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Trend analysis of temperature and wind speed characteristics over Fidii area of Makurdi, Benue State, Nigeria

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ABSTRACT

The study analysed trend in temperature and wind speed characteristics over Fidii area of Makurdi Local Government Area of Benue State. Temperature and wind speed data for Makurdi synoptic weather station for a period 30 years (1986 and 2015) were acquired from Nigerian Meteorological Agency, Oshodi, Lagos. Least Square Regression model was used to analyse trend, while Student's 't' Test statistics was to determine the significance of the trends at 0.05 degree of confidence. Mean, standard deviation and coefficient of variation were also employed in data analysis. The result shows that the variation in mean minimum, maximum and mean

temperatures over Fiidi area of Makurdi indicates slight negative trends which is not significant at 0.05 confidence level. The result further shows that temperatures in Makurdi have periodicity of ten (10) years which means that Makurdi usually go through cooling and warming phases in cyclic pattern of ten years with maximum temperatures currently upward oscillation (warming phase) after a downward oscillation of just six years instead of the usual 10-year periodicity. The result generally showed that wind speed in Fiidi, Makurdi varied seasonally during the study period with the months of December – April which constitutes dry season in Makurdi having high wind speed with the highest wind speed of 5.78m/s occurring in the month of April, while the lowest wind speed of 3.52m/s on average occurred in the month of October. Annually, result generally indicates a sharp declining trend in the wind speed in the study area during period with yearly decreasing rate of 0.0485m/s. Wind speed showed greater degree of variability than temperature characteristics. Consequently, the study recommends tree planting so as to ensure moderate temperature that would enhance physiological comfort of the inhabitants.

Key Words: Temperature, wind speed, Trend and Periodicity

1. INTRODUCTION

Wind and temperature are among the weather and climate elements with profound impact human activities and the environment. Consequently, the knowledge of variability and trends of these climate elements on temporal and spatial scales is important to understanding the nature of different climate systems and their impact on the environment and society (Oguntunde, 2012). For instance, temperature and surface wind speeds, among other meteorological variables, influence the hydrological cycle through evaporation and crop reference evapotranspiration (Rayner, 2007). Thus, understanding of the role of temperature and wind in surface flux is important for surface energy balance estimations (Monahan, 2006; Rayner, 2007). This is very crucial because heat and moisture are transported by winds; converging and diverging winds initiate convection, while near-surface ocean currents are forced by winds, and winds and temperature play a large role in air-sea interaction and gas Fluxes (Capps and Zender, 2008).

The need to investigate wind speed and temperatures is further underscored by the fact that winds and heat are important in atmospheric modelling and large scale model projections of climate change. This follows that temperature and wind are important variable for several processes and are critical in integrated resource management planning. Therefore, it is desirable that the patterns of wind speed and temperature changes over months and years be investigated and described.

In Fiidi area of Makurdi town, just like in other parts of Nigeria, the variation in wind speed, which is an important meteorological factor in characterizing the inevitable climate change, have not received desired attention from the available literature. More importantly, the available literatureshave show that current researches particularly on wind speed now mainly concentrate on regional or sub-regional near-surface wind speed change (McVicar et al. 2012). Meanwhile, there are evidences that changes in temperature and wind speed at local (small spatial coverage) have significant impact on society and environment especially urban areas. In view of various effects of temperature and wind in different regions, it is necessary to study the trend in temperature and wind speed changes. The only recent related work carried out by Mage, Agber and Nwoye (2017), is limited in term of temporal coverage as it studied temperature variability, intensity of wind speed and visibility during harmattan in Makurdi between 2001 and 2011 (11 years), which is not sufficient to establish reliable trend. The work was also restricted to dry harmattan months of dry season. Also in Makurdi, as commercial and industrialization continues to develop and emissions of air pollutants are growing, there is lack of information or data on the growing temperature and wind speed behaviours especially over months, seasons and years in Makurdi urban areas including Fidii.

However it appears temperatures are increasing while wind speed seems to be on a decreasing trend. Meanwhile, the declining of the wind speed does not favour the diffusion of pollutants in urban atmosphere. Consequently, adequate knowledge on the trends of these weather and climate variables is fundamental to planning and policy in urban development especially for human comfort. In the same vein, trend analysis of ambient air temperature and wind speed are fundamental in assessing environmental heat stress on the health of a given population. Therefore, accurate quantifications of recent trends in temperature and wind speed at local scales are needed given the fact that broad-scale analyses may mask considerable spatial and temporal variation in climatic trends. Data on local mean air temperature and wind speed are useful to develop an appropriate response to increase in temperature and heat exposure and to reduce uncertainties about future climate changes due to greenhouse gas emissions.

