Climate is changing; Temperature and Rainfall Pattern (Variability) in Jos-Metropolis, Plateau state, Nigeria

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Abstract
Temperature and Rainfall are the most important parameters in determining climatic change in any given environment. This study investigate temperature and rainfall pattern in Jos-metropolis over a given 30years (1989-2018) instruments records. Experience of sudden climatic change in temperature from lower reading of temperature to high temperature as well as in rainfall necessitated the study to observe the variability in the parameters. Descriptive method was implored in the research of which data were collected from synoptic station of Nigerian Meteorological Agency (NIMET), Heipang Jos-Plateau from 1989-2018 of temperature and rainfall. A line graph was used for the presentation of data and analytically analyzed using the Pearson Correlation Coefficient (PCC) at 0.05% confidence level. The findings revealed that irregularities temperatures and rainfall which brought about climate variation the area. There was sharp increase in 2010 with a stable high temperature from 2010-2018 while rainfall recorded high rainfall in 1993, 1999 and 2018. Thus, there was no relationship between average temperature and average rainfall but strong relationship between periods of years and temperature as well as rainfall at 0.05%. Furthermore, stipulated recommendations were offered to stakeholders in Jos-Metropolis.

Keywords: *Climate Change, Jos-Metropolis, Pattern, Rainfall, Temperature, Variability*

Introduction

Climate variability over the period of instrumental records and beyond on different temporal and spatial scale is important to understand the nature of different climate systems and their impact on the environment and society (Oguntunde et al. 2012). Most of the observational and numerical model studies on climate are based on the instrumental records of about a century which are aimed at the knowledge of the natural variability of climate system and to identify processes and forces that contribute to this variability. This is important to predict global and regional climate variations, determine the extent of human influence on the climate and make sound projections of human induced climate change. The climate of a location can be understood most easily in terms of annual or seasonal averages of temperature and rainfall (Akinsanola and Ogunjobi, 2014). The global climate has changed rapidly with the global mean temperature increasing by 0.7oC within the last century (IPCC 2007). However, the rates

of change are significantly different among regions (IPCC 2007). This is primarily due to the varied types of land surfaces with different surface albedo, evapotranspiration and carbon cycle affecting the climate in different ways (Meissner et al. 2003; Snyder et al. 2004). Several studies have been carried out at different temporal scales and in different part of the globe Hasanean, 2001; Fan elal, 2010; Ologunorisa, 2004).

Increasing temperature and decreasing rainfall in most part of the world are the greatest impacts of climate change (Wuyep and Daloeng, 2020; Audu et al, 2013). These bring about negative or positive ecological impacts in different parts of the world (Idowu, et al, 2011). 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 (Udayashankara, et al, 2016)

Temperature and rainfall are critical, because are parameters that determinants agricultural production, economic and other human activities. It is not only for meteorology but also for comfort of human existence. However, in reality it is difficult to simulate rainfall and temperature simultaneously due to the interdependence (correlation) between them [20–22]. Spatially, it is generally believed that there exists significant correlation between rainfall and temperature over tropical oceans and land [23].

The temperature is one of the key parameters in understanding climate change (Wuyep and Doaloeng, 2020). The variation of daily temperature is controlled mainly by incoming solar energy and outgoing long-wave surface radiation (Ahrens, 2011). Temperate does not vary in isolation and one of the cases is explained by Bryan et al. (Bryan et al, 2010) of high temperatures and high pollution concentrations being associated with strength of high pressure systems and sunny (with fast photolysis rates) conditions. Over a large area and over a long time, the temperatures can be averaged and thus assisting to describe the climate of area in terms of hotness/coldness. While weather elements vary from day to day or even place to place (Walter, 1989), climate too exhibits variability inter or intra season as well as inter or intra annual. One of the indicators of climate change is changes in temperature and according to Roy et al., (2009) local temperature change is influenced by urbanization. A change in average temperature, can the amount of cloudiness as well as the type and amount of rainfall that occurs and is attributed to changes in radioactive forcing (Thomas et al, 2012) such as changes in landscape leading to changes in surface reflection to solar radiation; surface moisture variability; modification of vegetation cover as well as anthropogenic heat release which combine and cause temperature rise. The increase in temperature has impacts such as: increased incidence and severity of heat-waves, droughts (Thomas et al 2012); shrinking of glaciers ice caps, mountain glaciers, and permafrost regions of the world (timothy, 2010). The global temperatures are estimated to have increased by 0.5-0.6°C over the last century and are estimated to increase by 0.3-0.7°C by 2035 (Jaswal et al, 2015).

