TRENDS AND VARIATIONS OF MONTHLY SOLAR RADIATION, TEMPERATURE AND RAIN FALL DATA OVER BIRNIN KEBBI METROPOLIS FOR THE PERIOD OF 2014-2016.

MagawataUsman Zayyanu[1],YahayaAbubakar Aliero[1]

1. **Department of Physics Kebbi State University of Science and Technology Aliero,.Kebbi State, Nigeria.**

Abstract

The investigation of rainfall, temperature and solar radiation variability at Birnin Kebbi metropolis, Kebbi State, Nigeria was carried out using observations of air temperature (^oC) rainfall (mm) and solar radiation (w/m^2) for the period of 2014 -2016 (3years), data was obtained at Sir Ahmadu Bello international Airport, analysis of data indicate for the occurrences of abrupt change in temperature, rainfall and solar radiation values. It was observed from the distributions of monthly average wind speed for the (3) three years are fairly similar with maximum wind speed with variation in some months, having deficit values in February and April 2014, February and March 2015, January and February 2016, its revealed that, the least global solar radiation in 2014 followed by the month of January 2015 and June in 2016. The variation between maximum solar radiation and minimum is said to be great in the months of January to March where there is increase in the intensity of heat as there is strong expectation of precipitation events that become extremely in the month of August/September 2016. The slight difference between maximum and minimum in the period advocates a different seasonal period between the regime of large difference and low difference in the Relative Humidity in the year. However 2016 show the maximum temperature which in turn when compared with 2014 and 2015 as the case reverse, significant increases in precipitation indicated in 2014 compare to other years (2015, 2016). It was concluded that there is a significant downward trend in the yearly total and mean rainfalls at Birnin Kebbi showing that 2014 has highest rain fall compared with 2015 and 2016, which can be attributed to climate change.

INTRODUCTION

The global atmosphere is undergoing a period of rapid human – driven change, with no historical precedent in either its rate of change or its potential absolute magnitude (intergovernmental Panel on Climate IPCC, 2002), Human activities currently affect the earth's energy budget by altering the emissions and resulting atmospheric concentrations of radiatively important gases and aerosols, and by changing land surface properties. One of the most common pointer of climate change is the surface air temperature. The global climate has changed rapidly with the global mean surface temperature that has increased by 0.74 ^{O}C during 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. For example, Hasanean (2001) examined trends and periodicity of air temperature from eight meteorological stations in the east Mediterranean and observed positive significant trends in Malta and Tripoli, and negative trend in Amman. Turkes et al. (2002) evaluated mean, maximum and minimum air temperature data in Turkey during the period 1929–1999. Their analysis revealed spatiotemporal patterns of long-term trends, change points, and significant warming and cooling periods. Easterling 1997, Fan et al. 2010 reported separately that diurnal temperature range (DTR) has been on the decrease in most region of the world. Karl et al. (1993) analyzed temperature data from 37% of global land mass and found high increment in the minimum compared to the maximum temperature. Studies on the spatio-temporal variability and trend in temperature are very limited in Africa. There are a vast amount of research papers that examined changes in global and regional mean temperatures over time (Karabulut*et al*., 2008, Turkes*et al*., 2002; Olofintoye and Sule, 2010; Jain and Kumar, 2012; Gil-Alana, 2008; Jones *et al*., 2013; Ewona and Udo, 2008), other studies have adduced extreme rainfall to be the major cause of flood worldwide, include Bunting et al. (1976), Folland et al. (1986), Odekunle (2001). Other studies have identified the characteristics of extreme rainfall that are associated with flood frequency to include duration, intensity, frequency, seasonality, variability, trend and fluctuation (Ologunorisa, 2001). Global climate has changed significantly in the last century. Climate change over a region would have a significant impact on agricultural production and related sectors, water resources management and overall economy of the country. Temperature and its changes impact a number of hydrological processes including rainfall, and these processes in turn impact temperature e.g. cooling due to rain or snow (Jain and Kumar, 2012; Ewona and Udo, 2011). Today, climate change has direct effects on increasing global temperature, alter precipitation patterns, alter pattern of agriculture, increase size and number of forest fires etc. Although regional effects of climate change vary based on location of regions, there is a growing consensus that temperatures are on the rise. Analysis of worldwide air temperature changes have shown that temperature has increased in both northern and southern hemispheres over the last century with warming more dominant in the northern hemisphere since the 1950s (Rebetez and Reinhard, 2008) in Karaburun*et al*., (2011). Many regional studies have also found a positive trend in temperature, although the changes vary slightly from one region to another (Karaburun*et al,* 2011, Liu *et al*., 2006). Urbanization makes significant changes in the surface parameters which have the potential to change the local climate in cities (Ezber*et al*, 2007) in Ustaoglu (2012). Therefore, the basic objectives of the study are: (i) to measure temperature, wind speed and solar radiation of the year 2014 – 2016 (*The basic objective (i) was to acquire or to measure the temperature, wind speed and solar radiation of the years 2014 – 2016?!)*, and (ii) to observe the variations of three (3) years metrological data i.e. temperature, wind speed, solar radiation and rainfall from the international airport Birnin Kebbi, Kebbi State Nigeria.