This study therefore, seeks to analyse of temperature and wind speed trends in Fidii Ward/Area of Makurdi Local Government Area of Benue State.

2. MATERIAL AND METHODS

Study Area

The study area is Fidii area of Makurdi Local Government Area of Benue State. However description will cover the whole of Makurdi especially the township. Makurdi town lies between Latitude 7^0 45'50"N and Longitude $8^0$32'10"E and is located within the floodplain of the lower River Benue valley (Figure 1).

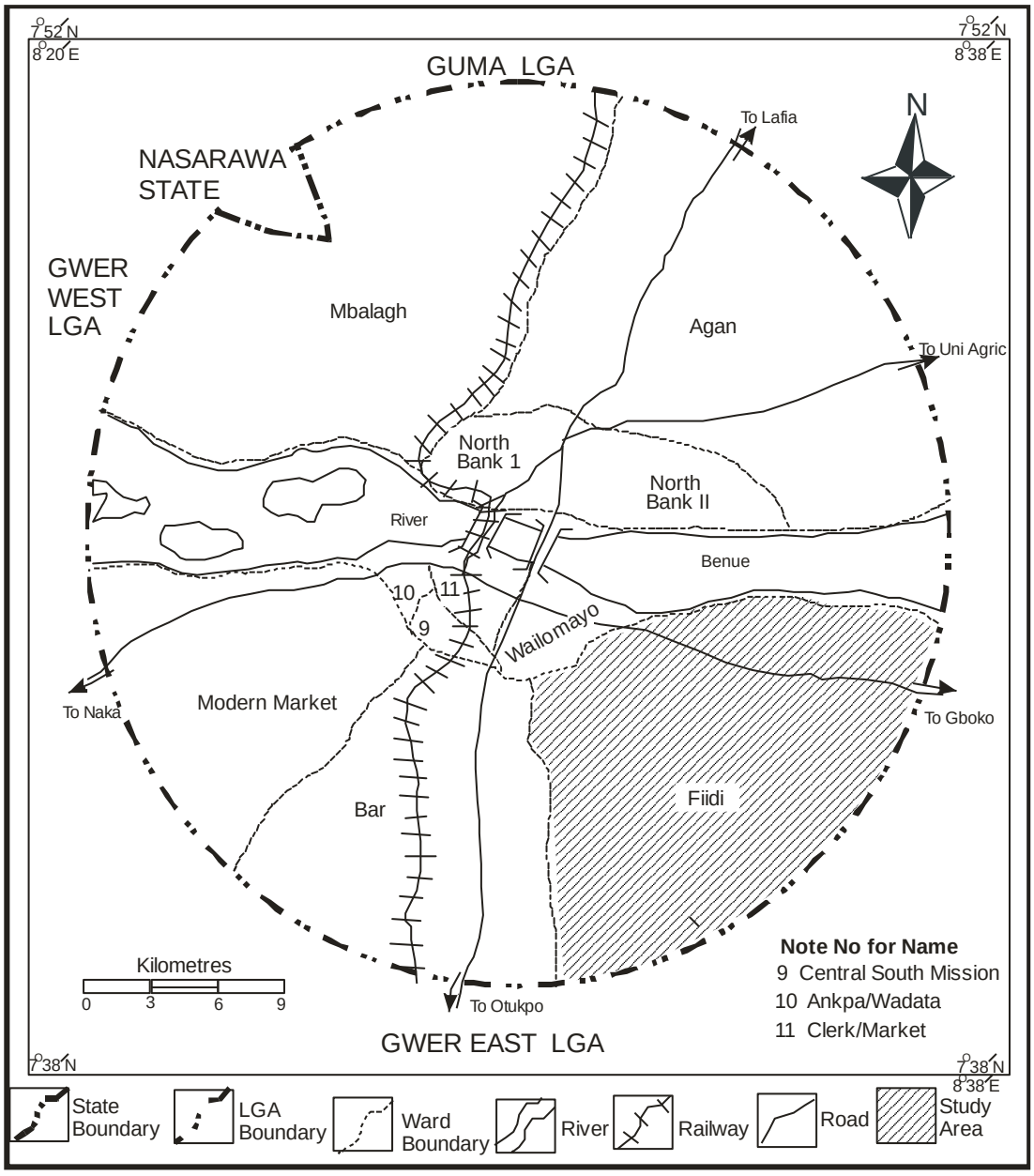

Figure 1.2: Map of Makurdi Local Government Area Showing Study Area
Source : Ministry of Lands and Survey Makurdi

The topography of the study area is generally low lying (averaging 100m - 250m) and gently undulating. Due to the general low relief, sizeable portion of Makurdi is waterlogged and flooded during heavy rainstorms including Fiidi area of the town. Makurdi is drained principally by river Benue which divides it into Makurdi north and south with the banks connected by two bridges other minor rivers that drain Makurdi town and empty their water in the river Benue include Idye, Genebe, Urudu, Kpege and Kereke rivers.