Rainfall trend is the general, movement or direction in (Odjugo, 2010) 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. A large number of rainfall events have been documented over the past decades (Coumou and Rahmstorf 2012; Seneviratne et al. 2012; Trenberth 2012; Westra et al. 2013; Espinoza et al. 2014; Guhathakurta et al. 2017;

Taylor et al. 2017; Thompson et al. 2017; Zilli et al. 2017). The observed shift in the trend distribution of rainfall is more distinct than for annual mean rainfall and the global land fraction experiencing more intense rainfall events is larger than expected from internal variability (Fischer and Knutti 2014; Espinoza et al. 2018; Fischer et al. 2013) of which is the variability. As a result of global warming, the number of record-breaking rainfall events globally has increased significantly by 12% during the period 1981–2010 compared to those expected due to natural multi-decadal climate variability (Lehmann et al. 2015). The IPCC SR15 reports robust increases in observed rainfall for annual maximum 1-day rainfall (RX1day) and consecutive 5-day rainfall (RX5day) (Hoegh-Guldberg et al. 2018; Schleussner, et al. 2017). A number of extreme rainfall events have been attributed to human influence (Min et al. 2011; Pall et al. 2011; Sippel and Otto 2014; Trenberth et al. 2015; Krishnan et al. 2016) and the largest fraction of anthropogenic influence is evident in the most rare and extreme events (Fischer and Knutti 2014). Furthermore, changes to the dynamics of the atmosphere amplify or weaken future rainfall extremes at the regional scale (O'Gorman 2015; Pfahl et al. 2017). Continued anthropogenic warming is very likely to increase the frequency and intensity of extreme rainfall in many regions of the globe (Seneviratne et al. 2012; Mohan and Rajeevan 2017; Prein et al. 2017; Stott et al. 2016).

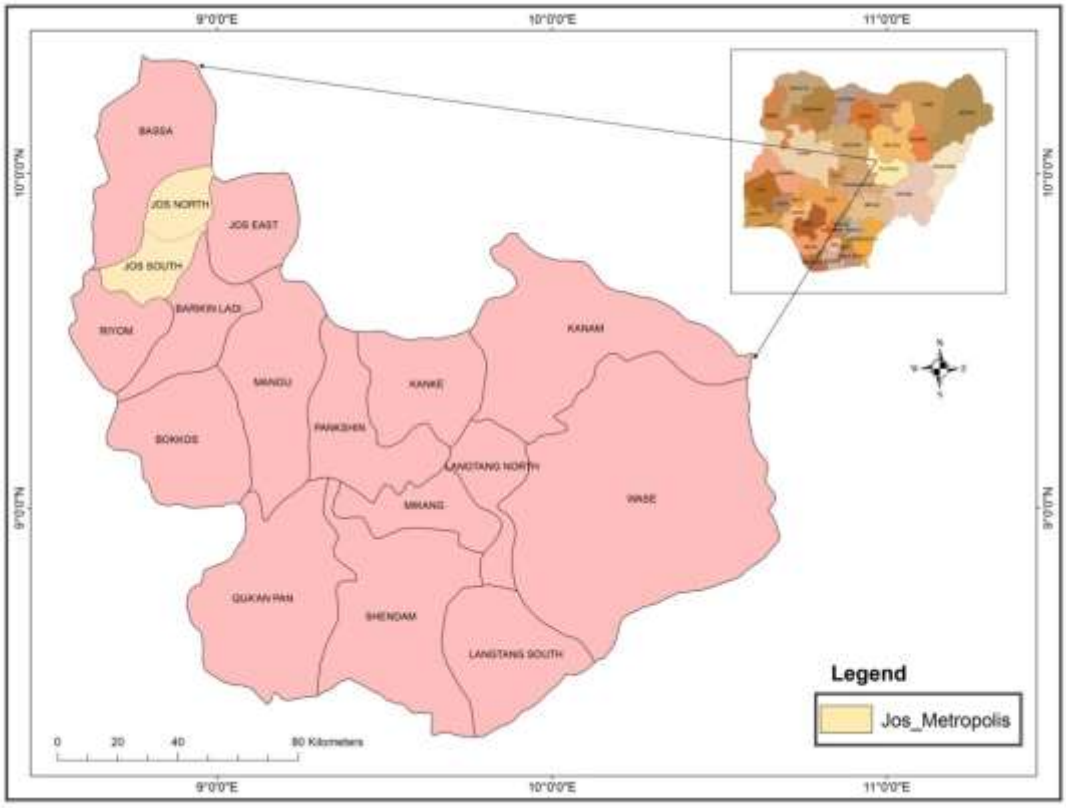
Rainfall variability can be understood as the degree to which rainfall amounts vary across an area or through time. Variability of rainfall can be used to characterize the climate of a region. Rainfall in Nigeria is subjected to wide variability both in time and in space. This variability has assumed a more pronounced dimension because of climate change (Wuyep and Doloeng, 2020). Ayansina et al. (2009) also investigated the seasonal rainfall variability in Guinea savannah part of Nigeria and concluded that rainfall variability continues to be on the increase as an element of climate change.

