Analysis of Trend and Variability of Temperature in Ebonyi State, South-eastern Nigeria, 1984-2015

Bridget Diagi[1], Vincent Weli[2]

Department of Geography and Environmental Management, University of Port Harcourt, Nigeria
Email:edeoli@yahoo.com
Department of Geography and Environmental Management, University of Port Harcourt, Nigeria
Email:welivinezi@yahoo.com

Abstract— *Temperature being one of the indicators of climate change has become one of the most important discussions of recent times. Changes in temperature influence a variety of processes directly or indirectly which cut across every aspect of man existences. This paper therefore examined the trend in temperature as tools of climate change over Ebonyi State, South-Eastern Nigeria, which is an area well known for crop agriculture. Temperature data covering a period of 31 years (1984-2015) were collected and analyzed using mean, moving average, standard deviation coefficient of variation and linear regression. Result revealed that there is a positive trend in temperature over the study period and that the area is getting warmer by 0.0037^{o}c annually, which is an Indication that Ebonyi State is experiencing a rise in air surface temperature. Since most of the inhabitants are dependent on economic activities that are temperature sensitive like farming, the study therefore recommends that measures should be taken by all stakeholders including the government, individuals and cooperate bodies to take the issue of climate variability serious in the study area in order to mitigate its impact in the long run.*

Keywords— Climate Change, Ebonyi, Trend, Temperature, Agriculture.

I. INTRODUCTION

Issues related to climate change and global warming arising from anthropogenic emission of greenhouse gases have emerge as one of the most important environmental issues in the past few decades (Singh et al., 2013). Human activities at present are altering the carbon cycle by adding more CO2 to the atmosphere and also by influencing the ability of natural sinks, like forests, to remove CO2 from the atmosphere. The emission of carbon dioxide comes from a variety of natural sources; but human-related emissions are responsible for the increase that has occurred in the atmosphere since the industrial revolution. Evidence has shown that the level of carbon dioxide in earth's atmosphere presently is higher than at any time in the last 800,000 years. For instance in 2014, global CO2 emissions were projected to increase by an additional 2.5% over the 2013 level (USNCDC, 2013). Other sources of these emissions include water vapour, chlorofluorocarbons (CFCs), methane, tropospheric ozone and nitrous oxide. These gases are released into the atmosphere due to human activities such as burning of fossil fuel, gas flaring and deforestation amongst others .These gases are termed greenhouse gases, because they act as the glass of a greenhouse or sunroom which is relatively transparent to solar radiation which is in short wavelength but absorbs and emits terrestrial radiation which is in long wavelength, and thereby increasing the temperature within the glass house or room. The continuous built up of greenhouse gases may induce changes in climatic system including increases in mean global temperatures. The global mean surface air temperature has risen by about 0.74°C from 1906 to 2005 and this rise has been attributed mostly to a rise in greenhouse gases (IPCC, 2007). Changes in temperature influence a variety of processes directly or indirectly for example the hydrological process. Temperature increases causes intensification of the hydrological cycle due to increase in evaporation and precipitation(Jain and Kumar, 2012; Tshiala et al., 2011) Temperature changes can also lead to changing patterns of precipitation, the spatial and temporal distribution of runoff, soil moisture, and groundwater reserves as well as increased frequency of drought and flood occurrences (Tshiala et al., 2011). Changing temperature patterns could also have effects on soil and plant growth characteristics since temperature and water content are important physical factors for plant growth especially in Ebonyi State were majority are engaged in one form of agriculture or another as their source of livelihood. Non-optimum levels of water and temperature conditions can strongly perturb plant development, especially at the early stages of growth such as seed germination and emergence (Tshiala et al., 2011). Changes in climate may also impact the water availability and water needs for agriculture. If temperature increases and more sporadic rainfall events result from global warming, this will increase the demand irrigation needs in the future. The increasing number of heat-related deaths worldwide over the last few decades have portrayed an alarming picture of the extreme weather

conditions and devastating impacts on human health to come if this warming continues unmitigated (CENR, 2008).Developing countries however have a challenge of inadequate information to tackle the inherent consequences that might result from the changes in temperature. Some of the measures put in place to tackle climate change such as mitigation, adaptation and vulnerability assessment may not yield valuable result if the extent to which these variables have varied is not known. This study therefore examines the trend and variability in temperature over Ebonyi State South- eastern Nigeria.

