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ANALYSIS OF TREND AND DECADAL VARIATION OF TEMPERATURE IN JIMETA METROPOLIS, ADAMAWA STATE, NIGERIA

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Abstract

The research aimed to examine trends and decadal temperature variability over the period of 41 years (1976-2016). The specific objectives to be achieved are, to evaluate the trend of mean annual temperature for a period of 41 years (1976-2016) in the study area and to examine the decadal variation of temperature between 1977-1986, 1987-1996, 1997-2006, and 2007-2016 in the area. The data used was obtained from Nimet Yola. The methods for data analysis were Timeseries for the trend and ANOVA for the decades. The results have a range of minimum show differences of (+4.69°C) while maximum with the difference of (+1.95°C). The ANOVA result shows a minimum P-value is 0.000 and a maximum Pvalue of 0.001 which are highly significant. In conclusion, trend analysis has indicated an increase in minimum and maximum temperature in the last 41 years. The study recommends embarking on a tree planting campaign should be initiated by the government and encourage individual planting around homes, public awareness campaigns on issues of global warming need to be introduced from the grassroots level this should be beyond the four walls of an academic environment, it can be done by organizing free lecture campaign within public gathering in schools or town halls last through social media.

Keywords: Temperature, Trend, Variation, Decades, Minimum & Maximum

Introduction

Ambient temperature refers to the temperature of a particular environment in a specific location at a given time. It is measured in degrees Celsius (°C) or Fahrenheit (°F) and indicates the thermal conditions experienced by living organisms in that environment pattern of life of people changes concerning the variation of the day-to-day atmospheric conditions of a place. There seems to be a regular change in the temperature of the environment over the decades which seems to have shaped and reshaped the lifestyle of the residents.. The total amount of radiation received at any place on earth depends on two factors, the duration and intensity of

insolation. These factors are controlled by the movement of the earth, its rotation around the axis, and the revolution around its orbit. Once solar radiation is absorbed by either the earth or the atmosphere, it is partly converted into a sensible heat or other form of energy. The degree of conservation of this sensible heat represents what is known as temperature (Ayoade, 2003).

However several other factors also influence surface temperature these include thermal uniformity, diurnal temperature variation, the effect of elevation, and the physiological temperature (Ayoade, 2003). Increasing temperature has already and will continue to

occur, this is referred to as global warming which is effectively induced by humans driving changes onto the surface of the earth through anthropogenic activities. Globally during the course of the 20th century global warming occurred at a linear rate of 0.7°C per decade but this warming has been more in the last 25 years (IPCC, 2012). Temperature increase in Europe is consistent with the global trend. Some authors have consistently projected a significant increase in surface air temperatures over Europe within the 21st century (Mohammed, 2012).

In Nigeria, the increasing trend in air temperature is about 0.036°C except for Jos which shows a decrease of -0.02°C (Akinsola & Ogunjobi, 2014). One of the major concepts of understanding temperature is through studying trends and decades of variability. Therefore the hotness and coldness of the place seem to determine the day-to-day activities of the people. The fundamental source of energy for the earth-atmosphere system is solar radiation. Hence, this research assessed temperature variability trends and decades changes in Jimeta metropolis.

Statement of the Problem

Temperature is one of the climatic elements used in detecting global warming and climate change. Spatial and temporal variability of temperature defines temperature changes. Globally during the 20th century global warming occurred at a linear rate of 0.7°C per decade but this warming has been more in the last 25 years (IPCC, 2012). The 2016 report on climate change encourages maintaining global temperature increases below 2°C to reduce global warming (IPCC, 2016). In Nigeria, the increasing trend in air temperature is about 0.036°C except for Jos which shows a decrease of -0.02°C (Akinsola & Ogunjobi, 2014). The study detects actual rate of changes in minimum and maximum temperature between 1976 and 2016 through trend and decadal variability of ambient temperature in the study area.

The transformation of Jimeta from a small town to state capital of Adamawa has prompted physical development and population growth. Jimeta with altitude of approximately 164-200m above sea level and located along the Benue valley mostly record high temperature. The has and is still changing the physical surroundings which in turn induce alterations in the energy regime near the surface (Zemba, 2010). Urban features such as constructed buildings and materials used like concretes, zinc, lost of vegetation cover around the city, transportation systems increasing rate of air pollution, buildings pattern spacing, height and orientation, decrease in vegetation layering, increasing population density, anthropogenic activities among others are major contributors of temperature changes in the area. The consequences of massive urbanisation result to urban heat Island which can influence temperature changes.

