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# Research Article
# Climate Change, Rainfall Trends and Variability in Jos Plateau

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## Abstract

**Background and Objective:** Climate change has caused a shift in the seasonal variability of weather and climate, thus a shift in the normal timing, length of wet and dry seasons and increase in the seasonal fluctuation of rainfall and drying of water bodies. It is for this reason that this study was carried out to examine the nature and extent to which climate change has affected rainfall trends and variability in Jos. **Materials and Methods:** The study used 30 years annual rainfall records from the meteorological station of the university of Jos. Statistical methods such as rainfall anomaly index (RAI), analysis of variance and the 5 years moving average was used to analyze the data. **Results:** The results revealed that Jos has a unimodal pattern of rainfall, rainfall trend is on a downward trend and rainfall variability has never gone above or below 400 mm with a mean of 1326.253 mm. **Conclusion:** There is a need for farmer to consider planting crops that do not require so much water as the analysis has shown a downward trend in rainfall. Months that has much and less rainfall, that is July/August and January/February and March, respectively should be taken into consideration when planting.

Key words: Rainfall, variability, climate change, trends, dry season, planting

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## INTRODUCTION

Rainfall is a renewable resource, which is highly variable in space and time subject to reduction due to human and natural causes[1]. With particular reference to rainfall, climate is known to be fluctuating worldwide and there has been growing concerns as to the effects and direction of these fluctuations on infrastructures, settlements and agriculture[2]. According to Inter-governmental Panel on Climate Change (IPCC)[3] define climate change as a change in the state of the climate that is known using statistical tests. This change occurs due to the inconsistency of climatic properties that continues for several decades.

Increasing temperature and decreasing precipitation in most part of the world are the greatest impacts of climate change[4]. These bring about negative or positive ecological impacts in different parts of the world[5]. The increasing temperature led to increase melting of the ice, therefore, adding more volume of water to oceans. The thawing of the arctic decreasing temperate, the increasing rainfall in some parts of the world and expansion of the oceans as water warms up, has started affecting sea level rise, coastal inundation and erosion[6]. Climate change will alter all aspect of the hydrological cycle ranging from evaporation through precipitation, run-off and discharge[7]. The global warming and decreasing rainfall together with the erratic pattern of rainfall produce a minimal recharge of ground water resources, wells, lakes and rivers in most part of the world especially in Africa, thereby creating water crisis. Climate change has started to and will continue to impact negatively on agriculture and food security especially in Tropical and sub-tropical regions, this is because Green House gas emission would increase the risk of hunger by additional 80 million people by 2080 in Africa and southern Asia[8-10].

Many rivers have been drying up or are becoming more seasonally navigable in Nigeria. Lake Chad shrunk in area from 22,902 km$^2$ in 1963-1304 km$^2$ in 2000. This indicates that Lake Chad has reduce to 5.7% from what[11] it was in 1963. This corroborates the result of Awake[12] that Lake Chad has shrunk by 95% from what it was in the 1960s. By 1960 Aral Sea in central Asia was the 4th largest lake in the planet. By 2007, it had shrunk from its original size to 10%. One of the greatest impacts of climate change is the worsening condition of extreme weather events like drought, flood, rainstorms, windstorms, thunderstorm, landslides, avalanche and tsunamis, among others[9].

The current global estimate of sea level rise is 0.2 m and it is projected to increase[13] to 1 m by the year 2100. The implication is that the present 0.2 m. Sea level rise has inundated 3,400 km$^2$ of the coastal region of Nigeria and if the sea level rise and attains the projected 1 m on or before 2100 then 8,400 km$^2$ of the coastal region of Nigeria may be inundated Coastal settlements like Bonny, Forcados, Lagos, Port Harcourt, Warri and Calabar among others that are less than 10 m above the sea level would will be seriously threatened by a metric rise of sea level[14]. It was reported that desert encroachment, drought and coastal inundation in some parts of Nigeria have started affecting the country's ecosystem. This is leading to ecological disruption due to climate change impact[15]. Odjugo[16] shows that climate change has led to a shift in crop's cultivated in Northern Nigeria.