Climate change and variability has remained a research problem over the years. The previous studies demonstrated changes in rainfall, temperature, and other climatic parameters as well as vegetation cover (Wang et al, 2012) and these changes have been linked to economic development and urbanization. Additionally, climate extremes have increased both in frequency and magnitude but other areas have seen notable decline (Roy, et al, 2009). The influence of temperature on rainfall has been incorporated in an indirect, or sometimes a direct way in a number of studies (Nkuna and Odiyo, 2016). Temperature influences rainfall in many ways; such that in some cases high temperatures may result in exceedingly high rates of potential evaporation and low precipitation in an area being dominated by an arid or semiarid landscape. In other cases, high temperatures lead to more evaporation and consequently increased condensation leading to high rainfall (Nkuna and Odiyo, 2016). The study is concerned with spatial change of temperature and rainfall experiencing in the recent times the Jos-Metropolis which is a low temperature environment with adequate rainfall. There is changeability in climate that has impact of temperature and rainfall of Jos-Metropolis. Observing the parameters records over the period of thirty (30) years would depict the variability of temperature and rainfall.

Methodology

Jos metropolis is located between latitudes 9° 54' N and 10° l0' N and longitudes 48' E and 9° 30' E (see figure 1) of Jos South and Jos North local Government Areas. Jos-metropolis from north to south is 18km while from east to west is about 18,5 km on an elevation of 1,250m above

sea level with Shere Hills having the highest peak of 1,777Km(square) above sea level with an area of 1002.19 Km^2 (Jidauna, et al, 2013; Gajere, Adigun and Folayan, 2010). Jos-metropolis experiences AW climatic type and falls within the Koppens AW climatic sub-region. Generally, weather conditions are warmer during the rainy season (April – October) and colder during hammattan (December – February) (Ariyo , 2000). The mean annual temperature in the city ranges between 20°C and 26°C.These temperature ranges are as the result of the influences of rainfall, relief and cloud cover at different periods and seasons in the year.(Nyong, et al 2008). Rainfall on the Jos metropolis is within a average of 70cm to 100cm at the peak period with a wet season of 8-9 months while dry season is between 3-4 months. The climate is affected by altitude and changing position of Inter-Tropical Convergence Zones (ITCZ) or Inter-Tropical Discontinuity or Inter-Tropical Front (ITF). Rainfall is high (1,305 mm) and characterize with two distinct season (wet and dry), with temperature range of 32° C to 18 ° C respectively (Eziashi, 2005).



A descriptive research method was applied for the study of which data were collected from a synoptic station of the Nigerian Meteorological Agency (NIMET), Heipang, Jos Plateau for two parameter (Temperature and Rainfall) ranging from 1989-2018) of 30years were used to seasonal and annual variability.. NIMET is federal government established agency to monitor and regulate climate activities in the nation. Therefore, data were available and reliable for usage. Statistically, the parameters data were presented descriptive statistics of line graphs and analytically, using the Pearson Correlation Coefficient (PCC) is a statistical measure used to test the relationship between the temperature and rainfall parameters using data between the periods of 2008 to 2018 monthly averages of the two parameters. However, the relationship

could be positive or negative at 95 confidence level. The Product Correlation coefficient (PCC) is represented by the following:

$$r = \frac{\sum(X-\overline{X})(Y-\overline{Y})}{\sqrt{\sum(X-\overline{X})^2}\sqrt{(Y-\overline{Y})^2}}$$

Where, $\overline{X}$ = mean of X variable
$\overline{Y}$ = mean of Y variable

Thus, ϒd = cross correlation coefficient
d = delay
X = Mean of Temperature range
Y= Mean of Rainfall range
Xi = raw temperature
Yi-d = delayed raw rainfall range
N = total number of values
I = ith term in series

However, the findings of the analysis was discussed in the result of the research

RESULTS AND DISCUSSIONS

The results of the finding in figure 2 revealed the Monthly Average Temperature (MAT) of Jos-Metropolis from 1989-2018 i.e periods of 30years that there are increase in the temperature from January (26.2^{0}C) MAT till it reached April (28.9^{0}C)MAT and began a gradual reduction until it was at August (24.2^{0}C)MAT that it began to increase before finally dropped in the month of December (25 ^{0}C)MAT. This shows fluctuations in the temperature within the period of 30years to the fact that climatic changes was occurring. In figure 3 shows an average yearly temperature ranging from 1998 to 1998 where increase was noticeable between 1989- 1992 with a decrease in 1993 and a sharp increase in 1993 that proceeded to 1996. In 1997, temperature for Jos-metropolis decrease but increase in 1998. By implication, the 10 years between 1989-1998 temperatures has been instable which signifies climate change with the period.