Description of the Study Area

Nigeria is a country with diverse ethnic groups practicing different cultures, and having variations in farming and religion beliefs. The country can primarily be divided into two major geographical zones namely the North and South, though that has historical underlying (Obot et al., 2010). Furthermore, both the North and South are segmented into three regions each, making a total of six geopolitical zones. These six geopolitical zones in the country are; North East, North West, North Central, South West, South East and South South. Policies, resource allocations, sites of infrastructures and even political and other appointments are mostly considered by zoning in Nigeria. Birnin kebbi is in Kebbi State which is in North West geopolitical zone of Nigeria. Kebbi State came into being on August 27, 1991.It was created out of the old Sokoto State. The capital is Birnin-Kebbi. Its major towns include Birnin-Kebbi, Argungu and Yelwa. The state has a population of 3,630,931 and has a total land area of 36,800 km^2. Kebbi State shares boundaries with Sokoto State on the North-Eastern axis, Zamfara State on the Eastern part, Niger state on the Southern part and Republic of Niger on the Western part. Kebbi State is divided into 21 local government areas, four emirate councils (Gwandu, Argungu, Yauri and Zuru), and 35 districts. The climate is semiarid with a zone of savannah-type vegetation as part of the sub-Saharan Sudan belt of West Africa. (Figure 1), the study was carried out at Kebbi State of Nigeria and various data collected was gotten from the Nigeria

Meteorological Agency, Sir Ahmadu Bello International Airport Birnin Kebbi. The method of data collection was on a daily basis for the three (3) years, i.e. for the year 2014, 2015, and year 2016 respectively. The data used in this study were direct data of the minimum temperature, solar radiation and rainfall and the wind Speed.

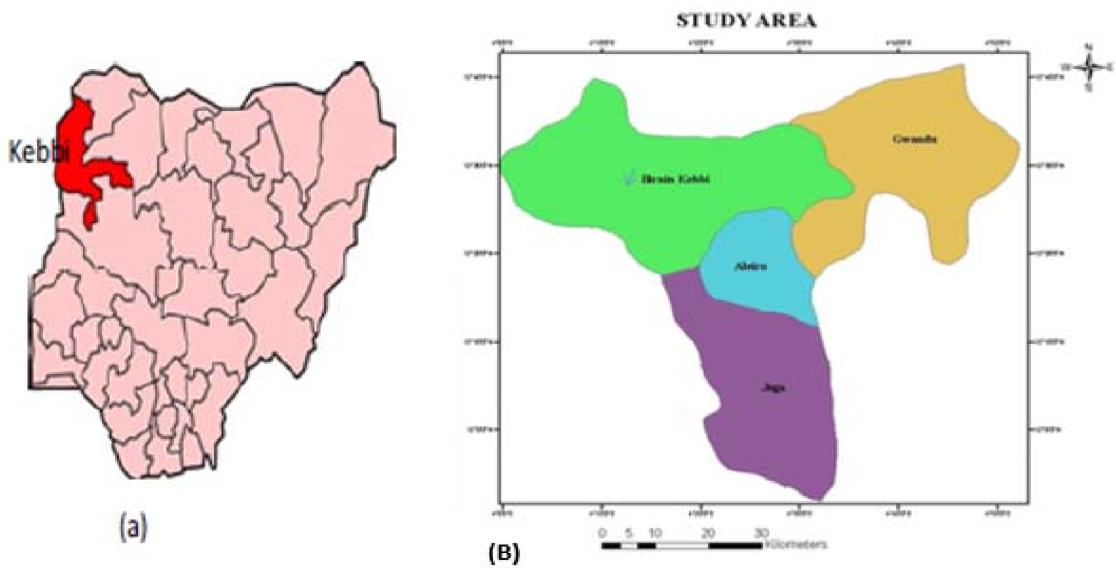

Figure 1: Map of Nigeria

(a) showing kebbi state

(B) Showing Study Location

Material and Method

The methodology used in carrying out this research is categorized as:

- preliminary investigation
- Acquisition of Data

Preliminary Investigation

Measurement was carried out at Sir Ahmadu Bello International Airport Birnin Kebbi, Kebbi State on 29th April, 2017, parameters to consider are Wind speed

- Solar radiation
- Temperature

1. *What for made these measurements on 29th April, 2017 when dwelt on in this study are the acquired measurements of temperature, wind speed and solar radiation of the years 2014 – 2016?!*
2. *Where and/or how these measurements n the study findings reported in this manuscript?*

Data Acquisition

Three years data (2014, 2015, and 2016), for temperature, wind speed, solar radiation and rainfall was obtained from Meteorological Agency of Sir Ahmadu Bello international Airport Kebbi State.