Area Description

The study area Ebonyi State, shown in fig. 1, is located in South-eastern part of Nigeria which lies approximately within latitudes 5° 40' and 6° 45' North and longitudes 7°30' and 8°30'East. The mean temperature range within the study area is usually between 27° to 30^0c over the year (Ogbuene, 2010). Temperature is highest from February to April and it is about 31^0c (Ogbodo, 2013). The soil is texturally clay loam, fairly to poorly drain with gravely subsoil in some locations especially the upland adjacent to lowland areas (Ekpe, Okpone, Ogbodo, & Nwite, 2005). Agriculture is a major industry in Ebonyi State, an estimated eighty-five per cent of the population earn their living from one form of agricultural activity (Ogbodo, 2013). The presence of large arable land, rivers and streams has made farming very attractive. Crops grown in the area include; rice, yam, cassava, cocoyam, groundnut, cowpea and vegetables. Livestock farming, especially the extensive system of rearing sheep, goats and native cattle, is also practiced by the people. Fishing activities are predominant in the southern zone of the State.

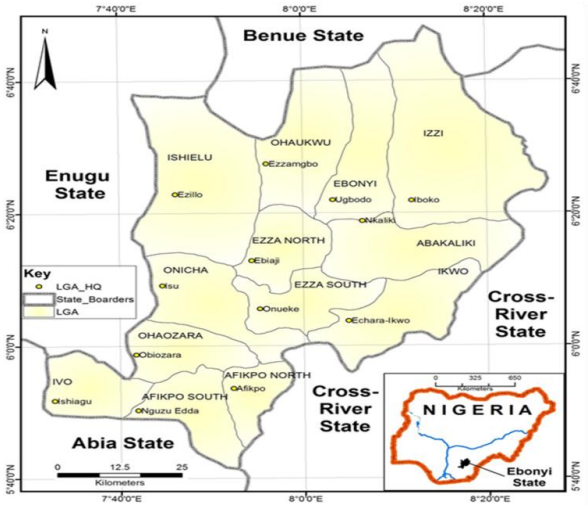

FIGURE 1: THE STUDY AREA: EBONYI STATE, SOUTH- EASTERN NIGERIA.

II. MATERIAL AND METHOD

2.1 Data Used

Mean monthly maximum and minimum temperature covering 31 years period for the study area were obtained from the Nigerian Meteorological Agency (NIMET), Oshodi, Lagos, The temperature data was transformed to mean monthly temperature and furthermore to annual.

2.2 Data Analysis

Data analysis was carried out from the temperature data obtained and analyzed for trend and fluctuation using mean, moving averages, Standard deviation, coefficient of variation and linear regression. Their expressions are as follows

The mean statistic is used in the study to determine the differences in the decadal means temperature as a way of showing decadal variation between 1984 and 2015 and also for the calculation of temperature anomaly i.e. deviation (d =$\boldsymbol{x} - \bar{x}$)

$$x = \frac{\sum_{i=1}^{n} xi}{n} \quad (1)$$

Where i runs from 1 to n; x, the temperature or rainfall values, and n, the number of years.

Moving average is a smoothing method that is needed to check out some up and down i.e. in finding trend that might exit in data as trends tend to be obscured by the random errors. The simplest way of smoothing a time series data is to use a moving average. An average value is computed by using only a specified set of values. In this study, a 10-year moving average is used.

The 10- years moving average is written as:

$$\frac{y_1 + y_2 + y_3 + y_4 \ldots . y_{10}}{n} \tag{2}$$

Where n is 10 years order and y the variable in this case temperature

Standard deviation is one of the simplest ways of measuring climate variability by using the standard deviation estimator in measuring dispersion. It is used in this study to show the absolute variability in temperature from 1984 to 2015. Sample standard deviation S_x is given as

$$sx = \sqrt{\sum \frac{xi - \overline{x)2}}{n-1}} \tag{3}$$

where Sx= the estimator of the standard deviation σx of a climate variable X

It is not easy to interpret the standard deviation as a measure of dispersion on its own. This is because a small value for standard deviation shows that the dispersion of the dataset is low. Nevertheless, the magnitude of these values depends on what is being analysed. Therefore, a method to overcome this difficulty of interpreting the standard deviation is to take into account the value of the mean of the data and employ the use of coefficient of variation. It is used in this study to show the relative variability of temperature over time. The coefficient of variation, Vx, is a relative measure of variability and is defined as follows (Waller, 2008):

$$Vx \frac{Sx}{\overline{x}} \tag{4}$$

The least squares regression is used to model the trends in temperature data over the 31 years period. The result helps to determine the overall average rates of change in trends of annual temperature in the study area.