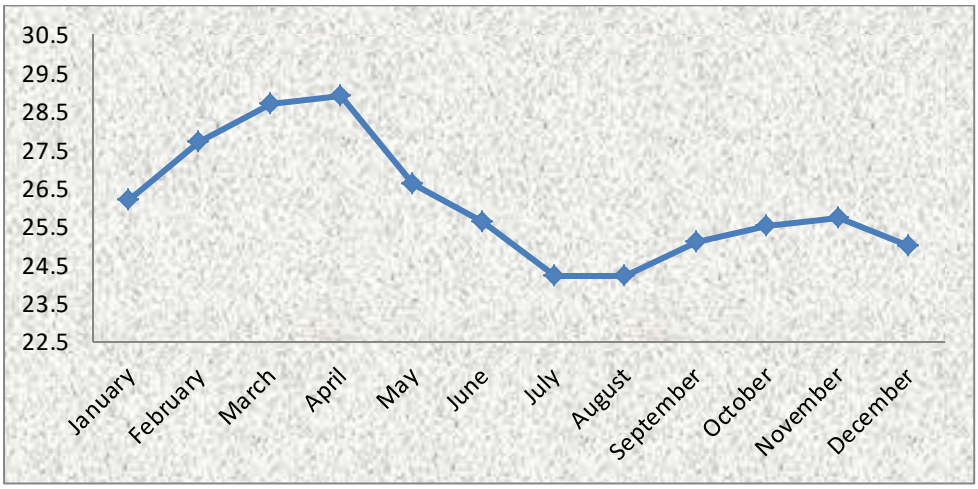


Figure2 Monthly Total Average Temperature ^{0}C (1989-2018) of Jos-Metropolis

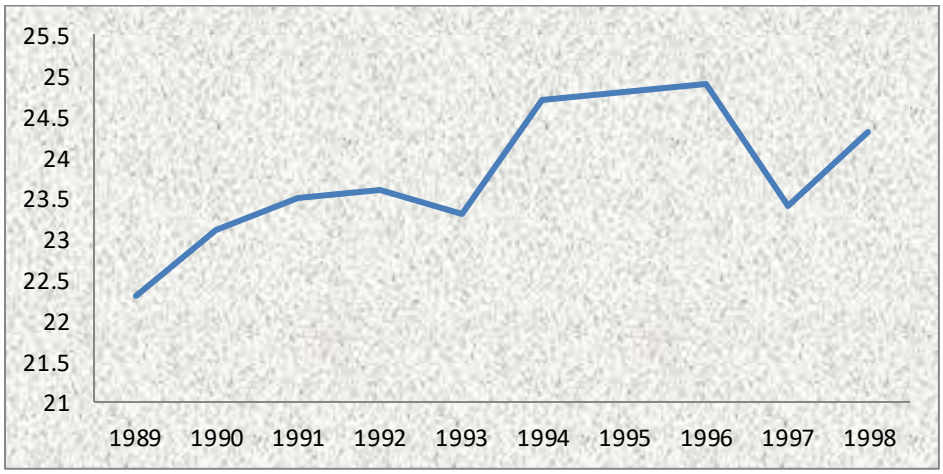


Figure 3 Average Temperatures (1989-1998) of Jos-Metropolis

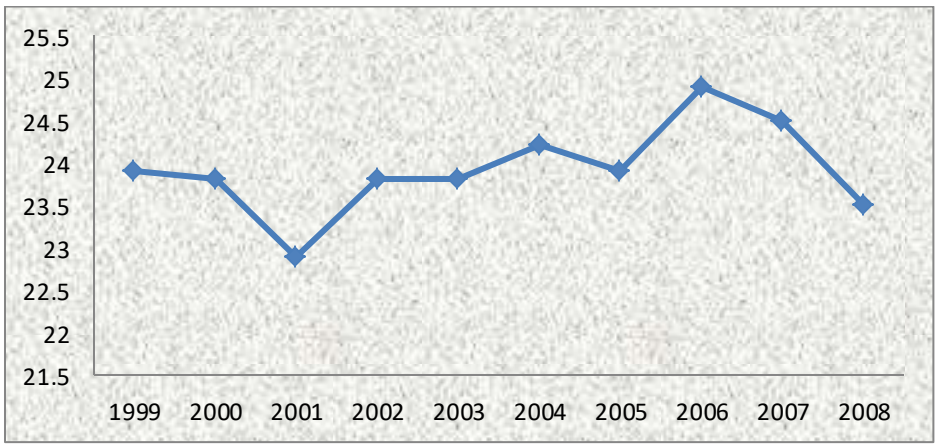


Figure 4 Average Yearly Temperatures in 0C (1999-2008)