Climate change is also affecting Nigeria energy sector profoundly[16]. Conflict over the use of water resources among different sector has adversely affected the hydro power plants in Kanji, Jebba and Shiroro, which is key to the security of electricity supply in the country and represent about one-third of the country's total installed electricity generating capacity. These plants have produced significantly lower energy leading to epileptic power supply because of excessive drought that lead to evaporation affecting water volume and the capacity of the power plants to produce optimally[17].

Rain is liquid water in form of droplets that have condensed from atmospheric water vapour, it then becomes heavy enough to fall under gravity[18]. Rain is a major component of the water cycle and is responsible for putting most of the fresh water on the earth. It provides suitable conditions for hydroelectric power plants, crop irrigation and many types of ecosystems as well as water for domestic purposes[19]. Rainfall is a determinant factor of many natural occurrences[20]. Animals breeding periods synchronize with rainfall periods, crop cultivation, yield and harvests are influenced by rainfall and are practiced in accordance with their respective enabling seasons to ensure improved productivity. Similarly, the moisture content of the soil is much affected by rainfall from time to time[19].

Rainfall trend is the general, movement or direction in which rainfall takes. In the global scene for example, rainfall trend analyses, on different spatial and temporal scales, has been of great concern during the past century because of the attention given to global climate change from the scientific community: they indicate a small positive global trend, even though large area are characterized by negative trends[3]. Nicholson and Grist[21] reported that most of the rainfall decline has occurred in South-eastern Australia. A similar rainfall decline occurred in the southwest of Western Australia around 1970 that have many common features with the southern eastern Australia decline. However, in the regional level Nicholson and Grist[21] observed that one of the most important

contrasts in rainfall is the multi decadal persistence of abnormalities over northern Africa. Nicholson and Grist[21] had identified several changes in the general atmosphere circulation that has accompanied the shift to drier conditions in West African Sahel region. Rotstayn and Lohmann[22] showed that anthropogenic activities play a prominent feature in the drying of the Sahel in North Africa.

Rainfall variability can be understood as the degree to which rainfall amounts vary across an area or through time[18]. Variability of rainfall can be used to characterize the climate of a region. Rainfall in Nigeria is subjected to wide variability both in time and in space. This variability has assumed a more pronounced dimension because of climate change. It is for this reason that this research is embarked upon to establish the seasonal pattern of rainfall in Jos, determine rainfall trend between the years 1988-2017 and to determine rainfall variability between the years 1988-2017.

## MATERIALS AND METHODS

Jos has a geo-coordinate of latitude 8-10°N and longitude 7-11°E, it is bounded in the north by Bassa local government, to the east by Bauchi state and the South by Riyom and Barkin-ladi local government areas[23]. The climate of Jos Plateau is dominantly influenced by its relatively high altitude and position along the Inter Tropical Convergence Zone (ITCZ) and has an average height of about 1250 m above mean sea level. It has a mean minimum and maximum temperature[24] of 16-26°C.

It is controlled by 2 wind systems that affect the Nigerian climate, the moist South-westerly winds during the rainy season and the dry North Easterlies during the dry season. The South-westerly winds are responsible for much of the rains occurring between April and October, while the North Easterlies are responsible for the dry season lasting from November to March[24].

Rainfall data were collected on monthly and annual bases for the period of 1988-2017, from the meteorological station of the Department of Geography and Planning, University of Jos. Primary type of data was chosen because, with primary data, degree of accuracy is usually known. This research was conducted from December, 2017 to August, 2018. The station is located on latitude 90570 N, Longitude 80530 E and at an altitude of 1159 m above means sea level. In order to properly analyze data collected for these study both annual and seasonal rainfall was analyzed using a regression trend line to give direction of change with respect to rainfall pattern on the Jos Plateau.

To determine rainfall variability between the years 1988-2017, the research used Rainfall Normality Index (RAI). This method stipulates that you sum the total rainfall under study and finds the average. Then you subtract each year's rainfall from the average to determine whether that particular year rainfall was above or below average. According to Nouaceur and Mursrescu[25] the formula for calculating rainfall variability is given as:

$$X-\bar{x} = .....i$$

Where:

X = Individual value

$\bar{x}$ = Mean

In order to determine the rain-fall trend for the study period the research made use of 5 years moving average. This method helps to smoothen out excessive high and low in annual rainfall figures.