The equation for least square regression is

$$y = a + bx \tag{5}$$

Where

$$b = \frac{n\sum xy - (\sum x)(\sum y)}{n\sum x^2 - (\sum x)^2} \tag{6}$$

and

$$a = \frac{\sum y}{n} - \frac{b\sum x}{n} = \bar{y} - b\bar{x} \tag{7}$$

a is the intercept; b the regression coefficient or slope;
y =the temperature values (dependent variable);
x=the time in years ;(independent variable)
$\bar{x}$ = the mean time; and
$\bar{y}$= the mean temperature value.

III. RESULT AND DISCUSSION

The results obtained for the study as well as its discussion are presented under this section. 4.1 Descriptive statistics and Variation in Temperature

Fig. 2 shows the relative variability of average temperature over time measured by standard deviation. It exhibits a steady ups and down indicating variability within the study period. Absolute variability of average temperature depicted in fig. 3 also exhibits a similar behavior with relative variability.

Three decades are considered to observe variability over time in this study as shown in Table 1.Which indicates significant variability in mean temperature. There was a significant increase between 1984-1993 and 1994-2003; while the decade between 2004 and 2013 experienced a slight increase over the period between 1984-1993 .Both absolute variability and relative variability increased steadily throughout the three decades over the study period.

TABLE 1
TEMPERATURE VARIABILITY FROM SIMPLE STATISTIC METHODS

climate variable	Statistical tool	1984-1993	1994-2003	2004-2013	2014-2015
Average temperature (℃)	Mean	27.32	27.50	27.40	27.30
	Standard Deviation	5.08	5.14	5.16	4.98
	Coefficient of variation (%)	18.61	18.69	18.82	18.25

Fig. 4 represents the anomalies of air temperature experienced in Ebonyi State using 1984-2015 mean. Here mean temperature ranged between 0.5℃ colder and 1.0℃ warmer than the baseline temperature of 27.4℃ .Fig. 4 shows that more areas are getting warmer at a higher rate than it is cooling. The highest positive anomaly recorded was in 2010 which gave an indication of the most probable warmest year in the period under study with surface air temperature of 1.0℃ in and is followed by 0.8℃ in 1998. Generally there is an indication of increasing warmer years which agrees with global temperature trend (IPCC, 2007) as well as Nigeria trend (Odjugo, 2010).