Research Question

- I. What is the trend of temperature from 1976-2016 in the study area?
- II. What is decadal variation of temperatures between 1977-1986, 1987-1996, 1997-2006 and 2007-2016 in the area?

Aim and Objectives of the Study

The main aim of the study is to analyse trend and pattern of temperature variability over the period of 41 years (1976-2016). The specific objectives to be achieved are:

- I. To examine the trend of mean annual temperature for period of 41 years (1976-2016) in the study area.
- II. To evaluate the decadal variation of temperature between 1977-1986, 1987-1996, 1997-2006 and 2007-2016 in the area.

Literature Review

Climate refers to the characteristic condition of the atmosphere deduced from repeated observations of weather over a long period. Climate is therefore the synthesis of weather at a given location over a period of about 30-35 years. Thus, in reality, climate is far from being average of weather condition; it is always changing on a variety of time scales (Adebayo, 2010). In this regard, an increasing number of studies endeavored to further understand of changes in climate mean and extremes.

The climate of a location can be understood most easily in terms of annual or seasonal averages of temperature. There is a minority opinion in the literature on the debate on global warming is exaggerated. It is acquired that thought the limited surface network of global weather stations have recorded a rise in temperature of 0.5°C during the last century including the increase of +0.15°C since 1998. The 2016 report on climate change encourages maintaining global temperature increases below 2°C to reduce global warming (IPCC, 2016). The issue of explaining the rise in air temperature has not been cleared. The two opposition viewers argued with the first view that global warming has occurred due purely to natural forces, while the second view was due to human activities through emission of greenhouse gases (NG, 2013). The concept variability or fluctuation of climate system depend on the degree and duration of variation. Climate variability or variation is a general term used to describe the interval variation of climate on various temporal scales monthly, seasonal, annual, and decade respectively (Mohammed, 2012).

A common perception holds that temperature will become more variable with “higher highs and lower lows” or at least that temperature will vary wide range over time. Evidently such studies shows daily and monthly land surface temperature record variability over the last 50 years. The global temperature has been warmed by 1°C (Zeke, 2014).

Decades Temperature Variability

Increasing interest in the analysis of temperature variability over the last decade (Diaz & Murnane 2008). The prominent observed change is an increase in the mean of the annual period (Jones & Moberg 2003). At a more localized scale, there is a good deal of evidence of average temperature over Europe in recent decades). Trend detection in temperature time series is one of the interesting research areas in climatology. Temperature changes are not uniform, several studies have evaluated the trend in temperature on different spatial and temporal scales (Klein Tank et al 2005).

Their knowledge of climate variability over the period on different temporal and spatial scales is important. Changes in temperature variability are also important in determining the future temperature distribution. Global warming has been noted by examining temperature variability in the Eastern Mediterranean Peninsula using a daily dense network for the period of 1958 – 2003 (Mohammed, 2012).

The global average temperature of the earth had increased by about 0.7 degrees Celsius per decade in the 20 century. The most prominent observed charges are increase in the mean annual period

and less seasonal variation (Jones & Moberg 2003) at local and regional scales, there is a good deal of evidence in average mean temperature over Europe in recent decades. The average mean annual increase across the continent is about 0.8°C. (Hulme & Sheard, 1999) noted that the annual mean temperature increased by 1.6 degrees Celsius during the last century at Iberian Peninsula. Analyzing long term variability in Spain from 1850 to 2005 the increase is at 0.10 degrees Celsius (Mohammed, 2012).

The global trend in temperature is likely to increase during the past decade (Luterbacher et al 2004). For example, Parry (2000) studied future climate trends in Europe that might increase by 2 - 6.3°C at the end of the century. Also projected an increase in the annual mean temperature. A study of trend analysis of climate variability over West Bank –East London Area in South Africa from 1975 – 2011. This study focused on local scale by analysing trends in rainfall and temperature data. Sen's and Kendall non-parametric test were performed on derived mean observed temperature data to establish trends for monthly, seasonal, annual and 30 year climate regimes. Results revealed maximum, minimum, and mean experience an increasing statistically significant trend at 95% level, the significant of findings lies in the linkage of temperature to climate change and its potential impact on vegetation and change in ecology. This study indicates upward warming trend (Kalumba et al 2013). In the same studies they quoted (Mukheibir & Spark 2005) state that temperature is expected to increase in South Africa at approximately 1.5°C along the coast and 2° - 3°C Inland of coastal mountains by 2050.