## RESULTS AND DISCUSSION

**Seasonal pattern of rainfall in Jos:** Seasonal pattern of rainfall in Jos is shown in Fig. 1. The total rainfall for every month of the year was summed up for the entire study period of 30 years and the mean monthly figures established and plotted. This indicates that rainfall in Jos is a single mode that is, having a unimodal rainfall regime. This finding corroborates the result of Adefolalu[26] that all stations north of 8° latitude experience a single maximum rainfall pattern. Only stations south of the given latitude enjoy double maxima. It was also observed that by the month of April, Jos station has recorded rainfall well above 50 mm. The months of April-October constitute the wet season in this location (Jos). During this period, it was also observed that no month received >60 mm of rainfall. Very little, amount of rainfalls in the months of January, February and March. However, none in December. Rainfall generally increases steadily from April to a maximum in August and then takes a downward trend to October. This movement could be explained by the general movement of the Inter Tropical Discontinuity (ITD) as explained by Binbol and Zemba[27]. According to them, the movement of the ITD and its associated zones of rainfall during the course of the year seem to be the major factor controlling rainfall in the state. The ITD moves to the southern part of the state in March, by August, it has reached its northerly position (about 20°N). At this point, all places south of 20°N will receive their maximum rainfall, thereafter, the ITD retreats at twice its normal upward speed.

**Rainfall trend:** In order to properly analyze the annual rainfall trend in Jos, the 5 years moving average was introduced and the result obtained is plotted in Fig. 2.