Makurdi is basically the tropical wet and dry climate. The area experiences a mean temperature of 28°c while mean monthly temperature values indicate that the coolest and hottest months are December (26^0C) and March (31^0C) respectively (Tyubee, 2008). Its relative humidity fluctuates with seasons, reaching its means monthly peak of about 92% in the rainy season. Rainfall, which is dominantly originated from southwest monsoon and synoptic disturbances, has mean annual rainfall total of 1190mm and annual

rainfall total ranging between 775mm and 1792mm. The vegetation of Makurdi is savannah type made of trees and grasses, however, urbanization has significantly changed the vegetation cover though natural vegetation can still be found at the out sketches of the town and few areas within the town.

Methods

The data on monthly temperature (maximum, minimum and mean) and wind speed for Makurdi synoptic weather station located at Fiidi area were collected for a period 30 years (1986 and 2015). The data were acquired from Nigerian Meteorological Agency Operational headquarters, Oshodi, Lagos.

Least Regression Model was used to analyse annual fluctuations and trends in temperature and wind speed variables. While Student's 't' Test was used to test the significance of the trend at 0.05 confidence level. The Pearson's Product Moment Correlation Analysis (PPMCA) was used to determine the relationship that exists between temperature characteristics and wind speed at 0.05 degree of confidence. Also, mean, standard deviation and coefficient of variation was computed were all employed in data analysis. These analyses were carried out with the aid of MS Excel and SPSS version 20.

3. RESULTS

Annual Variation in Temperature over Fiidi, Makurdi

The result of the variation in mean minimum temperature over Fiidi area of Makurdi is presented in Figure 2. The result indicates slight negative trend which is not significant at 0.05 confidence level. This suggests that statistically, there is no trend in the time series during the study period. The analysis of the 3-years moving average indicates two major downward and one upward oscillations. The downward oscillations occurred from 1988 and 2008 – 2015, while the upward oscillation occurred between 1998 – 2008. This implies that mean minimum temperature fluctuates in 10-years cycle within the last three decades.

The result further shows that the lowest and highest mean minimum temperature values of 21.6°c and 23.4°C occurred in 2008 and 2004 respectively. In the same vein, mean minimum temperature averages around 22.5°C during the study period with standard deviation and Coefficient of Variation (CV) of 0.484 and 2.15% respectively. The low values of standard deviation and coefficient of variation means that the temperature regime in the last 30 years in Makurdi has been relatively stable. The relative stability in temperature regime in Makurdi is very important in plan especially in the face of global warming. This also suggests that the present warmer condition currently being experienced in Makurdi particularly the in Makurdi urban area will likely be followed by cooler condition in the next 3-5 years.

