend

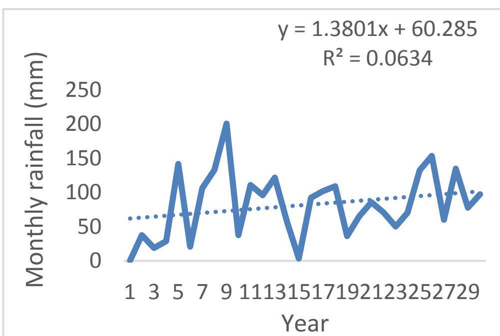

Fig 3(iii): March Trend

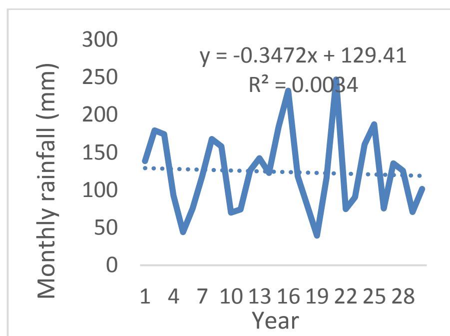

Fig. 3(iv): April Trend

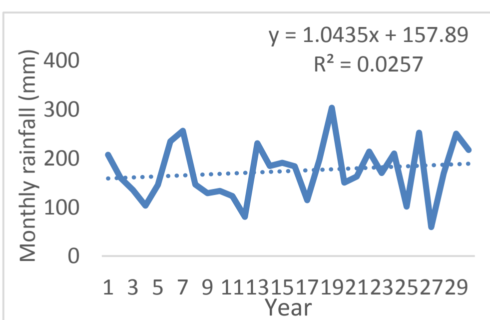

Fig 3(v): May Trend

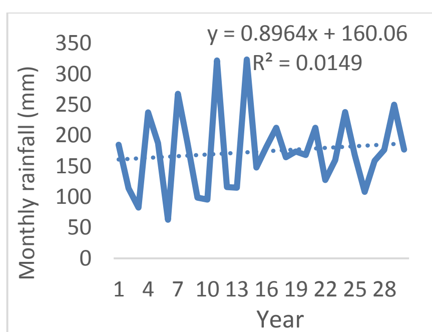

Fig. 3(vi): June Trend

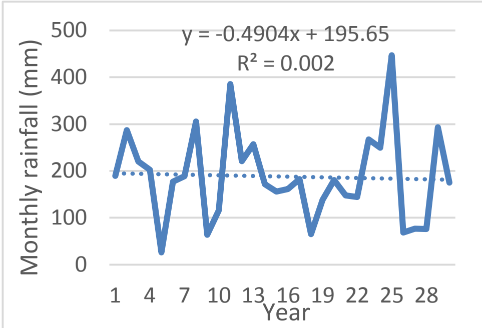

Fig 3(vii): July Trend

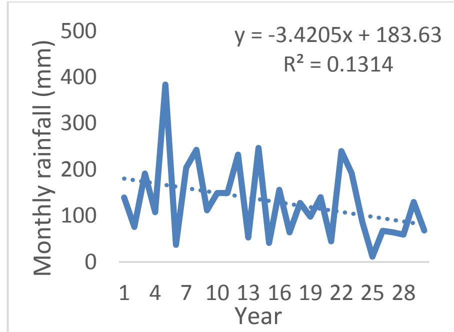

Fig. 3(viii): August Trend

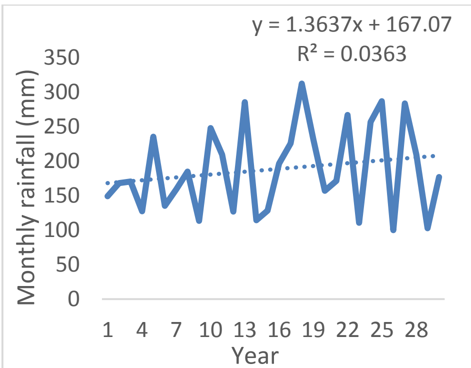

Fig 3(ix): September Trend

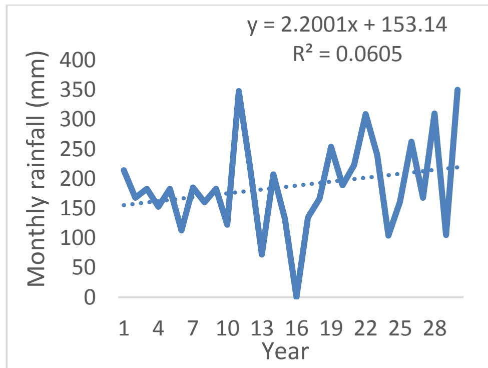

Fig. 3(x): October Trend

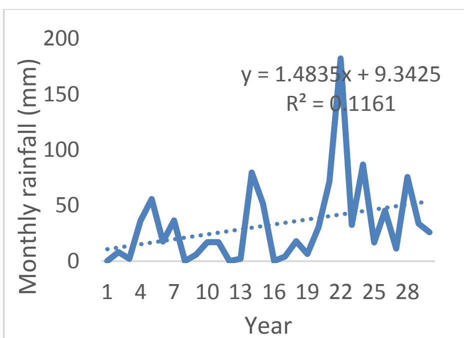

Fig 3(xi): November Trend

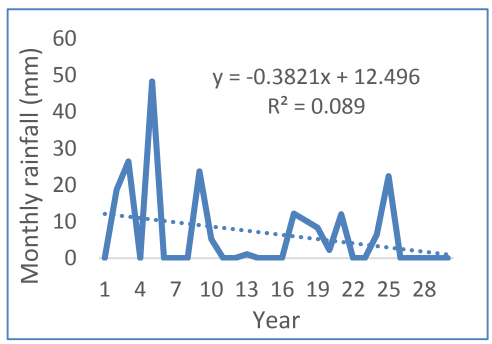

Fig. 3(x): December Trend

The results as presented in Table 2 shows that five (5) months of the year namely February, April, July, August and December have negative trend which implies that the rainfall event is at a decrease trend over the period of thirty years studied. On the other hand, the remaining seven (7) months namely January, March, May, June, September, October and November are observed to experience positive trend indicating increasing rainfall in the seven months and extended raining season. This observation was also made by Ogunrayi *et al*. (2016) in their study in Akure, Southwestern, Nigeria The results have implications for crop farming and water resources management in the study area. For instance, the negative trend recorded in the months of December and February, which are part of dry season in the study area, revealed that dry season farming can only thrive if only water supply for plants can be augmented from other sources. Even though, the results showed that more water was received in November which marks the commencement of dry season in the study area, and also more rain in January, the intense heat often characterized the period has the tendency to aggravate evapotranspiration which could hinder water availability for good plant growth in the period, thus, the need for water supply augmentation earlier mentioned (Atedhor, 2016; Sobowale *et al*., 2016; Eruola, *et al*., 2021). Water supply augmentation may include artificial water supply to enhance plant growth as also supported by Sobowale *et al*., 2016). Apart from this remedial method, other water conservation method may have to be employed to ensure the sustenance growth of plants. For instance, mulching and agroforestry may be required for moisture conservation and so preventing the plants from the intense heat that characterizes the season.