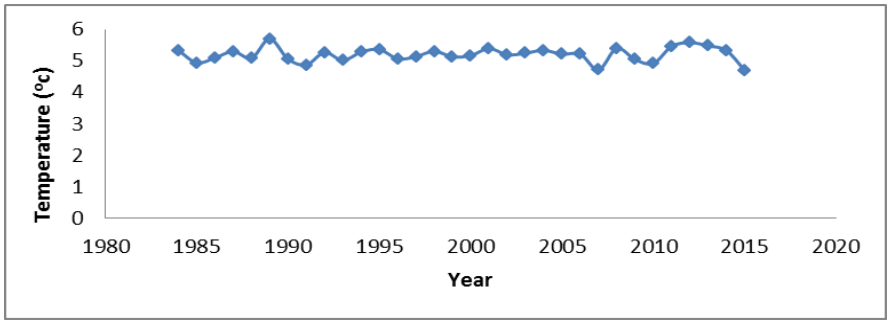

FIG. 2: STANDARD DEVIATION OF AVERAGE TEMPERATURE

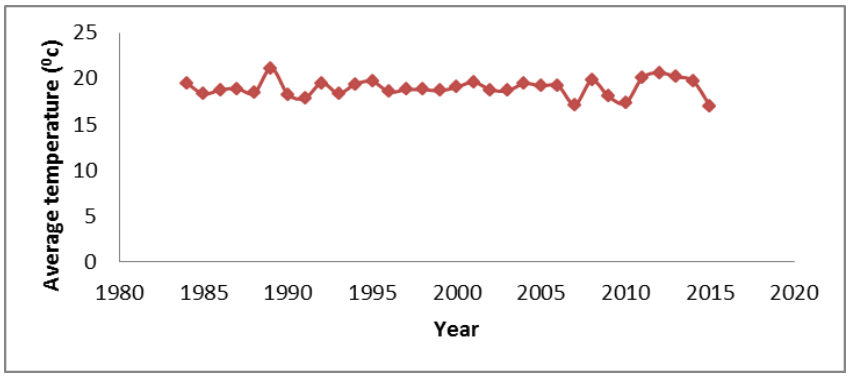

FIG. 3: COEFFICIENT OF VARIATION OF AVERAGE TEMPERATURE

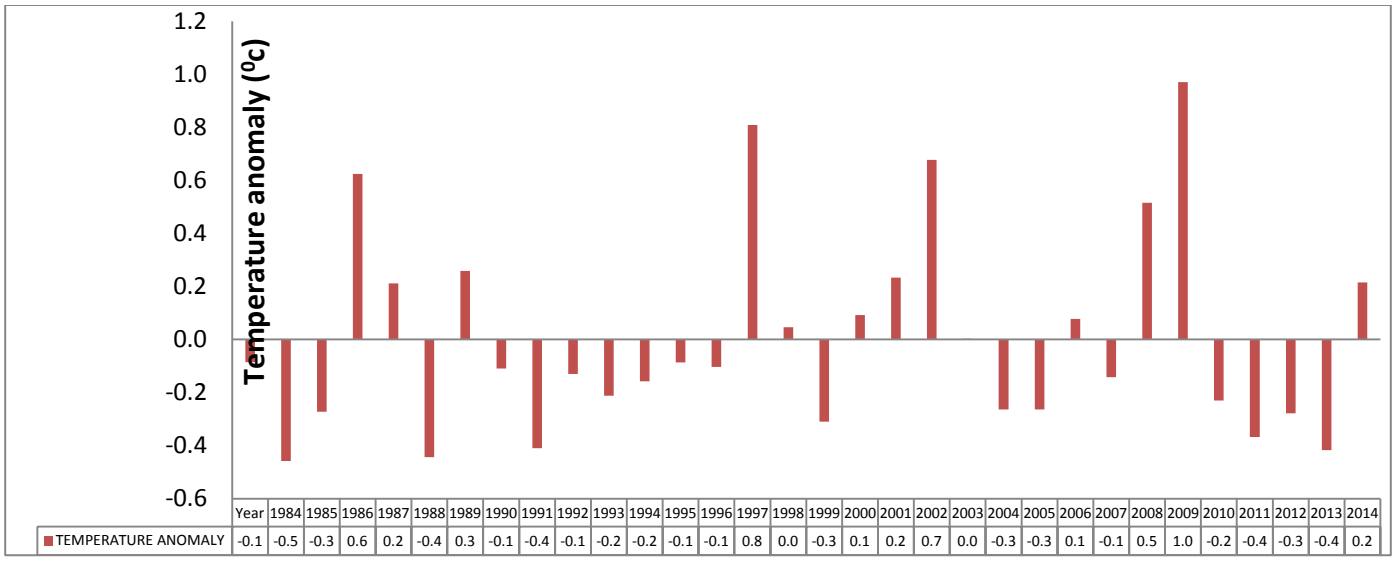

FIG. 4: TEMPERATURE ANOMALY (1984-2015)

Trend Analysis of Annual Temperature

The temporal air temperature trend exhibits a steady increase with some fluctuations over the period. Generally, the overall trend is upwards. The highest temperature recorded over this period was in 2010. After the application of the 10-years moving averages to filter out the erratic fluctuations for temperature observation, with few peaks and depression left annual temperature trend lines were fitted (fig. 5).