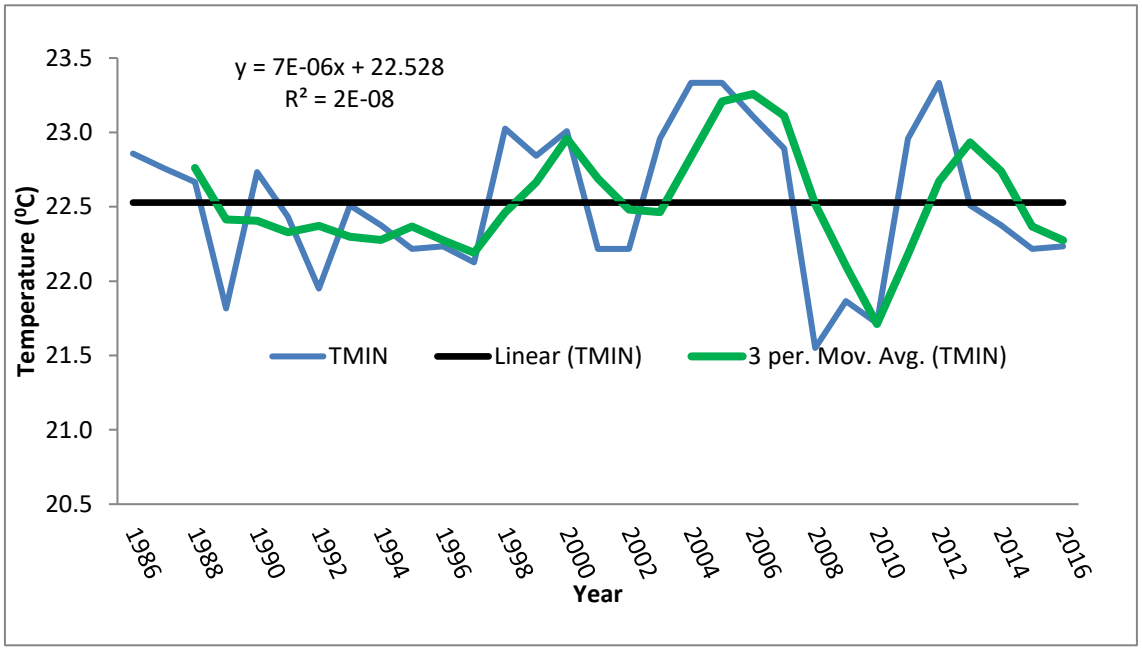

Figure 2: Annual Variation in Minimum Temperature over Fiidi, Makurdi (1986-2016)

Similarly, the result of the analysis of maximum temperature is presented in figure 3. The result generally showed a declining trend at the rate of 0.0081% per year. Again, the decreasing trend is not significant at 0.05 degree of confidence which suggests that

the downward trend occurred by chance statistically. This therefore gives room for an upward swing in maximum temperatures. The 5 – year moving average indicates one downward and one upward oscillation with the downward swing occurring between 2005 and 2014, while the upward oscillation earlier occurred between 1995 and 2005 that is about 10-years cycle which is the same with the periodicity of minimum temperature. This suggests that temperatures in an Fiidi and indeed Makurdi rises and falls in 10-years cycles which is therefore critical for planning. The result further revealed that the average mean maximum temperature during the period is 33.4°C, while standard deviation and coefficient of variation were 0.36 and 1.07% respectively. Just like means minimum temperature, mean maximum temperature deviated minimally from the mean which shows relative stability in temperatures in Makurdi in the last three decades.

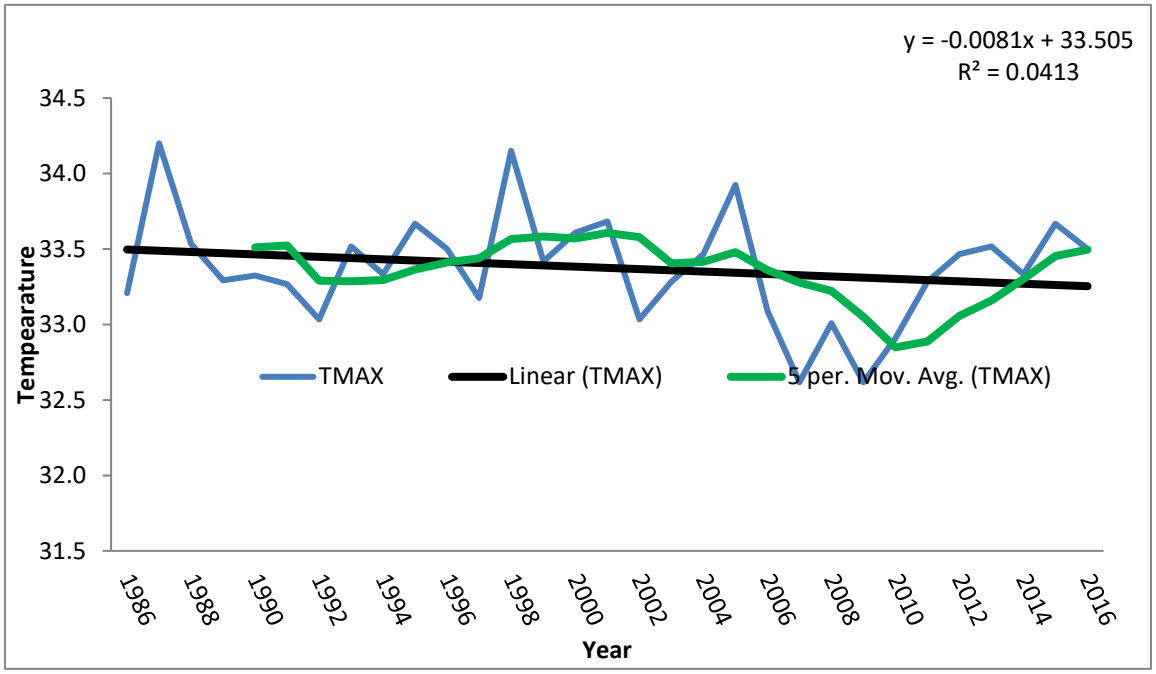

Figure 3: Annual Variation in Maximum Temperature over Fiidi, Makurdi (1986-2016)