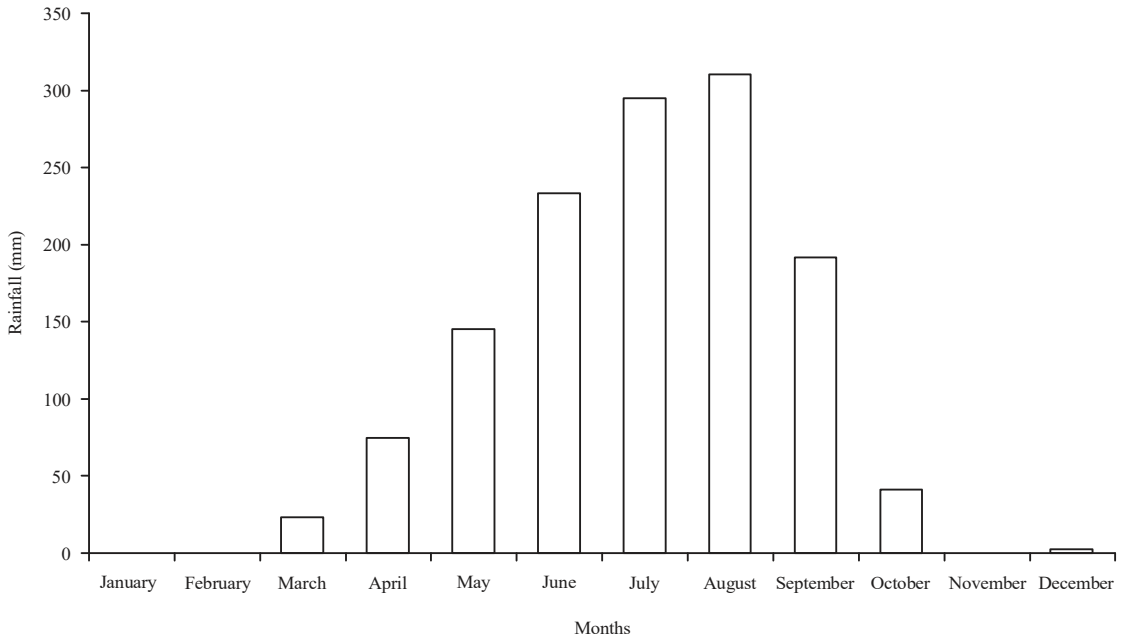


Fig. 1: Seasonal pattern of rainfall in Jos North

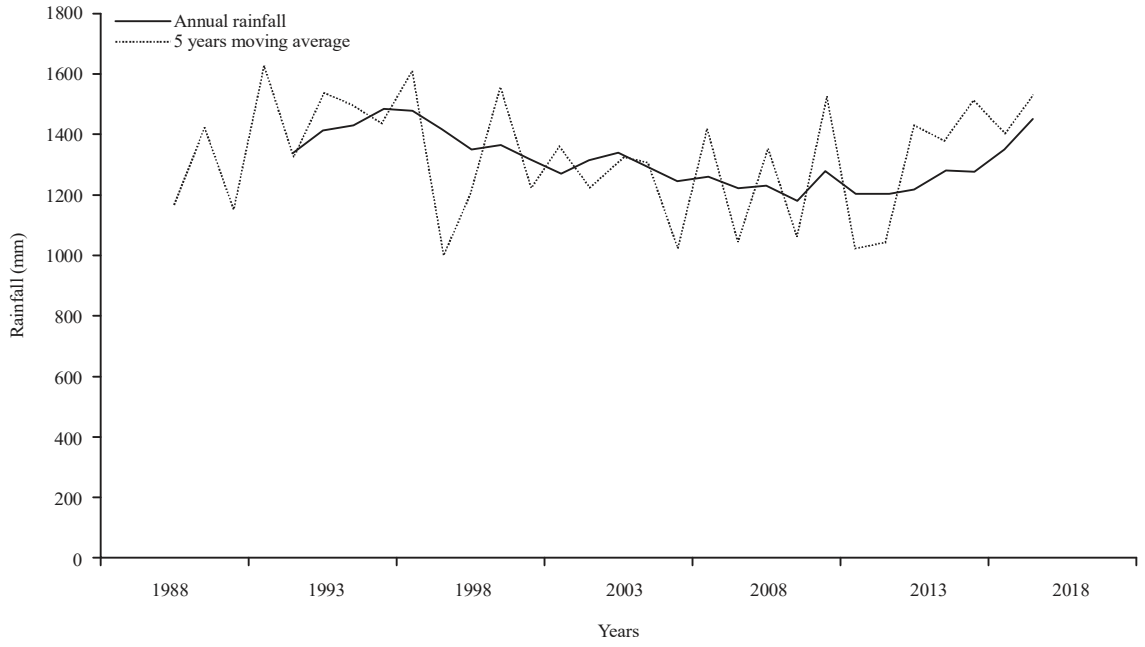


Fig. 2: Annual rainfall with 5 years moving average in Jos

From the plotted graph in Fig. 2, the year with the highest rainfall is 1991 with an annual rainfall of 1630 mm which is 304 mm above the mean observed for the whole study period. The 5 years moving average indicates that from the year 1990, rainfall seemed to be on the increase up until 1996 when it started decreasing. It increased a little around 2010 and then continued with a decreasing trend that was brought to an end with an increasing trend from 2014-2017. The rainfall in Jos from the 5 years moving average seemed to be fluctuating and so the needed information or trend could not be properly deduced. Binbol and Zemba[27] observed that one of the greatest characteristics of rainfall especially in the tropics is its annual variability, they therefore suggested the imposition of a trend line to enable a more definite pronouncement of rainfall trend for any location. Following this, a graph was plotted and a trend line was imputed as shown in Fig. 3.

The result produced a trend line with a downward tilt (Fig. 3). It also generated a regression equation of best fit. This