Table 2: The summarized Monthly results of the M-K analysis over the 30-Year Period

S/N	Month	Y-Value	R^2- Value	Trend Description
1.	January	0.3267x + 5.1432	0.0253	Positive
2.	February	-0.8355x + 48.314	0.0258	Negative
3.	March	1.3801x + 60.285	0.0634	Positive
4.	April	-0.3472x + 129.41	0.0034	Negative
5.	May	1.0435x + 157.89	0.0257	Positive
6.	June	0.08964x + 160.06	0.0149	Positive
7.	July	-0.4904x + 195.65	0.0002	Negative
8.	August	-3.4205x + 183.63	0.1314	Negative
9.	September	1.3637x + 167.07	0.0363	Positive
10.	October	2.2001x + 153.14	0.0605	Positive
11.	November	1.4835x + 9.3425	0.1161	Positive
12.	December	-0.3821x + 12.496	0.089	Negative

Source: Authors' work, 2021

The results further revealed that the March commencement of raining season in the study area was consistent and with increasing trend. This is followed by declining rainfall in April and increasing trend in the months of May and June over the thirty-year period investigated. This finding was also corroborated by Atedhor (2016). This scenario was subsequently followed by another two months of declining rainfall in the months of July and August, rising again from the months of September through November. The rising and falling pattern in the trend of rainfall during the period of raining season could pose serious threat to agricultural yields and water resource availability in the study area. Akinniran *et al*. (2013) in supporting this finding discovered that production of maize and yam had suffered from erratic rainfall over a period between 1990 and 2009 in Oyo State while only cassava production was not affected by the trend, probably because of its food conservation capacity. The situation of acute shortage of rainwater in the middle of growing period of plants may result in wilting of plants and even entire death of plants, especially for plants that possess less resistance to erratic supply of soil moisture (see also Akinniran *et al*., 2013).