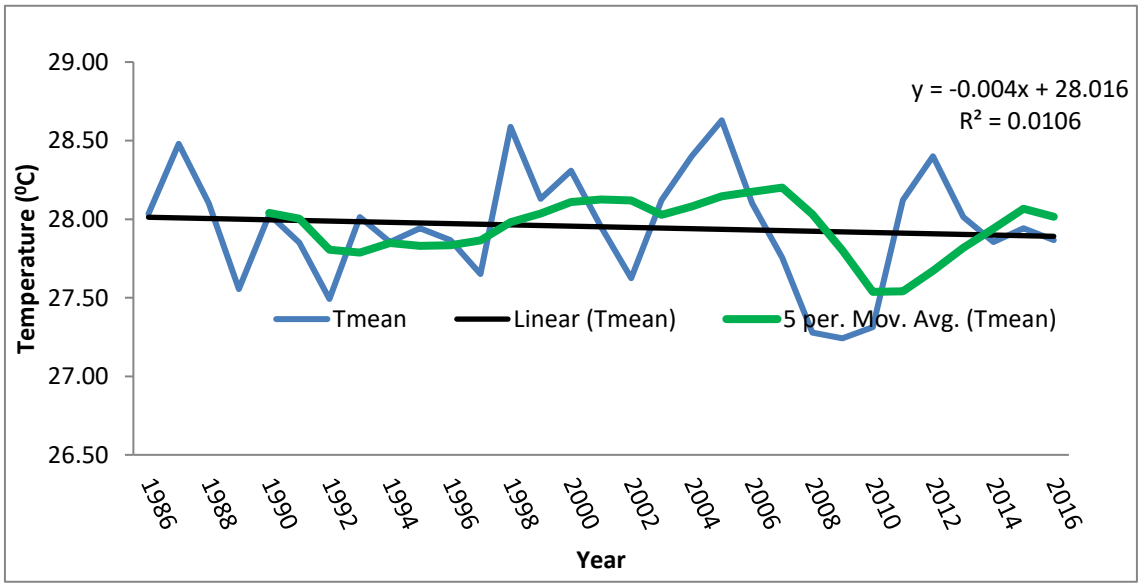

Figure 4: Annual Variation in Mean Temperature over Fiidi, Makurdi (1986-2016)

Likewise, the result of the mean temperature is presented in Figure 4. The result equally showed slightly declining trend just like minimum and maximum temperatures. This means that mean temperature decline at the rate of 0.004°C annually. However, since this decline is not significant statistically at 0.05 confidence level, there is a tendency for the decreasing trend to be reversed

especially in view of the current global warming. Furthermore, the result shows that average mean temperature for the study period is 27.95°C, while standard deviation from this mean and the coefficient of variation were found to be 0.35 and 1.25% respectively. From the result is clear that mean temperature in Makurdi area temperature in Makurdi area varied minimally between 1986 and 2016. In the same vain, the result revealed that the 5-year moving average showed three oscillations, two downward swings and one upward swing. The downward oscillations occurred from 1988 – 1998 and 2008 – 2014, while the upward oscillation occurred between 1988 and 2008.

This result therefore demonstrated that temperatures in Makurdi have periodicity of ten (10) years which means that Makurdi usually go through cooling and warming phases in cyclic pattern of ten years. However, the result of the mean temperature showed that the last downward phase only lasted for six (6) years that is between 2008 – 2014 and then assumed an upward oscillation which is on-going which may be response for the current warmer weather conditions being experienced in Makurdi and its environs.

Monthly and Seasonal Variation in Temperatures over Fiidi, Makurdi

The result, of the monthly and seasonal variation in minimum, maximum and mean temperature over Fiidi is presented in figure 5. The result showed that the mean maximum temperature are higher during dry season in the months of February, March and April with the higher mean maximum temperature of 37.3°C occurring in the month of March. On the other hand the mean maximum temperatures are lower during rainy season with the lowest mean maximum temperature of 30.0°C occurring in the month of August. Generally the result indicates that mean maximum temperature decreases gradually from the month of April to August before rising steadily to peak in the month of March.

In the same vein, the result showed that the mean monthly temperature followed the same pattern as monthly maximum temperature. The highest mean monthly temperatures of 31.50°c occurred in the month of March during dry season, while the lowest mean, mean monthly temperature for wet season of 26.40°C equally occurred in the month of August. However, the overall lowest mean temperature value of 26.25°C occurred in the month of December.