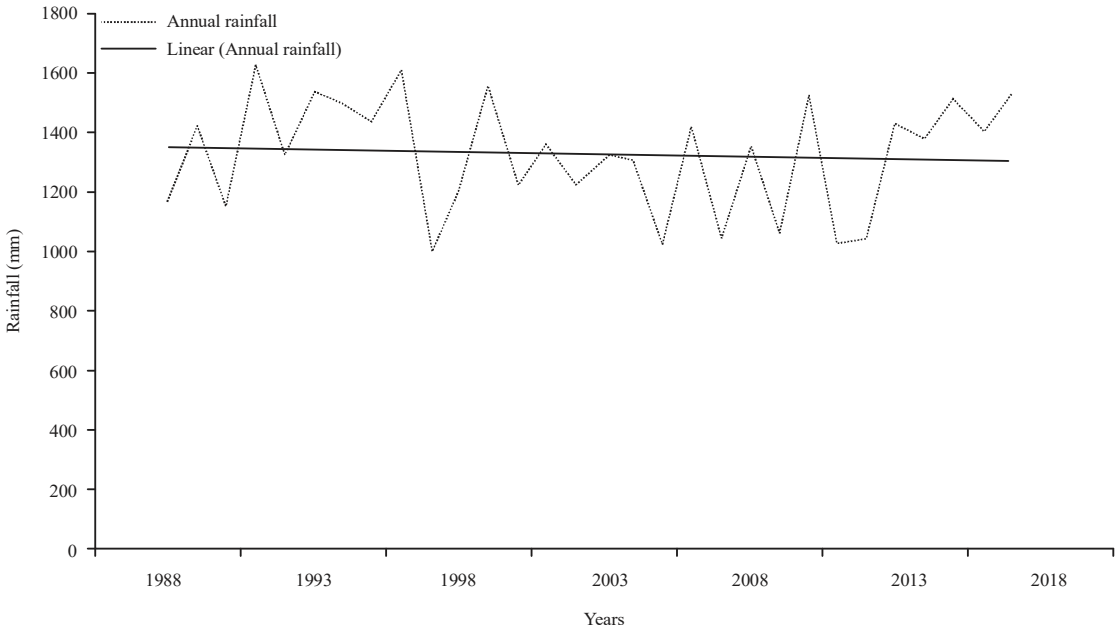


Fig. 3: Annual rainfall Jos North 1988-2017

Table 1: Rainfall anomaly index (RAI)

| Years | Annual rainfall | RAI |
|---|---|---|
| 1988 | 1165.5 | 100.500 |
| 1989 | 1429.0 | 100.747 |
| 1990 | 1155.0 | -171.253 |
| 1991 | 1630.0 | 303.747 |
| 1992 | 1329.69 | 3.437 |
| 1993 | 1537.8 | 211.547 |
| 1994 | 1499.8 | 173.547 |
| 1995 | 1438.9 | 112.647 |
| 1996 | 1613.4 | 287.147 |
| 1997 | 1006.8 | -319.453 |
| 1998 | 1202.8 | -123.453 |
| 1999 | 1562.2 | 235.947 |
| 2000 | 1222.6 | -103.653 |
| 2001 | 1361.2 | 34.947 |
| 2002 | 1226.3 | -99.953 |
| 2003 | 1325.6 | -0.653 |
| 2004 | 1308.4 | 17.853 |
| 2005 | 1025.6 | -300.653 |
| 2006 | 1422.8 | 96.547 |
| 2007 | 1045.3 | -280.953 |
| 2008 | 1354.2 | 27.947 |
| 2009 | 1065.3 | -260.953 |
| 2010 | 1527.7 | 201.447 |
| 2011 | 1028.2 | -298.053 |
| 2012 | 1046.8 | -279.453 |
| 2013 | 1431.8 | 105.547 |
| 2014 | 1379.2 | 52.947 |
| 2015 | 1511.4 | 185.147 |
| 2016 | 1408.0 | 81.747 |
| 2017 | 1528.3 | 202.047 |

indicates that though rainfall in Jos is fluctuating annually, deviations of annual rainfall figures from the longs time mean are on the decrease. Hence the regression equation y = -1.6719x+1352.2. With the coefficient of determination $R^2$ = 0.0058. This means that the rainfall in Jos is decreasing annually by 0.0058 mm. This finding corroborates the result of previous research[28], that there will be a gradual decrease of rain in Jos till 2030 because of the decrease in the numbers of rainfall days hence, it will affect the ecology of plant. This finding confirms the results of different researchers[29-31] that plants are critical part of terrestrial ecosystems, therefore changes in water cycles inevitably will affect their growth. It further validates the results that a change in amount and/or pattern of precipitation can affect most life history[32-34].

**Rainfall variability:** In order to determine the degree of variability from the mean, the research adopted the use of rainfall anomaly index, this techniques stipulate that the total amount of rainfall under study be summed up and divided by the time (30 years), then, subtract each year's rainfall from the average to determine variability from the observed or calculated mean.

From Table 1 above, it shows clearly that throughout the study period, the degree of variability has never exceeded 400 mm . This is to say rainfall variability between the years 1988-2017 has never gone beyond the mean by 400 mm nor has it gone below the mean by 400 mm. Also, from the Table 1 more years have recorded excess rainfall above the mean (18 years have rainfall above the mean of 1326.253 and 12 years have rainfall well below the mean).