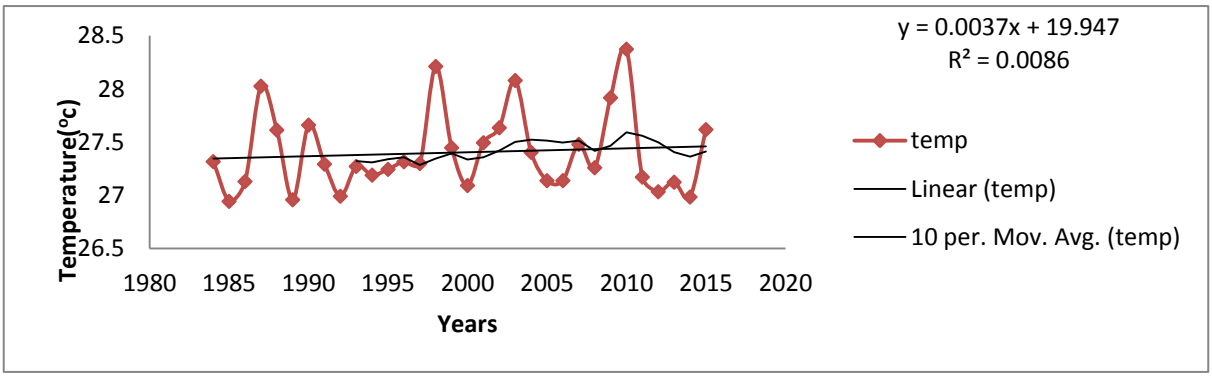

FIG. 5: TRENDS OF MEAN ANNUAL TEMPERATURE FOR EBONYI STATE

Thereafter, the linear regression was applied to highlight the general tendency, intercepts, slopes and regression lines were generated. The result generated is shown in Table two and as graphs in fig. 5. Results revealed that temperature possess an upward trend. This means that the area is warming by 0.0037°c per annum. Though the annual rate of increase in mean temperature (0.0037°c) appears insignificant but has implication for other element of weather and climate for instance rainfall.

TABLE 2
TRENDS IN MEAN TEMPERATURE FOR EBONYI STATE

Climate variable	period	Regression line equation
Mean temperature	1984-2015	Y= 19.947+0.0037x

This increase in mean annual temperatures will make the area even hotter than before. This would bring about increase in evapotranspiration if wet surfaces exist (and by extension other component of the ecosystem such as vegetation, agriculture,

water-bodies. This is because as climate is caused to change, other components of the earth atmosphere system might respond to influences exerted on them by these changes. NEST (2003) provided indicators that can be used to assess the evidence of climate change in a region to include increasing temperature. Others includes increasing evapotranspiration, decreasing rainfall amount in the continental interiors, increasing rainfall in the coastal areas, increasing disruption in climate patterns and increasing frequency and intensity of unusual or extreme weather related events such as; thunderstorms, lightning, landslides, floods, droughts, bush fires, unpredictable rainfall patterns, sea level rise, increase desertification and land degradation, drying up of rivers and lakes and constant loss of forest cover and biodiversity. This study however reveals that an indicator is already present in Ebonyi State by way of increasing temperature, as this study agrees with the studies of Amadi, Udo and Ewona (2014) and Abiodun et al. (2011) on the rising trend in temperature over Southeast Nigeria.

Potential impact of temperature variability on crop agriculture

Climate change through increasing temperature can impact on agricultural sector directly or indirectly by impacting on crop productivity and production which can either enhance crop availability or a decrease in crop production. The most significant factors in climate are temperature and rainfall this is because of their role not only as elements of weather and climate but also as factors of climate with the implication that any change in them will likely cause change in the other elements. A continuous rise in temperature beyond a certain threshold will affect productivity in crop and could cause growing season to become shorter, thereby causing a reduction in yield. Climate change being experienced at present has resulted in extreme events such as flooding, droughts, heat/cold waves, changes in weather patterns which have posed serious challenges to the sustainability of crop production especially in regions were agriculture is dependent on weather. Ebonyi State being an agricultural State, that is experiencing climate change by way of increasing temperature, may experience a situation whereby crops will be smothered by excessive heat thereby reducing crop production in the State. Khanal (2009) stated that heat stress might affect the whole physiological development, maturation and finally reduces the yield of cultivated crop. As crop water requirement is directly linked to evaporative demand of the atmosphere in which the crop is grown. Increasing temperature will further increase the water demand of crops and if there is no corresponding moisture could lead to a drought situation. However, increasing temperature could be beneficial to some crops but detrimental to others this is because various crops require certain optimum temperature to survive. That is to say for any particular crop, the effect of increased temperature will depend on the crop's optimal temperature for growth and reproduction (USGCRP, 2014). In some areas, warming may benefit the types of crops that are typically planted there, or may give opportunity to farmers to shift to crops that are currently grown in warmer areas. However, if the higher temperature exceeds a crop's optimum temperature, yields will decline. On the other hand, Increase in temperature could reduce the length of the effective growing season, particularly where more than one crop per year is grown .Increased temperature could also affect the physiological processes necessary for crop growth and development thereby resulting to a drop in yield. Consequently, a drop in yield will lead to increased dependence on importation of crop to feed the population which could result to food insecurity.