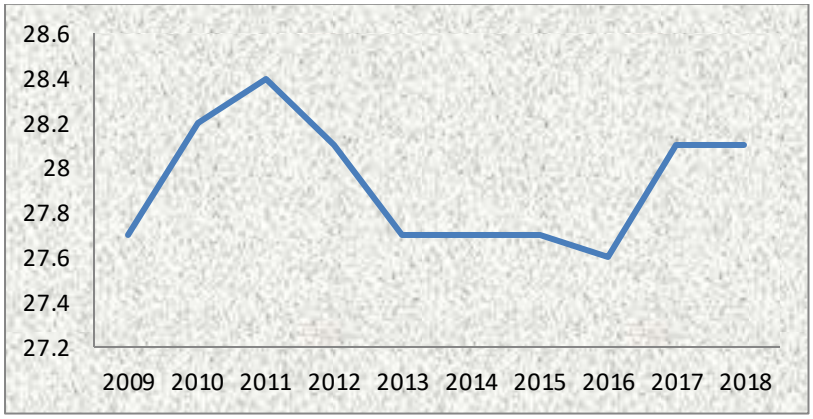


Figure 5 Average yearly Temperature in 0C (2009-2018)

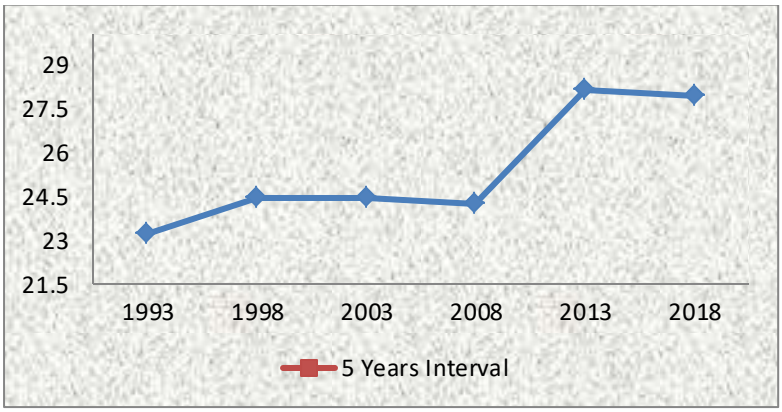


Figure 6 Average Yearly Temperatures ^{0}C Five (5) year Intervals

Figure 4 revealed a decrease in temperature from 1999 -2001, an increase from 2002, slide decrease in 2003 with increase in 2004 and then decrease in 2005 and increase in 2006. The temperature gradual decreases in 2007 -2008. The temperature fluctuate from 1999-2001 was on a consistence level beyond the year 1989-1998 which means there are more factors influences climate change. In Fig 5 high temperature increase was experience between 2009-2010 and fall in between 2011-2013 while it maintain a constant temperature from 2013-2014, less in 2016 then increases and remain stable from 2017-2018. An interval of five (5) temperature data observed for the period of 30years in fig 6 which indicated that temperature increases between 1993-1998 with slight decrease from 1998 -2008 and a sharp increase between 2008-2013 while temperature was less from 2013-2018 and such fluctuation were indication of temperature variability. However, Fig 7 revealed yearly average temperature for 30 years (1989- 2018) with increase and decrease (zigzags) from 1989-2008, sharp increase in 2010 and stable high temperature from 2010-2018. According to the study Tingneyuc Sekac, et al, (2020) Temperature increasing trends were found to be more significant than decreasing trend which was the experience in Jos-metropolis.

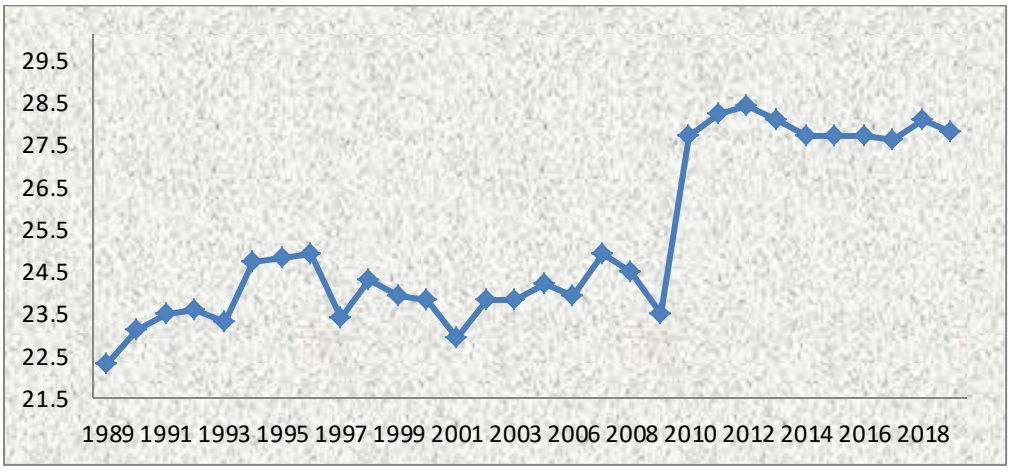


Figure 7 Average Yearly Temperature in ^{0}C of 30 years (1989-2018)