Solar Radiation Data:

Solar radiation can briefly described as energy transmitted in form of rays from the sun. This solar radiation measurements were carried out with the help of an apparatus called pyranometer; A solar radiation sensor used to measure the broad band solar radiation flux density (e.g. in watt per metre) from a field of view of 180 degrees. The first correlation proposed for establishing the average monthly solar radiation of Sokoto based on the method of angstrom.

Rainfall data:

This can be briefly described as water falling in drops from vapor condensed in the atmosphere. The approach used in this study was to analyze the data for rainfall amount in Birnin Kebbi local government; the data here are secondary data and were obtained in Birnin Kebbi from Nigeria Meteorological Agency, Collage of Agriculture waziri umaru federal polytechnic Birnin Kebbi. This study was for a period of three years in Birnin Kebbi. The individual daily rainfall were added up for each week and month to give the weekly and monthly rainfall total, and the monthly rainfall total for each year added up to give the annual rainfall total, for a particular year.

Wind data

Saharan dust is emitted to the atmosphere in pulses (Kubilay, 2003). Often dust events result from collection of many small-scale dust plumes emerging from separated point sources within an area of a few square kilometers (Koren*et al,* 2003), describe the evolution of dust storms and show that dust is emitted from the Sahara from a few, well defined sources. One of the most vigorous sources for dust in the Sahara is the Bedele depression (17N, 18E) located northeast of Lake Chad, and composed of a series of ephemeral lakes collecting erosion from a few sources (Mounkaila, 2003), the study analyze all the dust storms observed during January-April 2011 and the wind speed and direction of the dust movement (*where and/or how the underlined was considered in the study and the reporting of its findings in this manuscript?*).

Temperature data:

The data for both minimum and maximum temperature was collected at the station with the help of a material (*what material?*), the data collected was then sorted (*sorted for what*?) by using appropriate formula in the calculation of the data. In this study the average mean for maximum temperature and the average mean for the maximum temperature for study year from 2014 to 2016 in Birnin Kebbi local government were calculated and computed (*clarify how*).

Theory of Solar Radiation

The original Angstrom-Prescott type regression equation-related monthly average daily radiation to clear day radiation in a given location and fraction of possible sunshine hours is given by this equation.

$$\frac{H}{Ho} = a + b \left(\frac{S}{So}\right) \quad (1)$$

Where

H is monthly average daily solar of Birnin Kebbi on a horizontal surface (w/m^2/day),

Ho is the monthly average daily hours of bright sunshine,

S is monthly mean daily bright sunshine hour

S_O is the Maximum possible monthly mean daily sunshine

a and *b* values are the angstrom empirical constants (regression constant)

The monthly average daily extra-terrestrial radiation on a horizontal surface (H_o) was calculated for the number of days in each month of the year (Iqbal, 1983; Zekai, 2008).

$$H = \left(\frac{24}{\pi}\right) I_{sc}\left[1+0.033\cos\left(\frac{2\pi n}{365}\right)\right] \left[\cos\Psi\cos\delta Ws + \left(\frac{2\pi Ws}{360^O}\right)\cos\Psi\sin\delta\right] \quad (2)$$

Where

I_{sc} - solar constant (= 1362Wm^{-2}),

Ψ - latitude of the site,

δ - Solar declination and

W_s - The mean sunrise hour angle form the given month and

n- is thenumber of the days of the year starting from 1st of January to 31st of December.

The solar declamation, δ and the mean sunrise hour angle, W_s can be calculated using the following equation (Zekai, 2008):

$$\delta = 23.4\sin\{360\left(\frac{284+n}{365}\right)\} \quad (3)$$

$$W_s=\cos^{-1}(-\tan\Psi \tan\delta) \quad (4)$$

For a given month, the maximum possible sunshine duration (S_o) can be computed (Iqbal, 1983; Zkai, 2008) by the equation below:

$$S_o = \frac{2}{15}W_s \quad (5)$$

Clearness index (K_T) can defined as ratio of the observed horizontal terrestrial solar radiation H, to the calculated horizontal extraterrestrial solar radiation H_o. This gives the percentage % deflection by the sky of the incoming global solar radiation and therefore indicates both level of availability of solar radiation and changes in atmospheric condition in a given environment. The probability density function of the wind data was calculated using the Weibull and Ray light probability density function formula, Russak, V. (1990).

$$F(v) = [k/c]\,[v/c]^{K-1}\exp\text{-}[v/c]^{K}\ \text{(s/m)} \quad (6)$$

Where

$F(v)$ - probability density function,

K - Dimensionless shape factor,

C -Weibull scale factor (m/s).