In the same vein, such plants like maize, yam, groundnut and the likes whose flowering and fruiting period falls within the period of falling water supply via rainfall could lose their yields (also in Abdulkadir *et al*., 2017). Odekunle (2004) had noticed the similar scenario when it was revealed that the rainfall distribution in his study stations remain insufficient for dependable agricultural yields and productivity, but becomes better from the month of May. Oyinbo *et al*. (2014) had made similar observations when it was revealed that the pattern of rainfall caused by climate change will lead to declining water resources and also, decreased agricultural productivity. Thus, it was suggested that measures should be put in place to avert the disastrous consequences of this situation. The suggested measures include use of heat-resistant crop varieties, use of early maturing crop varieties, planting of cover of crops, shift in the planting dates, minimum tillage.

The result has implications for water resources availability, accessibility and quality in the study area. The zig-zag pattern in the rainfall events as observed in the results could impact on groundwater recharge and yields.

The major source of potable water for the majority of the residents in the study area is subsurface (Ogunbode and Ifabiyi, 2017). Thus, the availability of water from this source is highly dependent on unhindered and continuous replenishment through rainfall. The trend pattern as observed in this study could pose a serious threat to that natural replenishment of subsurface water, especially, the situation that may engender poor access to water, and when accessible, may infringe on the quality of such water, the view supported by Haider (2019). Similarly, Twisa and Buchroithner (2019), in corroborating this observation, stated that in view of the declining trend in rainfall in Wami River Basin in Tanzania, it was discovered that water points were significantly affected in terms of water availability and quality.

Conclusion: The trend of rainfall in Iwo between 1989 and 2018 was studied in view of the prevailing global climate change scenario. The results showed that there was generally negative trend in rainfall in the study area. The monthly analysis showed that rainfall is no longer dependable for a viable agricultural practice, and so water conservation methodologies are desirable. It is recommended that shifting in the planting dates, irrigation, planting cover crops among others should be considered by farmers. Stakeholders in water resources management's efforts on averting water scarcity and the implied challenge of water pollution are required.

REFERENCES

Abdulkadir, A; Lawal, MA; Muhammad, TI (2017) Climate change and its implications on human existence in Nigeria: A Review. *Bayero J. Pure Appl. Sci.*, 10(2):152-158

Akinniran, TN; Ezekiel, AA; Ganiyu, MO; Adeyemo, SA (2013) Effect of rainfall variability on crops production in Oyo State, Nigeria (1990-2009). *Int. J. Sci. Engrng Res.* 4(9):1737-1745

Atedho, GO (2016) Planting season's rainfall trends and droughts in the forest belt of Nigeria. *Ghana J. Geogr.*, 8(2):43-58.

Danodia, A; Sastri, ASRAS (2015) Impact of rainfall variability on water resources of Chhatttisgarh State with special reference of Mann-Kendall test statistics on the context of climate change. *Eco, Environ. Conserve.* 21(4):125-132.

Dutta, S; Patel, NK; Srivastava, SK (2001) District wise yield models of rice in Bihar based on water requirement and meteorological data. *J. Indian Soc. Remote Sens.*, 29(3): 175-182.

Eruola, AO; Makinde, AA; Eruola, GA; Ayoola, KO. (2021) Assessments of Rainfall Exceedance in Nigeria. *Nig. J. Technol.*, 40(4):751-761.

Farrell, D; Nurse, L; Moseley, L. (Undated) *Managing water resources in the face of climate change: A Carribean perspective.*

Feng, X; Liu, C; Xie, F; Lu, J; Chiu, LS; Tintera, G; Chen, B (2019) Precipitation characteristic changes due to global warming in a high-resolution (16 km) ECMWF simulation. *Qtly J. R Meteorol Soc*. 145(718):303-317

Ghosh, RK (1999) *Practical hydrology, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur 741252, Distt., Nadia, West Bengal, India.*

Haider, H (2019) *Climate change in Nigeria: Impacts and Responses. K4D Helpdesk Report 675*, Brighton, UK: Institute of Development Studies.

Idowu, AA; Ayoola, SO; Opele, AI Ikenwelwe, NB (2011) Impact of Climate change in Nigeria. *Iranica J. Ener. Environ.*, 2(2): 145-152.

Ifabiyi, PI; Ashaolu, ED. (2013) Analysis of the impacts of rainfall variability in public water supply in Ilorin. *J. Met and Clim. Sci*., 11(1):18-26.

Ishaku, HT; Majid, ML (2010) X-raying rainfall pattern and variability in Northeastern Nigeria. Impacts on access to water supply. *J. Wat. Resour. Protec.* 2: 952-959.

Kumar, S; Kumar, S (2015) Rainfall variability analysis and its impact on crop production in Bihar. *Afr. J. Agric. Res.* 10(9): 983-989.

Lawal, A; Yamusa, AM (2018) Changing pattern of rainfall amount and raindays in Samaru, Northern Nigeria and their im*plications on Crop Production. World J. Agric. Res., 8(4): 134-141*

Messay, A (2006) The onset, cessation and dry spells of the small rainy season (Belg) of Ethiopia. National Meteorological Agency, Addis Ababa, Ethiopia.