Figure 8 shows annual rainfall from 1989-1998 of Jos-Metropolis, 1429mm of rainfall was recorded in 1998 but decrease in 1990 to 1155mm of rainfall, slight increase in 1991 with 1630mm then a fall in 1992, increase in 1993, less from 1994- 1995 and an increase in 1996 while 1997 appreciated to 1998. This shows that there are fluctuations in rainfall within 1989-1998 in Jos-metropolis. For 1999-2008,(see fig 9) shown high rainfall in 1999 with 1552.2mm then decrease in 2000 with continuous high and low rainfall recorded in between 2001 -2005. High rainfall was seen in 2006 (1422.8)mm then decrease from 2007 but in 2008 there was increase to 1354.3mm. 2009 as seen in 9 shows low rainfall (1065.3mm), high rainfall in 2010 with a record of 1552mm, in 2011 rainfall dropped to 1028.2mm and from 2012-2017 rainfall kept increasing and decreasing in the following 1046.8mm, 1431.8mm,1379.2mm, 1511.4mm, 1408mm,1528.3mm and 1918.8mm while 2018, there was a high increase of rainfall 1918.8mm. This shows an dramatic climate changes of records of rainfall experience within the periods of 2009 -2018. Interval of five (5) years was observed for 30years for the periods of 1998-2018, This revealed that from 1993 to 2013 on an average level shows depreciation in rainfall while 2018 revealed a high rainfall. A study by Ekpe , Afangideh and Offiong, (2013) evaluate annual rainfall amount for the period 1982 to 2011 (30 years) demonstrates the existence of marked variations and trends in the rainfall characteristics of the area. The result reflects a continuous inconsistency in the pattern of rainfall with an increasing trend, which clearly indicates that the climatic change.