The relationship of C, K, and the average wind speed is given below

$$V_m = o\Gamma (1+ [1/k]) \quad (7)$$

Where,

Γ- Gamma function

K and C be calculated by the linear regression of the cumulative Weibull distribution given below:

$$F(v) = 1- \exp [-v/c]^k \quad (8)$$

Variation of the wind speed with respect to height, a wind speed is greater at higher distance above the ground. This is due to the effects of surface features and then turbulence diminishes as the highest increases (Walker and Kekins, 1997). The acceptable expression used in the calculation of wind speed variation is a shown below:

$$\frac{V}{Vo} = \left(\frac{h}{ho}\right) \quad (9)$$

Where V - Wind speed at required height

V_o - wind speed at the original height,

h - Wind height;

h_o - original wind height and

o - surface roughness coefficient (0.143).

The wind potential height is estimated using the formula below.

$$o = 0.2965pv^3t \quad (10)$$

Where

p - Density of air in K/gm^3

a - available energy for doing the work on the wind turbine.

t – time of work on the wind turbine.

Results and Discussion

Three years data 2014, 2015, and 2016 for the solar radiation, rainfall, and maximum/ minimum temperatures obtained from Birnin Kebbi international airport Kebbi State, The wind speed recorded is in knots and converted to m/s using the relationship, the average wind speed increase progressively from 1.18m/s in 2014, 2015 and 1.83m/s in 2016.

Note that, 1 knot = 0.515m/s (meter per second).

Wind Speed

The monthly and annual average wind speed distributions for the three years over the studied period. The table series distributions of the monthly average values for the locations are shown in Figure 4.1a, the distributions give annual mean values of 0.72, 0.38.04?, 38.04, 0.32m/s respectively, for 2014, 2015 and 2016. It could easily be observed from Figure 4.1a that the distributions of the monthly average wind speed for the three years are fairly similar, peaking in the month of October November 2014, 2015, 2016, and having minimum values in February and April 2014, February and March 2015, January and February 2016. Perhaps, the result is as expected since difference in wind speed distributions may be related to the difference in altitude between the years and locations (*clarify the underlined*).