Unlike maximum temperature that rises steadily from August to peak in March, the mean monthly temperature rises steadily from August to November and then decline in December before assuming upward trend in the month of January and then continue rising to peak in the month of March.

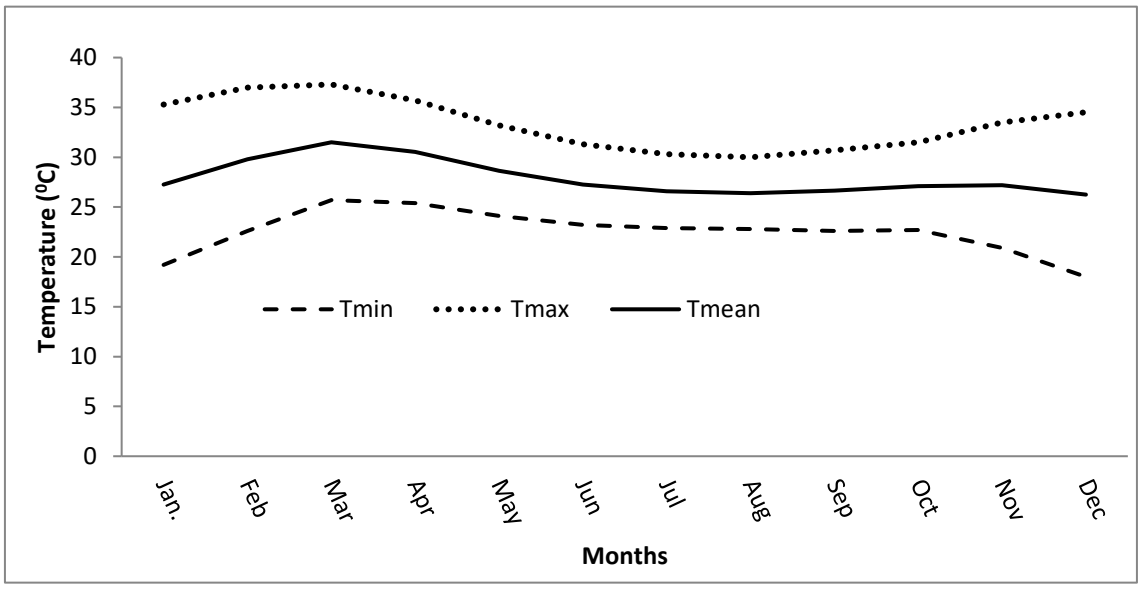

Figure 5: Monthly in Minimum, Maximum and Mean Temperatures over Fiidi, Makurdi (1986-2016)

Furthermore, the result of the mean minimum temperature generally followed the same pattern as maximum and mean temperatures. However, the highest and the lowest mean minimum temperature of 25.7% and 18.0% all occurred during dry season in the months of March and December. From these results its is clear that the month of March is the hottest or warmest month in Makurdi and perhaps its environs. The mean minimum temperatures decrease steadily from March through September and rose slight in October before decreasing to its lowest ebb in December. From the result, the temperature range is higher in during dry season.

Overall, maximum temperature rises during dry season, while mean and minimum temperatures decrease during the same season. All the temperature characteristics (mean, maximum and minimum) are relatively stable in the during rainy season than they are during dry season which suggests that temperatures during dry season showed wider variability as compared to rainy season. This might be connected to higher relative humidity in rainy season that moderate temperatures during wet season in the study area.

In terms of season and monthly variability, the result of this agree with the findings of Ogbonmwan, Ogbomida, Uwadia, Efegoma and Umoru (2016) in their study of "Analysis Of Trends in the Variability of Monthly Mean Minimum and Maximum Temperature and Relative Humidity in Benin City". They found that mean monthly temperature over Benin City was highest in March 2012 and lowest in August 2012 with average values of 28.29°C and 24.41°C respectively. This confirms that fact that the month of March and April are the warmest months in many parts of Nigeria.

On the other hand, the result of this study differs with the one of Olujumoke, Folorunso, Valerie and Christian (2016) in their study of "Descriptive analysis of rainfall and temperature trends over Akure, Nigeria", where they reported that an increasing temperature trend that is responsible a warmer environment, with consequences on human health amongst others at Akure, Ondo state, Nigeria.