Studies of Global temperature trend until 2000 were warmer by more than 1°C when compared to the overall 20 century. However mean temperature for 2014 and 2015 recorded the highest except 1998 which show an increase of +0.68°C (GISS, 2015). Changes in temperature extremes over a 40-yr period are analyzed, based on daily minimum and maximum temperatures over Argentina. Trend analysis was performed on seasonal means, standard deviations, and extremes (5th and 95th percentiles) over the 1959–98 period. The strongest (positive) changes over time occurred in mean summer minimum temperature, whereas the standard deviation decreased. Mean maximum temperatures mostly decrease over time in summer over northern Argentina, but they increase in Patagonia (Southern Argentina). Generally, negative trends were obtained in the number of cold nights and warm days per summer, while the number of warm nights and cold days has increased at certain locations. Patagonia shows many stations with an increasing number of warm days and nights in winter and a decreasing number of cold days and nights in summer. The summer mean temperature is more sensitive to extremes than the winter one.

Research on analysis of temperature and rainfall variability in Nigeria using the observation of air temperature from 25 stations for 30 years (1971-2000). Analysis of long-time trend and decadal trends in time series suggested a sequence of alternately decreasing and increase in mean annual air temperature in Nigeria during the period studied. The method used in the study for variability was coefficient of skewness, the observations were significant at 95% or 99% level in most of the station. The result of the entire country shows that increasing trend in air temperature with about 0.036°C except for Jos which shows a decrease of -0.02°C (Akinsola & Ogunjobi, 2014).

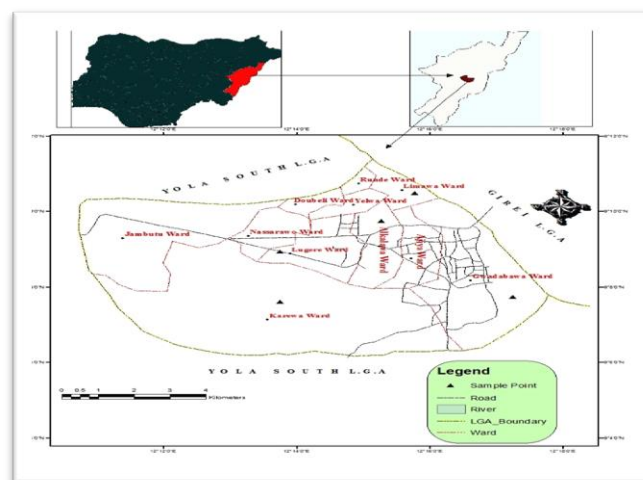
Methodology

Study Area

Jimeta lies on latitude 9° 07' to 9° 23'N and longitude 12° 17' to 12° 33' E, between the altitude of 164 – 200m above sea level. It is bounded by Girei LGA to the north, Yola South LGA to the east, and Demsa LGA to the west with an approximate land area of 231.6 km² (Zemba, 2002). The study area is now urban with woodland vegetation sparsely distributed in undeveloped parts.

Jimeta area exhibits a typical tropical climate the average daily hours of bright sunshine is about 7-8 hours and the wind speed averaging about 76.1 km/hr. It has monthly mean sunshine hours of about 220 from January to April. This decreased to a mean value of 207 hours between May and September due to increases in cloudiness. The mean sunshine hours increase again to about 255 for the period between October and December. The average sunshine hours for the year as a whole stand at about 2750 approximately (Adebayo 2010, Zemba 2010).

Temperature characteristics in Adamawa state as a whole is typical of West African savannah climate. The temperature in this region is generally high through out the year. In Jimeta, there is a seasonal change, indicating a gradual change from February to April. This is because at these period the sky become clear leading to more receipts of solar radiation. The seasonal maximum usually occur in April reaching as high as 39.5°C (Adebayo and Zemba, 2003). There is a distinct drop in temperature at the onset of rain due to the effect of cloudiness. A slight increase after cessation of rain (October –November) is common before the onset of harmattan in December wind temperature drops further. The minimum temperature value for the area can be as low as 15.4°C between December and January.



Method of Data Collection & Analysis

The study used secondary data, temperature data obtained from Nigerian Metrological Agency Yola. The research acquired temperature data for period of 40 years, between 1976 to 2016 to assess monthly and annual temperature variability.