IV. CONCLUSION

This study reveals that Ebonyi State is experiencing a rise in air surface temperature which by implication means that the State is susceptible to the attendant consequences of global warming. As a result, the inhabitant who are mostly farmers who sources of livelihood is dependent on returns from agriculture that is temperature sensitive are vulnerable to the risk pose by increasing temperature. As changes in temperature may have impact on water availability and water needs for agriculture, thereby increasing the need for alternative source of water such as irrigation for crop survival in Ebonyi State. Plant and animal also respond to temperature variability which could have economic consequences on agricultural productivities and thereby increasing food scarcity The implication of the rising trend in temperature will also have impact on the environment as well as the wellbeing of the inhabitant of Ebonyi State for example, the human body responds to thermal stress by forcing blood into peripheral areas to promote heat loss through the skin, therefore health disorders are expected at higher temperature. The inhabitants of Ebonyi State, Southeastern Nigeria could be vulnerable to medical disorder which can include heat stroke, heat rash, heat cramp, heat exhaustion and heat syncope. Therefore, proactive steps should be taken by all stakeholders ranging from government, individuals and cooperate bodies to take the issue of climate variability serious and put measures in place to mitigate its effect in the study area and Nigeria in general.

ACKNOWLEDGEMENTS

The Authors expresses deep appreciation to the anonymous reviewers of this study and this Journal platform for the opportunity granted it to publish this paper.

REFERENCES

[1] B.J. Abiodun, A.T. Salami, and M. Tadross, "*Climate change scenarios for Nigeria: understanding the biophysical impacts"*: A Report by the climate systems Analysis Group, Cape Town, for building Nigerian's response to climate change project.

[2] S.O. Amadi, S.O. Udo, and I.O Ewona, "Trends and variations of monthly mean minimum and maximum temperature data over Nigeria for the period 1950-2012". International Journal of pure and applied Physics. Vol. 2, No. 4, pp.1-27, 2014.

[3] Committee on the Environment and Natural Resources (CENR), "Scientific Assessment of the Effects of Global Change on the United States", 2008.

[4] I.I. Ekpe, E.G. Okpone, E.N. Ogbodo, and J.N. Nwite, "Physico-chemical properties of four ultisor under different vegetation cover in South-eastern Nigeria." Journal of Science of Agriculture, Food Technology and Environment. Vol 5, pp74-78, 2005.

[5] IPCC, "Climate Change 2007": impacts, adaptation and vulnerability: contribution of Working Group II to the fourth assessment report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK, 2007.

[6] IPCC, "*Climate Change 2013: The Physical Science Basis". Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2013.

[7] S.K. Jain and V. Kumar, "Trend analysis of rainfall and temperature data for India.Current Science", Vol 102(1), pp37 – 49, 2012.

[8] Nigerian Environmental Study/Action Team (NEST), "Climate Change in Nigeria. A Communication Guide for Reporters and Educators". Ibadan: NEST. 5-16, 2003.

[9] P.A.O. Odjugo, "Regional evidence of climate change in Nigeria". Journal of Geography and Regional Planning", Vol 3(6), pp142-150, 2010.

[10] E.N. Ogbodo, "Assessment and management strategies for the receding watersheds of Ebonyi State, Southeast Nigeria". Journal of environment and earth Science, vol 13, no3, 2013.

[11] E.B. Ogbuene, "Impact of Meteorological Parameters on Rice Yield: An Approach for Environmental Resource Sustainability in Ebonyi Rice Farmland". Journal of environmental issues and agriculture in developing countries, vol 2, No 2 and 3, 2010.

[12] O. Singh, P.O. Arya, and B.S. Chaudhary, "On rising temperature trends at Dehradun in Doon Valley of Uttarakhand, India", J. Earth Syst.Sci., vol 122(3), pp613-622, 2013.

[13] M.F. Tshiala, J.M. Olwoch, and F.A. Engelbrecht, "Analysis of temperature trends over Limpopo Province, South Africa", Journal of Geography and Geology, vol3 (1), pp13-21, 2011.

[14] D.L. Waller, "Statistics for Business", Butterworth- Heinemann: Amsterdam.

[15] R.C. Khanal, ''Climate change and organic agriculture" The journal of agriculture and environment, vol.10, pp 100-110, 2009

[16] USGCRP ,J.G. Hatfield, R.Takle, P. Grotjahn, R.C.Holden, T.Izaurralde, E. Mader, Marshall, &D. Liverman, : Agri-culture. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 150-174,2014.