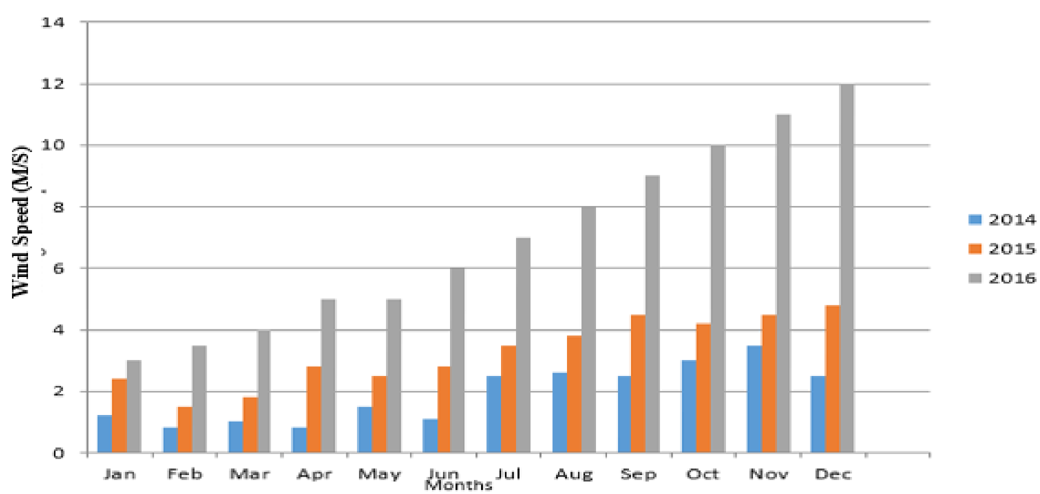

Figure 4.1: Monthly Average Wind Speed for 2014, 2015, 2016

Solar Radiation

Figure 4.2 depicts the comparison in the monthly mean global solar radiation for each year from 2014-2016. Standard deviation of 5.4, 1.9 and 0 w/m^{2,} the figures revealed that the month of June present the least global solar radiation in 2014 followed by the month of January 2015 and June in 2016. The average values of global solar radiation for these months are 15.8, 17. 8 and 0 w/m^2/day, respectively. This is not expected as these months fall within the dry season of the year when it is always not cloudy and dull as a result of there is no rainfall, this is because the observed values of solar radiation are higher during the dry season compared to the wet season. It has been observed in the distribution of the monthly amount of global solar radiation, which may be due to differences in the atmospheric circulation. Cloud cover, rainfall and relative humidity are the most important atmospheric phenomena limiting solar radiation at the earth surface. It was also observed that the regions with higher cloud density (for example humid regions) receive less solar radiation than the cloud-free climates (for example deserts). For any given location, solar radiation reaching the Earth's surface decreases with increasing cloud cover.The highest value of global solar radiation occurs in the month of November 2014, 2015 with mean value of 17.6 w/m^2/day and standard deviation of 2.9 w/m^2/day, 17.9 w/m^2/day, 2.1 w/m^2/day follows by the month of December 2016 with the average value of 0 w/m^2/day and standard deviation of 0 w/m^2/day. It can be inferred from the figure that many years of observed data are required to make a reasonable conclusion on the implementation of any solar power project as a result of wide variation in solar characteristic.

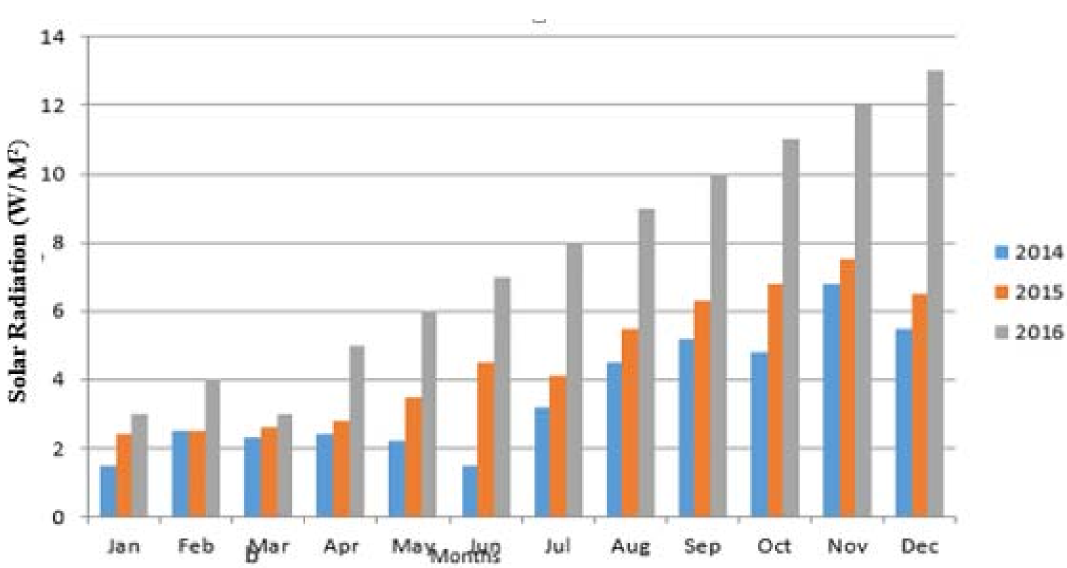

Figure 4.2: Monthly Average Solar Radiation for the Period of 2014, 2015, 2016

Minimum Temperature

The monthly data for the 3 year period of temperature was plotted against the month as shown in Figure 4.3. This was examined to select the minimum value of each month over the period. The plot of these minimum points deduced two minima. The first one occurred in April-May before the rainy season sets in 2014, 2015 while the second minimum temperature occurred around July during rainy season. 2016 gave an undulating form in the first three months followed by a gently increasing value that rose to a maximum in the month of May up to the month of December. The rains occurred between end of May and beginning of November which shows up as continuous drop in Temperature with a minimum between August and September. Looking closely at the behavior of the maximum points, several features could be observed. There is an isolated maximum of relative humidity (RH) occurring in February and a broader maximum in June-December. The first maximum of February is in harmattan season which often leads to condensation and observation of dew in the morning as a result of low temperature. The later maximum that occurred in September is due to high water content from rain and vaporization. As highlighted by Odjugo (2009; 2010). Literatures presents the change in temperature across Nigeria within this period, between 1901 and 1935 the temperature change was $0.50^{O}C$ ($28^{O}C$ –