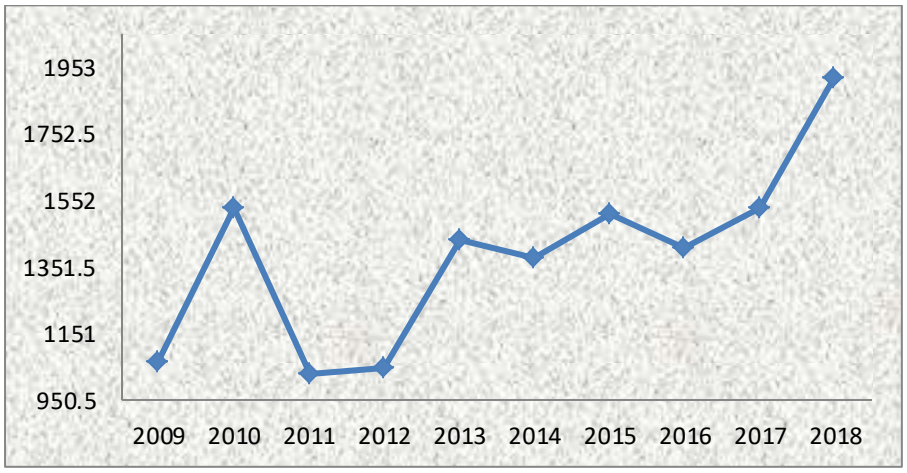


Figure 10 Annual Yearly Rainfall from 2009-2018

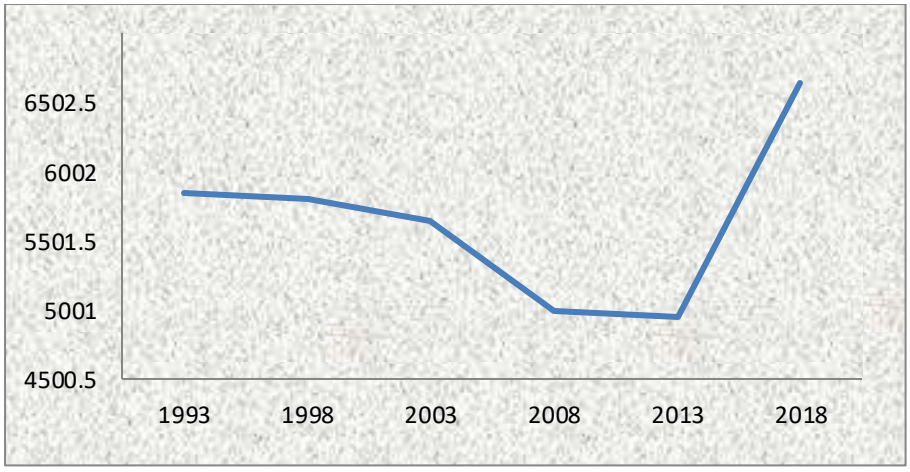


Figure 11 Interval of Five (5) Years Rainfall for 30 years

The total annual Rainfall recorded from 1998-2018 of Jos –Metropolis as seen figure 12 revealed rainfall variability with a zigzag changes of rainfall. Between 1989 to1998 shows highest rainfall recorded in 1993 and low rainfall was in 1997, between 1999 to 2008, the highest rainfall was recorded in 1999 while low rainfall was in 2007 and between 2009 to 2018, the highest rainfall was recorded in 2018 while 2013 recorded low rainfall. Thus, 1993, 1999 and 2018 in 30years indicated high rainfall 1537.78mm, 1562.2mm and 1918.8mm respectively.