Mehta, DR; Kalola, AD; Saradava, DA; Yusufzal, AS (2002) Rainfall variability analysis and its impact on crop productivity- A case study. *Indian J. Agric. Res.*, 36(1):29-33.

Muhammad, H (2009) Nigeria Meteorological Agency predicts low rainfall. *Daily Trust, February 20, 2009* accessed on 18th September, 2012 from www.allafrica.com

Odekunle, TO. (2004) Rainfall and the length of the growing season in Nigeria. *Int. J. Climatol,* 24:467-479.

Odjugo, PAO. (2009) The impacts of climate change on water resources, global and regional analysis. *Indon. J. Geogr.,* 39(1): 23-41

Ogunbode, TO (2015) Pattern of domestic water utilization and management in the rural areas of Osun State, Nigeria. A PhD Thesis, Dept of Geography and Environmental Management, University of Ilorin, Nigeria, pp288

Ogunbode, TO and Ifabiyi, IP (2017) Domestic water utilization and its determinants in the rural areas of Oyo State, Nigeria using multivariate analysis. *Asian Research Journal of Arts and Social Sciences,* 3(3):1-13

Ogunbode, TO; Ifabiyi, IP (2019) Rainfall trends and its implications on water resources management:

A case study of Ogbomoso City in Nigeria. *Int. J. Hydrol.*, 3(3):210-215

Ogunbode, TO; Ogungbile, PO; Asifat, JT; Odekunle, O (2019) Climate change awareness and its determinants in a growing city in the southwestern, Nigeria, using multivariate analysis. *J. Environ. Sustain.* 7(1):15-27.

Okafor, GC; Ogbu, KN (2018) Assessment of the impact of climate change on the freshwater availability of Kaduna River Basin, Nigeria. *J. Wat. Land Dev.* 38:105-114.

Okorie, FC. (2015) Analysis of 30-year rainfall variability in Imo State of Southeastern Nigeria. Hydrological Sciences and water Security: Past, Present and Future. *Proc 11th Kovacs Colloq., Paris, France, June 2014, IAHS Publ.366, 2015.*

Ogungbenro, SB; Morakinyo, TE (2014) Rainfall distribution and Change detection across climatic zones in Nigeria. *Weather and Clm. Extre.,* 5-6:1-6

Ogunrayi, OA; Akinseye, FM; Goldberg, V; Bernhofer, C (2016) Descriptive analysis of rainfall and temperature trends over Akure, Nigeria. *J. Geogr. Reg. Plann.* 9(11):195-202.

Ologunorisa, TE;.Tersoo, T (2006) The changing rainfall pattern and its implication for flood frequency in Makurdi, Northern Nigeria. *J. Appl. Sci. Environ. Mgt,* 10(3):97-102.

Onyenechere, EC; Azuwike, DO; Enwereuzor, AI. (2011) Effects of rainfall variability on water supply in Ikeduru LGA of Imo State, Nigeria. *Afr. Res. Rev.* 5(5):22 223-241.

Oyinbo, O; Duniya, KP; Rekwort, GZ (2014) Rainfall pattern and Agricultural Production in Nigeria: Implications for Food security. *In* T.T. Amos, P.B. Imoudu and J.O. Oseni (eds) Climate change, Agriculture and Food Security. Proceedings of the 14th Annual National Conference of the Nigerian Association of Agricultural Economists, Federal University of Technology, Akure, Nigeria, Feb. 24th-27th, pp.82-87

*Sob*owale, A; Sajo, SO;.Ayodele, OE (2016) Analysis of onset and cessation of rainfall in southest, Nigeria: Food security impact of variability in the length of growing season. *Hungar. Agricul. Enging*, 30/2016:23-30.

Tabari, H (2020) Climate change impact on flood and extreme precipitation increases with water availability. *Sci. Rep.* 10: 13768

Trenberth, KE (undated) The impact of climate change and variability on heavy precipitation, floods and droughts. National Centre for Atmospheric Research, Boulder, CO, USA.

Twisa, S; Buchroithner, MF (2019) Seasonal and annual rainfall variability and their impact on Rural Water Supply Services in the Wami River Basin, Tanzania. *Water*, 2019, 11, 2055. Doi:10.3390/w11102055

UN Water (2010) Climate change adaptation: The pivotal role of water. Accessed on 28th Nov. 2011from www.unwater.org

Valipour, M (2012) Critical areas of Iran for agriculture water management according to the annual rainfall. *Eur. J. Sci. Res*. 84(4):600-608.

Woo, M. and Tarhule, A. (1998) Change in rainfall characteristics in Northern Nigeria. *Int. J. Climatol.* 18:1261-1271.