## CONCLUSION AND RECOMMENDATION

Based on the findings, climate change has caused a shift in the seasonal variability of weather and climate and thus a shift in the normal timing and length of dry and wet season. Therefore, there is a need for people to start living a greener lifestyle, by using clean energy and growing of trees. Farmer should consider planting crops that do not require so much water as the analysis have shown a downward trend in rainfall. Months that have much and less rainfall, that is July/August and January/February and March respectively should be taken into consideration when planting.

## SIGNIFICANCE STATEMENT

The research is targeted at a simplified approach to establish and determine variability, trend and seasonal pattern of rainfall in Jos Plateau and its effects on the planning and suitability of crop planting.

This study discovered that mean rainfall amount for the period stood at 1326.253 mm. In addition, this study reveals that there are variations in the amount and pattern of rainfall received in Jos or recorded in the Jos university meteorological station over time. This irregular pattern of rainfall in the study area has negative implication such that farmers have trouble in planning for the suitable time to plant their crops. In addition, locations or places of the same latitude should be researched on, to solidify findings and give more light into the rainfall characteristics of these places (Guinea savannah region of Nigeria). It is expected that the results of this study will provide a better basis for planning and developing projects in agriculture, hydrology, water resources and urban engineering that many researchers were not able to explore. Thus, a new theory on climate plant relationship may be arrived at.

## REFERENCES


1. Abaje, I.B., 2010. Recent trends in the rainfall supply and its implication for infrastructural development. Proceedings of the 51st Annual Conference of the Association of Nigeria Geographers, March 7-11, 2010, Kogi State University, Anyigba, Nigeria.
2. Chaponniere, A. and V. Smakhtin, 2006. A review of climate change scenarios and preliminary rainfall trend analysis in the Oum Er Rbia Basin, Morocco. Working Paper 110 (Drought Series Paper 8), International Water Management Institute, Colombo, Sri Lanka, pp: 1-16.
3. IPCC., 2007. Climate Change 2007: Impacts, Adaptation and Vulnerability: Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK., ISBN-13: 9780521880107, Pages: 976.
4. Audu, E.B., H.O. Audu, N.L. Binbol and J.N. Gana, 2013. Climate change and its implication on agriculture in Nigeria. Abuja J. Geogr. Dev., Vol. 3, No. 2.
5. Idowu, A.A., S.O. Ayoola, A.I. Opele and N.B. Ikenweiwe, 2011. Impact of climate change in Nigeria. Iranica J. Energy Environ., 2: 145-152.
6. Udayashankara, T.H., B.M.S. Murthy and M. Madhukar, 2016. Impact of climate change on rainfall pattern and reservoir level. J. Water Resour. Eng. Manage., 3: 10-14.
7. McGuire, B., I. Mason and C. Kilburn, 2002. Natural Hazards and Environmental Change. Arnold, London, UK., ISBN-13: 9780340742204, Pages: 187.
8. DeWeerdt, S., 2007. Climate change, coming home: Global warming's effects on populations. World Watch, 20: 8-13.
9. Odjugo, P.A.O., 2010. Regional evidence of climate change in Nigeria. J. Geogr. Reg. Plann., 3: 142-150.
10. Suzuki, D., 2017. Impacts of climate change. David Suzuki Foundation, Vancouver, BC., Canada. https://davidsuzuki.org/what-you-can-do/impacts-climate-change/
11. Odjugo, P.A.O., 2007. The impact of climate change on water resources, global and regional analysis. Indones. J. Geogr., 39: 23-41.
12. Anonymous, 2009. Are we running out of water? Awake! January 2009. https://www.jw.org/en/library/magazines/g200901/Are-We-Running-Out-of-Water/
13. Hengeveld, H. and B. Whitewood, 2005. Understanding climate change-2005: A Synthesis of climate change science. Environment Canada, Gatineau, QC., Canada.
14. NEST., 2004. Executive summary of five multi-sector surveys on Nigeria's vulnerability and adaptation to climate change. Nigerian Environmental Study/Action Team (NEST), Abuja, Nigeria, March 2004.
15. Ayuba, H.K., U.M. Maryah and D.M. Gwary, 2007. Climate change impact on plant species composition in six semi-arid rangelands of Northern Nigeria. Niger. Geogr. J., 5: 35-42.
16. Odjugo, P.A., 2005. An analysis of rainfall patterns in Nigeria. Global J. Environ. Sci., 4: 139-145.
17. Onyenechere, E.C., D.O. Azuwike and A.I. Enwereuzor, 2011. Effect of rainfall variability on water supply in Ikeduru L.G.A. of Imo State, Nigeria. Int. Multi-Disciplin. J. Ethiopia, 5: 223-241.
18. Udo-Inyang, U.C. and I.D. Edem, 2012. Analysis of rainfall trends in Akwa Ibom state, Nigeria. J. Environ. Earth Sci., 2: 60-70.
19. Mercy, I.C., 2015. Trend analysis of rainfall pattern in Enugu state, Nigeria. Eur. J. Stat. Probability, 3: 12-18.
20. Kumar, V., S.K. Jain and Y. Singh, 2010. Analysis of long-term rainfall trends in India. Hydrol. Sci. J., 55: 484-496.