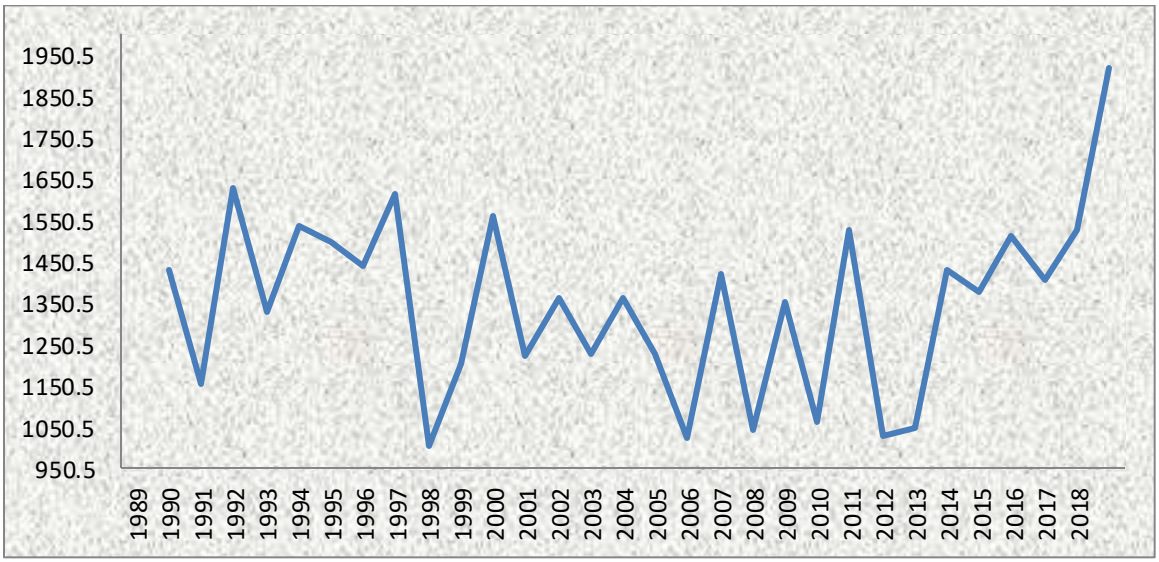


Figure 12 Total Mean Annual Rainfall (1989 – 2018) for 30years of Jos-Metropolis

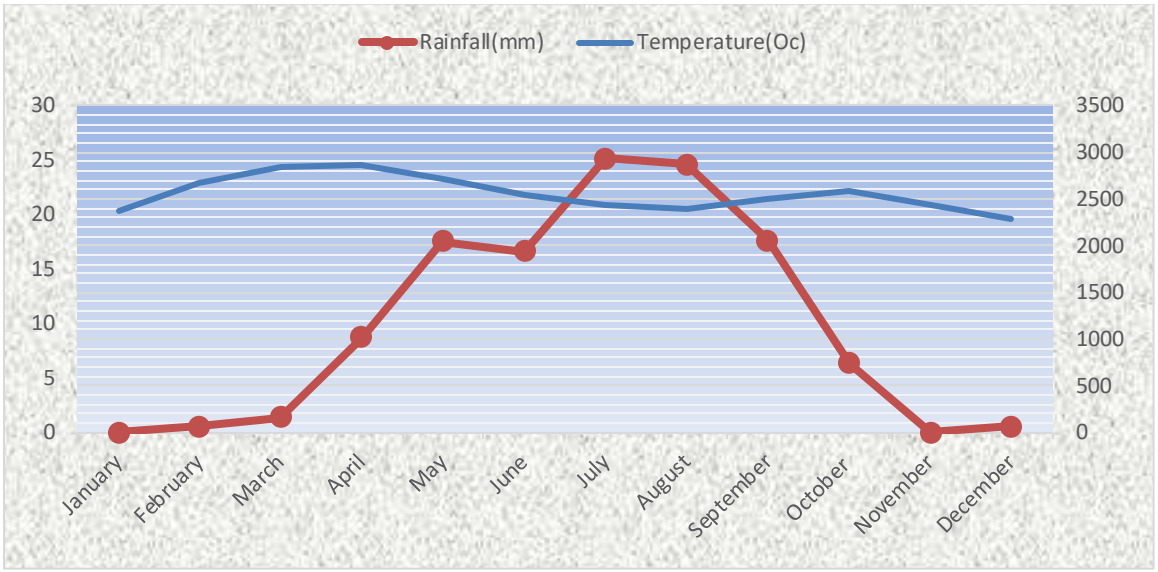


Fig 1 Total Mean Annual temperature and Mean Annual Rainfall of Jos- Metropolis

By virtual of figure 13 a presentation of average annual temperature and average annual rainfall in Jos-metropolis for 10 years (2008-2018) revealed high temperature at the period that there was low or no rainfall and in the same pattern, low temperature when the rainfall is at its season. This show changes occur in variation between temperature and rainfall as direct or indirectly temperature affects rainfall reversal may be the case in terms of climatic change. The influence of temperature on rainfall has been incorporated in an indirect, or sometimes a direct way in a number; such that in some cases high temperatures may result in exceedingly high rates of potential evaporation and low precipitation. This results in an area being dominated by an arid or semiarid landscape. In other cases, High temperatures lead to more evaporation and consequently increased condensation leading to high rainfall (Macatsha, 2006; Buishand and Brandsma, 1999;

Longobardi and Villani 2010; Gebrehiwot and Veen 2013; Nkuna and Odiyo, 2016). However, relationship between temperature, rainfall and years (period of data collected) were tested through plotting of scatter graph which were shown below:

Figure 14 Scatter diagram of Temperature and Rainfall

Figure15 Period of Years and Temperature

Figure 16 Periods of Years and Rainfall

There was no linear relationship between average annual temperature and average annual rainfall as seen in fig 14 of the scatter plot where the calculated PCC revealed the correlation of temperature and rainfall $r = 0.122$, $p > 0.005$ which indicated no statistically significant linear relationship between temperature and rainfall. Followed the relationship between periods of years and temperature (fig 15) showed a linear relationship where $r= 0.846$, $p< 0.005$ an indication of statistically significant linear relationship while relationship between periods of years and annual rainfall (see fig16) shows $r = 0.041$, $p> 0.831$

CONCLUSION/RECOMMENDATIONS

The study on temperature and rainfall pattern in Jos-Metropolis over the periods of 30years (1989-2018) revealed the irregularities and fluctuations of temperatures as well as rainfall which indicates that climate is changing or variation within given time. There were instable significant changes in temperature between 1989-1998, 1999-2008, and 2009-2018 and by virtual of interval of five (5) temperatures increases between 1993-1998 with slight decrease from 1998 -2008 and a sharp increase between 2008-2013 while temperature was less from 2013-2018 and such fluctuation were indication of temperature variability. Yearly average temperature for 30 years (1989- 2018) was increasing and decreasing (zigzags) from (1989-2008), sharp increase in 2010 and slight stable high temperature from 2010-2018.

For rainfall, variation among years was noticeable in a zigzag pattern, high rainfall in 1993, 1999 and 2018 (1537.78mm, 1562.2mm and 1918.8mm) respectively while low rainfall was recorded 1997, 2007 and 2013. Observation of 10 years (2008-2018) revealed high temperature at the period that there was low or no rainfall and in the same pattern, low temperature when the rainfall is at its season as if direct or indirectly temperature affects rainfall reversal may be the case in terms of climatic change. Such happening affects agricultural activities that could be devastation on people livelihood. However, no linear relationship exits between temperature and rainfall, periods of years and rainfall only between temperature and periods of years. Climate change in this 21st Century have impacts to the livelihood of people in several aspect of their lives; agricultural production, adaptation to changing and economic activities that require intervention from government through the NIMET to inform citizenry on the expected climate changes on periodic seasons to be able to acclimatized with the changes and also areas affected

by the temperature and rainfall variability should be interference by the government projects such as drought resistant varieties of crop, irrigation schemes, livelihood diversifications, clothing among others to reduce the magnitude of the effects of temperature and rainfall pattern in Jos-Metropolis of Plateau State, Nigeria.

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