Statistical techniques used were inferential and descriptive methods. The descriptive statistics involve Arithmetic mean value, obtain through calculating mean minimum and maximum for both monthly and annual. The temperature trend and variability (fluctuation) were analysed using time series. For computing decadal variation one way analysis of variance (ANOVA) was applied, the decades are (1976-1985, 1986-1995, 1996-2005 and 2006-2016).

Results and Discussion

Trend of Annual Temperature in Jimeta 1976-2016

Temperature in the study area shows fluctuating pattern. The mean annual minimum temperature of 1977 records the lowest with 19.35°C and 2014 records highest with 24.04°C showing differences of (+4.69°). The mean minimum temperature between 1976-1985 shows increase (+0.1°C - +0.69°). It decreases in 1981 with (-0.08°C) and 1989 with (-1.32°C). There was continuous increase till 2006 which decrease with (-2.08°C). The increase from 1990-2016 ranges between (+0.05°C - +1.62°C). This results shows rise in mean minimum justifying the evidence of global warming in the area. The summary of the result is presented on table 1. These changes are linked to population growth, increase in volume of transportation and development transformation. These corroborate the report of climate which is estimated temperature increased by 0.6 on average over the last century, and that by 2100 temperature increase could range between 1.4 °C to 5.8 °C (IPCC, 2007). In addition there projections regional climate for Africa suggest that for West Africa, East Africa, South Africa, and the Sahara, regardless of the season temperatures are predicted to increase (3 °C-4 °C) between 1900 and 2100. In particular, a regional study by Mukheibir and Sparks (2005) indicates that temperature is expected to increase everywhere in SA at approximately 1.5 °C along the coast and 2 °C-3 °C inland. In addition, Kruger and Shongwe (2004) study reveals that between 1960 and 2003, SA's mean temperature increased by 0.13 °C cited by (Kolumba et al 2013)

Maximum temperature range from 34°C- 36°C and linear trend shows a constant of "0.0245" is between 34.6°C-35.5°C. The pattern overlaps the trend in 1977, 1984, 1999 and 2001. The pattern shown gradual increase but 1987 and 2013 records shows highest maximum temperature. The pattern fluctuates in 1976, 1981, 1988, 1989, 1991-1997 are below the actual pattern. In summary 20 years of the pattern are below the trend. While 16 years of the studied pattern are above trend, this is presented on figure 3. Major factors which leads to changes in temperature of the area can be linked to population growth and development strategies over the years, transformation in nature and pattern of building and other antropogenic activities carried out in Jimeta serve as the key factors that triggers temperature variability. This corroborate with study carried out in Turkana, Kenya an arid environment which records a signifiant increase in temperature of the area (Frances et al, 2014).

Table :1 Summary of Minimum and Maximum Temperature of Jimeta 1976-2016

| Results | Minimum | Maximum |
|------------------------|----------|----------|
| Mean | 22.34805 | 35.04171 |
| Standard Error | 0.168274 | 0.069858 |
| Standard Deviation | 1.077481 | 0.447308 |
| Sample Variance | 1.160966 | 0.200085 |
| Range | 4.69 | 1.95 |
| Minimum | 19.35 | 34.03 |
| Maximum | 24.04 | 35.98 |
| Confidence level (95%) | 0.340095 | 0.141188 |

Source: Computed from data obtained from Nimet, 2016

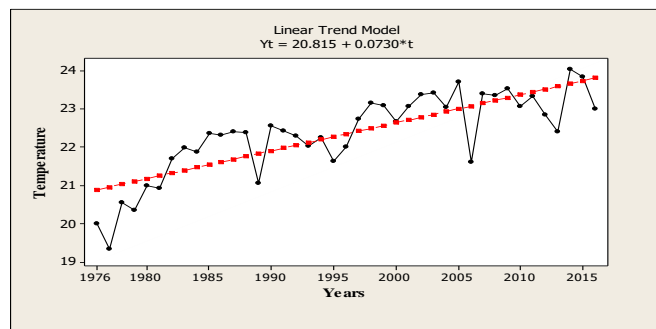


Figure 2: Changes in Linear Trend of Minimum Temperature 1976-2016

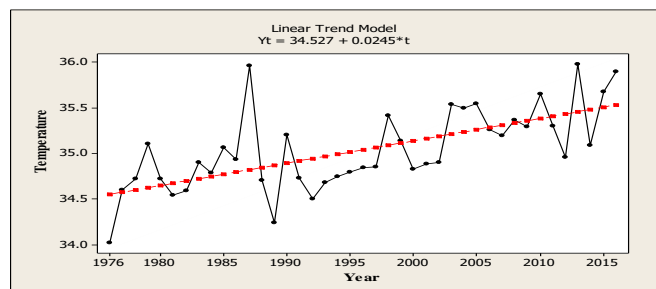


Figure 3: Changes in Linear Trend Maximum Temperature in Jimeta 1976-2016

Decadal Variation of minimum and maximum temperature for the period of 40 years from 1977-2016