21. Nicholson, S.E. and J.P. Grist, 2001. A conceptual model for understanding rainfall variability in the West African Sahel on interannual and interdecadal times cales. Int. J. Climatol., 21: 1733-1757.
22. Rotstayn, L.D. and U. Lohmann, 2002. Tropical rainfall trends and the indirect aerosol effect. J. Climate, 15: 2103-2116.
23. Binbol, N.L., C.Y. Oche, A.C. Eziashi and V.D. Choji, 2016. Assessment of hydrological drought characteristics on the Jos, Plateau, Nigeria. Jos Plateau J. Environ. Sustainable Dev., 1: 12-17.
24. Guntul, T.K., C.Y. Oche and M. Madaki, 2007. Climate records of Jos Plateau. University of Jos Weather Station. https://irepos.unijos.edu.ng/jspui/bitstream/1234567
25. Nouaceur, Z. and O. Murărescu, 2016. Rainfall variability and trend analysis of annual rainfall in North Africa. Int. J. Atmos. Sci., Vol. 2016. 10.1155/2016/7230450.
26. Adefolalu, D.O., 1989. Ecological and Land use mapping of Niger state. Phase III Report.
27. Binbol, N.L. and A.A. Zemba, 2007. Analysis of rainfall data for effective agricultural producation in Adamawa State, Nigeria. Multidiscip. J. Empirical Res., 4: 169-175.
28. Adakayi, P.E., 2012. An assessment of the rainfall and temperature variations in parts of Northern Nigeria. Ph.D. Thesis, Department of Geography, University of Jos, Nigeria.
29. Prieto, P., J. Peñuelas, R. Ogaya and M. Estiarte, 2008. Precipitation-dependent flowering of *Globularia alypum* and *Erica multiflora* in Mediterranean shrubland under experimental drought and warming and its inter-annual variability. Ann. Bot., 102: 275-285.
30. Gornish, E.S., Z.T. Aanderud, R.L. Sheley, M.J. Rinella, T. Svejcar, S.D. Englund and J.J. James, 2015. Altered snowfall and soil disturbance influence the early life stage transitions and recruitment of a native and invasive grass in a cold desert. Oecologia, 177: 595-606.
31. Husen, A., M. Iqbal and I.M. Aref, 2017. Plant growth and foliar characteristics of faba bean (*Vicia faba* L.) as affected by indole-acetic acid under water-sufficient and water-deficient conditions. J. Environ. Biol., 38: 179-186.
32. Ensslin, A. and M. Fischer, 2015. Variation in life history traits and their plasticities to elevational transplantation among seed families suggests potential for adaptative evolution of 15 tropical plant species t o climate change. Am. J. Bot., 102: 1371-1379.
33. Gao, R., X. Yang, G. Liu, Z. Huang and J.L. Walck, 2015. Effects of rainfall pattern on the growth and fecundity of a dominant dune annual in a semi-arid ecosystem. Plant Soil, 389: 335-347.
34. Chen, Y., X. Shi, L. Zhang, J.M. Baskin, C.C. Baskin, H. Liu and D. Zhang, 2019. Effects of increased precipitation on the life history of spring-and autumn-germinated plants of the cold desert annual *Erodium oxyrhynchum* (Geraniaceae). AoB Plants, Vol. 11, No. 2. 10.1093/aobpla/plz004.