28.5^{O}C) for the region; between 1936 and 1970 the temperature change was 0.50^{O}C (28.5^{O}C – 29^{O}C) and between 1971 and 2006 the temperature change was 0.50^{O}C (29^{O}C – 29.5^{O}C) and between 2007 and 2016 the temperature change was 0.50^{O}C (29.5^{O}C – 30^{O}C), all these show that there is an increase in temperature of (1.5^{O}C). December/January are months of severe hamattan when the Temperature is low and the Relative Humidity is also low. This is to say that the combination of low relative humidity and low temperature occurring simultaneously produce the hamattan season spell which is responsible for the severity of hamattan cold usually experienced. This implies in the remaining part of the year, the behaviors of Relative Humidity and Temperature are opposite to one another. This can be seen from the behaviors of Relative Humidity and Temperature in July-August when the Relative Humidity is high and Temperature is low without the feeling of the severity of the cold as in harmattan period. From the above, two separate seasons have been identified namely, Harmattan and Rainy seasons occurring between November and February, and between May and October respectively of the year. The third season is the Dry season occurring between February and April of the year. Using the parameters considered, in the harmattan season, both RH and T are low; in the Rainy season, RH is high and steady while T is low and for the dry season, the RH is rising while the T is dropping.

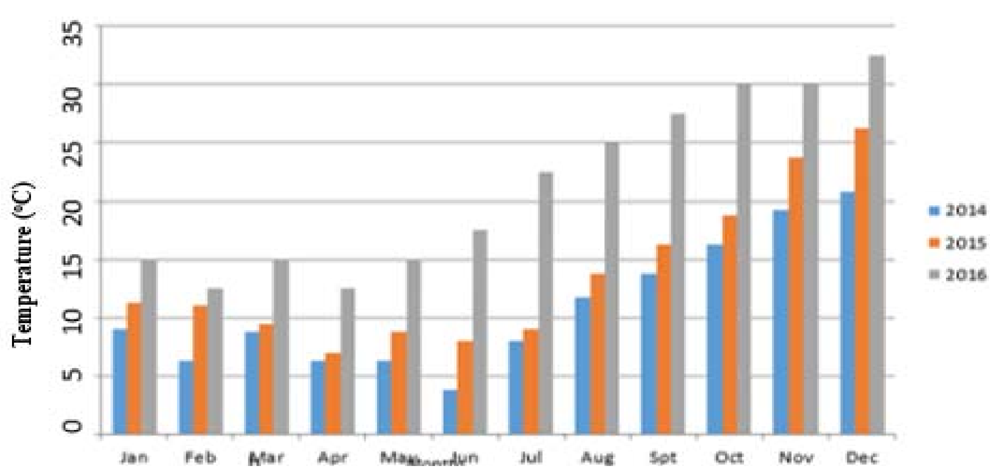

Figure 4.3: Minimum Temperature for the Period of 2014, 2015, 2016

Total Rainfall

The figure below presents monthly mean, median, maximum and minimum rainfalls in the city. Thus revealed that the rainy period in Birnin Kebbi is between April and October, with June, July, August and September as significant rainy months. The month of August has the highest magnitude of monthly rainfall with July, September and June in decreasing order, the total, yearly mean, maximum, minimum and standard deviation (SD) of the rainfall for all years (2014 – 2016). The table shows spatial distribution of the rainfall. From the table yearly total rainfall has a decreasing trend with the strongest downward magnitude in the group of 2015 – 2016. The lowest magnitude in downward trend was in the period of 2016. The same trends were observed for the yearly mean, median and yearly minimum rainfalls. These trends show that there is a decline in the magnitude of rainfall in the city. Also these results agree with literature such as Adelana*et al*. (2006). These downward trends in rainfall can be attributed to climate change as highlighted in Odjugo (2009; 2010).

Sequence of the rainfalls

Figures 4.4 present sequential values of the rainfalls in Birnin Kebbi. The figures apparently show decreasing trends in the rainfalls, the downward trends appearance of the yearly total, maximum, minimum and mean rainfalls. In all these cases the appearance of strongest decreasing trend occurred in monthly rainfall 2015, but 2016 show lowest decreasing as compared to 2015. While 2014 present appearance of slightly increasing trends in rainfall within the period (in the months of June, July, August and September), while 2014, 2015, 2016, some months presents neither increasing nor decreasing trends in rainfalls. These trends can be attributed to climate change, which manifest itself in the city as temperature increment and reduction in rainfall in the month of April, May, and October.