The descriptive analysis for decades are presented on Table 2 and 3 mean standard deviation and differences of minimum and maximum temperature. The variation of decades for minimum temperature are as follows (+1.124) is the difference between 1977-1986 and 1987-1996, (+0.887) is the difference between 1987-1996 and 1997-2006, (0.121) is the difference between 1997-2006 and 2007-2016. The variation of maximum decades are as follows (+0.141) is recorded as the difference between 1977-1986 and 1987-1996, (+0.295) is the difference between 1987-1996 and 1997-2006 and +0.232 is the difference between 1997-2006 and 2007-2016. The variation further analysed using ANOVA, the findings shows variation among the decades (1977-1986, 1987-1996, 1997-2006 and 2007-2016) at 95% level of significant for minimum Pvalue is 0.000 and maximum Pvalue 0.001 which are highly significant. From the above interpretation both minimum and maximum temperature are increasing. The summary for minimum and maximum temperature are presented on Table 4 and 5. The minimum model summary is 0.6837 Rsquare 68.42%. The Maximum model summary is 0.3560 Rsquare 37.07%, thus the greater R² defined significant variation among the decades. The temperature of the area have shown significant changes within the period studied. This corroborate scientist studies on average global temperature on the earth revealed that it has increased by 0.8°C since 1880 at the rate of 0.15°C - 0.20°C per dacade (GISS, 2014).

Table 2: Decadal Difference in Minimum Temperature of Jimeta 1977-2016

| Decades | Number of years | Mean | StDev | Differnce |
|-----------|-----------------|--------|-------|-----------|
| 1977-1986 | 10 | 21.015 | 0.969 | |
| 1987-1996 | 10 | 22.139 | 0.457 | +1.124 |
| 1997-2006 | 10 | 23.026 | 0.470 | +0.887 |
| 2007-2016 | 10 | 23.147 | 0.708 | +0.121 |

Table 3: Decadal Difference in Maximum Temperature in Jimeta 1977-2016

| Decades | Number of Years | Mean | StDev | Difference |
|-----------|-----------------|--------|-------|------------|
| 1977-1986 | 10 | 34.709 | 0.307 | |
| 1987-1996 | 10 | 34.850 | 0.467 | + 0.141 |
| 1997-2006 | 10 | 35.145 | 0.322 | +0.295 |
| 2007-2016 | 10 | 35.377 | 0.307 | +0.232 |

Table 4: Decades Variation in Minimum Temperature 1977-2016

| Source | DF | SS | MS | F | P |
|--------|----|--------|-------|-------|-------|
| Factor | 3 | 29.176 | 9.725 | 20.10 | 0.000 |
| Error | 36 | 16.827 | 0.467 | | |
| Total | 39 | 46.003 | | | |

Table 5: Decades Variation of Maximum Temperature 1977-2016

| Source | DF | SS | MS | F | P |
|--------|----|-------|-------|------|-------|
| Factor | 3 | 2.687 | 0.896 | 7.07 | 0.001 |
| Error | 36 | 4.561 | 0.127 | | |
| Total | 39 | 7.248 | | | |

Source: Computed from data obtained from Nimet,2016

DF- Degree of Freedom, MS- mean square, F-ratio P-Pvalue

Conclusion & Recommendations

In conclusion trend analysis have indicated an increase in minimum and maximum temperature in the last 40 years. The decadal variation of both minimum and maximum are significant.

The results of this study indicated increasing minimum and maximum temperature hence, the following recommendations are made:

1. The finding shows increase in minimum and maximum temperature based on this, there is need for people to stay in well ventilated homes which will regulate temperature around home. Another important point to be noted in future development planning and buildings it is useful to incorporated trees into building designs. There is need to consider the temperature fluctuation by both government and individual to allow open space between buldings which will assist in regulating ambient temperatures.

The decades findings also shows variation between the decades should embark on tree planting campaign should be initiated by government and encourage individual planting around homes, public awareness campaign on issues of global warming need to be introduced from grassroot level this should be beyond the four walls of academics environment, it can be done by organising free lecture campaign within public gathering in schools or town halls.

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