Also Akinsanola and Ogunjobi (2014) in their "Analysis of Rainfall and Temperature Variability Over Nigeria" reported that there have been statistically significant increases in precipitation and air temperature in vast majority of the country and that analyses of long time trends and decadal trends in the time series further suggest a sequence of alternately decreasing and increasing trends in mean annual precipitation and air temperature in Nigeria between 1970 and 2000. This result is equally similar to the findings of this study.

Monthly and Seasonal Variability in Wind Speed

The result of the monthly and seasonal variation in wind speed during the study period is presented in figure 6. The result generally showed that wind speed in Fiidi, Makurdi varied seasonally during the study period. The months of December – April which constitutes dry season in Makurdi have high wind speed with the highest wind speed of 5.78m/s occurring in the month of April, while the lowest wind speed of 3.52m/s on average occurred in the month of October. The result further showed that wind speed is relatively uniform in the months of December, January, February, March and April, and then decreases sharply from the month of May to its lowest point in the month of October, before another sharp increase from November through December.

The observed high wind speed during dry season may be attributed to Hamattan winds. Also during dry season, bush burning is common in the study area, while vegetation especially tree leaves wither considerably which reduces vegetation cover thereby reducing friction and allow free flow of air which consequently increases wind velocity. Conversely, vegetation regenerate and become thicker during rainy season which tends to reduce wind velocity. High wind speed are necessary for the generation of wind energy.

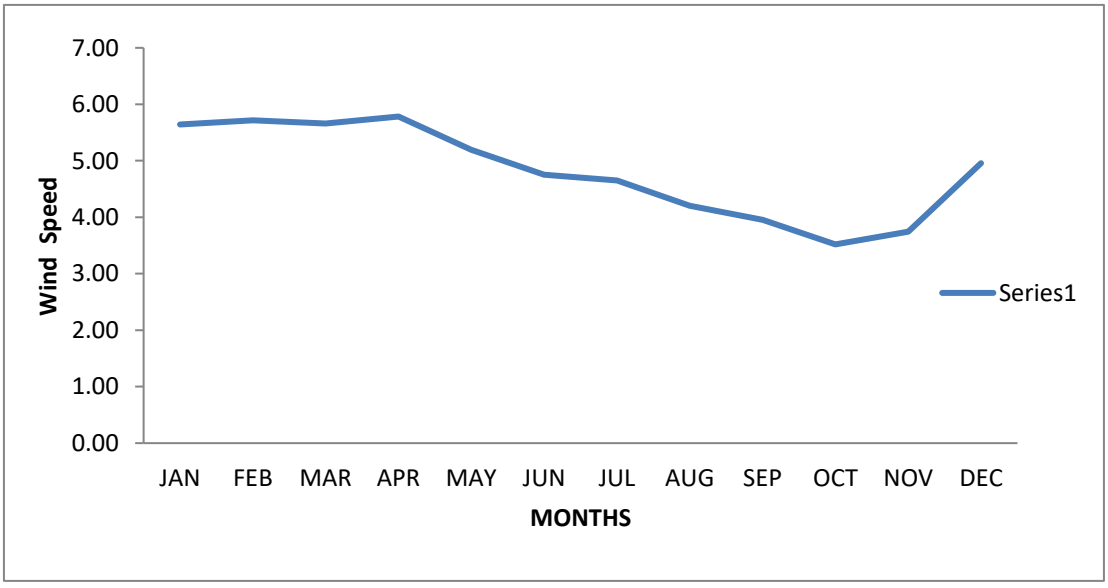

Figure 6: Monthly Wind Speed Variation over Fiidi, Makurdi (1986-2016)

Annual Variation in Wind Speed over Fiidi, Makurdi

The result of annual variations generally indicates a sharp declining trend in the wind speed in the study area during period with yearly decreasing rate of 0.0485m/s. The rate of decline is however not significant at 0.05 degree of confidence. The analysis of 5-year moving average showed one upward oscillation occurring between 1991 and 2001 and downward oscillation starting from 2001 – 2011 with periodicity of about 11 years each (Figure 7). The decreasing trend in wind speed over Fiidi, Makurdi can be attributed increase friction occasioned by increasing urban area that is characterized by high rise buildings.

The result further shows that the average wind speed during the study period is 4.82m/s with standard deviation from the mean and coefficient of variation of 1.47 and 30.54% respectively (Table 1). The relatively high coefficient of variation showed that wind speed varied considerably during the study period. What this also means is that the wind speed is not reliable and relatively difficult to predictable, hence, planning wind energy with is kind of unreliable and highly varied wind may create technical challenges.