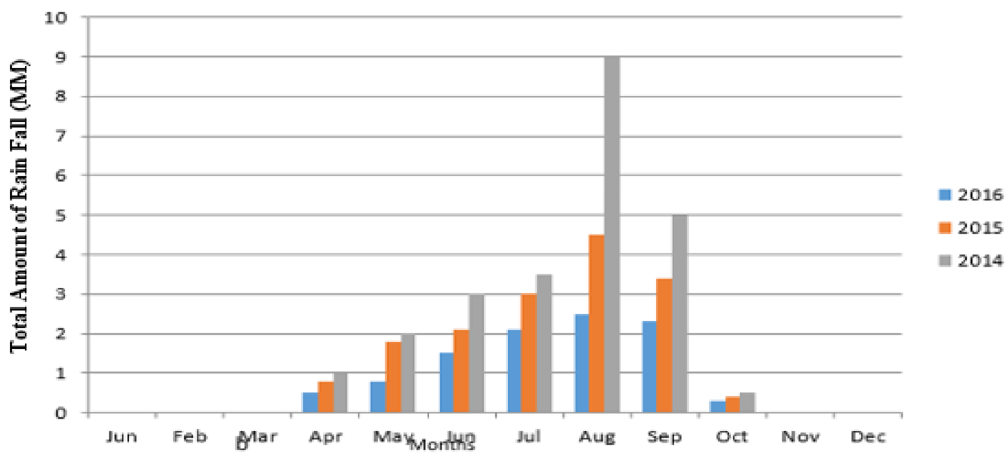

Figure 4.4: Total Amount of Rain Fall for the Period of 2014, 2015, 2016

Conclusion

This study investigate rainfall, temperature and solar radiation trend and variability at Birnin Kebbi metropolis, Kebbi State, Nigeria (*for what?*), using observations of air temperature (^{O}C) rainfall (mm) and solar radiation (w/m^2) for the period of 2014 -2016 (3years), It was observed that the distributions of the monthly average wind speed for the 3 three years are fairly similar, however the month of June present the least global solar radiation in 2014 followed by the month of January 2015 and June in 2016, the rainy period in Birnin Kebbi is mainly between April and October, with August and September as most occurring rainy months. The month of August has the highest magnitude of monthly rainfall with October and November in decreasing order. It conclude that there is variations in metrological parameters investigated in the land surface interface.

Acknowledgments

The researchers wants to thank Nigeria Meteorological Agency, Sir Ahmadu Bello international Airport Birnin Kebbi, kebbi state Nigeria, for making the data used in the study available.

References

A.C. Fabian (1994). Cooling Flows in Clusters of Galaxies, Annual review of astronomy and astrophysics, Volume 32, 1994, pp227318.

Adelana SMA, Peter I, Olasehinde P .I (2006). Quantitative Estimation of Groundwater Recharge

In Part of the Sokoto Basin, Nigeria. J. Environ. Hydrology. 14(5), 1-16

Budyko, M.I. (1969). “The effect of solar radiation variations on the climate of the earth.” Tellus 21 (5): 611-619. Doi:10.1111/j.2153-3490.1969.tb00466.x.

Bunting, A. H., Dennett, M. D., Eliston, J. and Milford, J. R. (1976). Rainfall trends in the West Africa Sahel. Q.J.R. Meteorological Society. 102, pp.56-64.

Easterling, D. R. (1997). Maximum and minimum temperature trends for the global. Science 277:
364–367.

Ewona, I. O and Udo, S. O (2008). Trend studies of some meteorological parameters in Calabar. *Nigerian Journal of Physics,* 20(2), 283-289

Ewona. I. O and Udo, S. O (2011). Climatic conditions of Calabar as typified by some meteorological parameters. *Global Journal of Pure and Applied Sciences,* 17(1), 81-86.

Ezber, Y., Sen, O.M., Kindap, T., and Karaca, M. (2007). Climatic effects of Urbanization in Istanbul: a statistical and modeling analysis. *Int. J. Climatology*, 27:667 – 679

Fan, Z., Brauning, A., Thomas, A., Li, J., and Cao, K. (2010). Spatial and temporal temperature trends on the Yunnan Plateau (Southwest China) during 1961–2004. International Journal Climatology. doi:10.1002/joc.2214.

Folland, C. K., Palmer, T. N. and Parker, D. E. (1986). Sahel rainfall and worldwide sea temperatures 1901-85; Observational, modelling. And simulation studies. Nature, 320, pp. 602-607.

Gil-Alana, L.A. (2008). Warming break trends and fractional integration in the northern, southern, and global temperature anomaly series. *J. Atmos. Oceanic Technology*, 25 (4), 570 – 578.

Hasanean, H. M. (2001). Fluctuations of surface air temperature in the east Mediterranean. Theoretical Apply Climatology 68 (1–2):75–87.

Karabulut, M., Gurbuz, M. and Korkmaz, H. (2008). Precipitation and temperature trend analyses in Samsun. *Journal .Int. Environmental Application and Science*, 3(5), 399 – 408.

IPCC, (2002). *Climate Change 2001*: *The Scientific basis.* Cambridge University Press.

IPCC (2007). Climate change and world foodsecurity: a new assessment, Global Environmental Change 9:S51–S67.