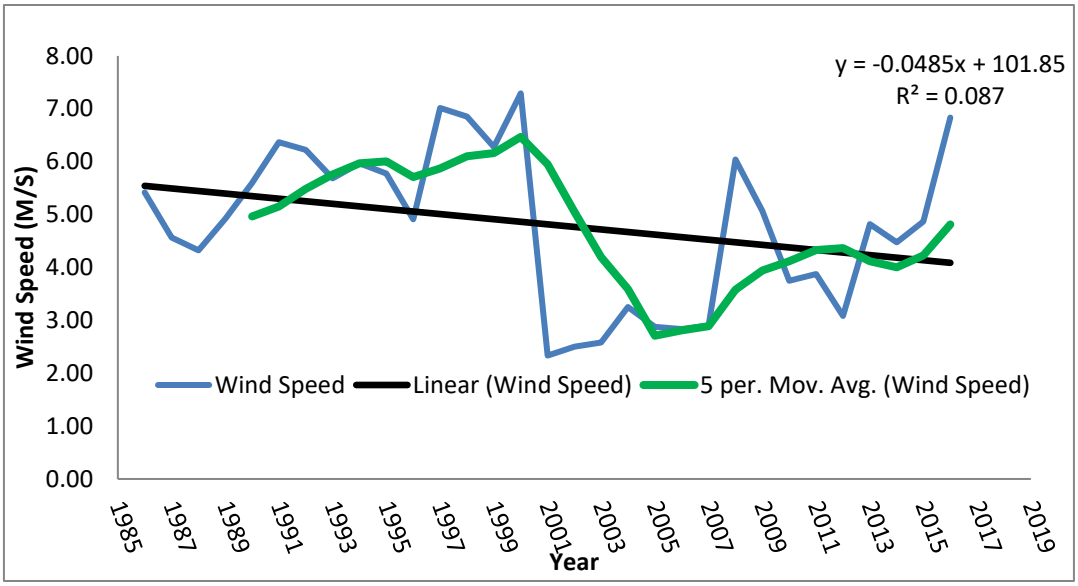

Figure 7: Annual Variation in Wind Speed over Fiidi, Makurdi (1986-2016)

Relation between Wind Speed and Temperature in Fiidi, Makurdi

The result of the correlation between average wind speed and temperature characteristics is presented in Table 4.2. The result showed that wind speed is negatively associated with mean minimum temperature (-0.304) and positively correlated with mean maximum (0.132) though there are all not significant at 0.05 confidence level. The relationship is very weak which suggests that wind speed minimally determines temperature regime in the study area and vis versa. The result further showed that minimum temperature is positively correlated with mean and maximum temperatures with correlation on coefficients of 0.379 and 0.877 respectively. Similarly maximum temperature is positively correlated with mean temperature (0.775). What this means is that temperature variables or characteristics are closely associated meaning one can determine the behaviour of others.

From the wind speed/temperature relationship, minimum temperatures and wins speed tends to influence each other as compared to other temperature characteristics. The result therefore suggests that the higher the wind speed, the lower the minimum temperature in the study area, while the reverse holds for other temperature variables.

Table 4.1: Summary of Wind Speed and Temperature Variables

Variable	WS	Tmin.	Tmax	Tmean
Average	4.82	22.5	33.4	27.95
Standard Deviation	1.470367	0.483845	0.356676	0.351898
Coefficient of Variation (CV)	30.53687	2.147755	1.068692	1.258961

Source: Computed from Temperature and Wind Speed Data from NiMet, Lagos

Table 4.2: Zero-order Correlation Analysis of Temperature and Wind Speed Variables

Variable	Wind Speed	TMin.	TMax.	TMean
Wind Speed	1	-.304	.132	.137
TMin.		1	.379*	.877*
TMax.			1	.775*
TMean				1

Source: Computed from Temperature and Wind Speed Data from NiMet, Lagos

Note:

Tmin is Minimum Temperature; Tmax is Maximum Temperature;
Tmean is Mean Temperature; and WS is Wind speed.

4. CONCLUSION

Based on the findings of the study, the following conclusions have been drawn: that there is weak correlation between wind speed and temperature characteristics in the study area. That both wind speed and temperature varied seasonally with dry season generally have higher temperatures and wind speed, while temperatures and wind speed are lower during wet months of the year. Also, the warmest month is March though the months of February and April are equally high. Wind speed showed greater degree of variability than temperature characteristics. Temperatures increases and decreases in 10-year cycle or periodicity in Fiidi and by extension in Makurdi and its environs.

In view of the serious challenges higher temperatures poses to human physiological comfort, food security, emergence of new diseases and biodiversity loss, planting of trees that can moderate temperatures is recommended.

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