Iqbal, M. (*1983*). An Introduction to Solar Radiation. Academic ... TITLE: Using Earth's Moon

As*a* Test bed for Quantifying the Effect of the Terrestrial atmosphere, pp231.

Jain, S.K and Kumar, V. (2012). Trend analysis of rainfall and temperature data for India.

Current Science, 102(1), 37 – 49.

Jones, P.D., Parker, D.E., Osborn, T.J., and Briffa, K.R. (2013). Global and hemispheric

Temperature anomalies – land and marine instrumental records. In *Trends: A compendium of Data on Global Change*, Doi: 10.3334/CDIA/cli.002.

Koren et al (2009). Quantifying the Cost of Climate Change Impact in Nigeria:

Karl, T. R., Janes, P. D., Knight, R. W., Kukla, J.,Plummer, N., Razuvayev, V., Gallo, K. P.,

Lindesay, J., Charlson, R. J. and Peterson, T. C. (1993). Asymmetric trends of daily maximum and minimum temperatures: empirical evidence and possible causes. Bull Am Math Soc 74:1007–1023.

Liu X., Yin, Z., Shao, X. and Qin, N. (2006). Temporal trends and variability of daily maximum And minimum, extreme temperature events, and growing season length over the eastern and central Tibetan Plateau, during 1961-2003. *Journal of Geophysical Research*, 111, D 19109.

Meissner K, Weaver A, Matthews H, Cox P (2003). The role of land surface dynamics in glacial Inception: a study with the UVic earth system model. ClimDyn 21:515–537

N.I Obot, et al (2010). Evaluation of Rainfall Trends in Nigeria for 30 Years, international journal of the physical sciences Vol. 5(14), ISSN 1992- 1950@2010 Academic Journals.

Nilgün Kubilay(2003). Regional simulation of aerosol impacts on precipitation during the East Asian summer monsoon Longtao Wu, 1,2 Hui Su,2 and Jonathan H. Jiang2 https://doi.org/10.1029/2003JD003798.

Odekunle, T. O. (2001). The magnitude – Frequency Characteristic of Rainfall in Ondo, SouthwesternNigeria. Ife Research Publications in Geography, Vol. 8, pp. 36 – 41.

Odjugo P.A (2009). Quantifying the cost of climate change impact in Nigeria: Emphasis on wind and Rainstorm. Jour. Hum. Ecology, 28(2), 93- 101.

Odjugo, Peter A O (2010). Regional evidence of climate change in Nigeria. Journal of Geography and Regional Planning Vol. 3(6), pp. 142-150, June. Available online at http://www.academicjournals.org/JGRP.

Olofintoye, O.O. and Sule, B.F (2010). Impact of global warming on the rainfall and temperature in the Niger Delta of Nigeria. *USEP Journal of Research Information and Civil Engineering*, 7(2), 33 – 48.

Ologunorisa, E. T. (2004). Rainfall Flood Prediction in the Niger Delta, Nigeria (Abstract), International Conference in Hydrology: Science and Practice for the 21st Century, London, U.K.

Rebetez, M. and Reinhard, M. (2008). Monthly air temperature trends in Switzerland 1901 – 2000 and 1975 – 2004. *Theoretical and Applied Climatology*, 91:27 – 34.

Russak, V. (1990). “Trends radiation, cloudiness and atmospheric transparency during recent Decades in Estonia”. Tellus B42 (2): 206. “The physical Basis for Seeding Clouds”. Atmospheric Inc. 1996.Retrieved 2008-04-03.

Snyder, P. K., Delire, C. and Foley, J. A. (2004).Evaluating the influence of different vegetation Biomes on the global climate. ClimDyn 23:279–302.

Turkes M, Sumer UM, Demir I (2002). Re-evaluation of trends and changes in mean, maximum And minimum temperatures of Turkey for the period1929–1999. Int. Journal Climatology 22:947–977.

Turkes, M., Sumer, U.M. and Demir, I. (2002). Re-evaluation of trends and changes in Mean, Maximum and Minimum temperatures of Turkey for the period 1929 – 1999. *Int. J. Climatology*, 22, 947 – 977, DOI: 10.1002/joc.777.

Ustaoglu, B. (2012). Trend analysis of annual mean temperature data using Mann-Kedall rank Correlation test in Catalca – Kocaeli Peninsula, North West of Turkey for the period of 1970 – 2011. *IBAC*, 2, 276 – 287.

Walker, J. and Kekins, N. (1997).Wind Energy Technology. John Wiley and Sons, Ltd Wind Energy Technology1st EditionISBN-13: 978-0471960447
ISBN-10: 0471960446.

Zekai S. (2008). Atmosphere, Environment, Climate Change and Renewable Energy Author: ISBN 978-1-84800-134-3.